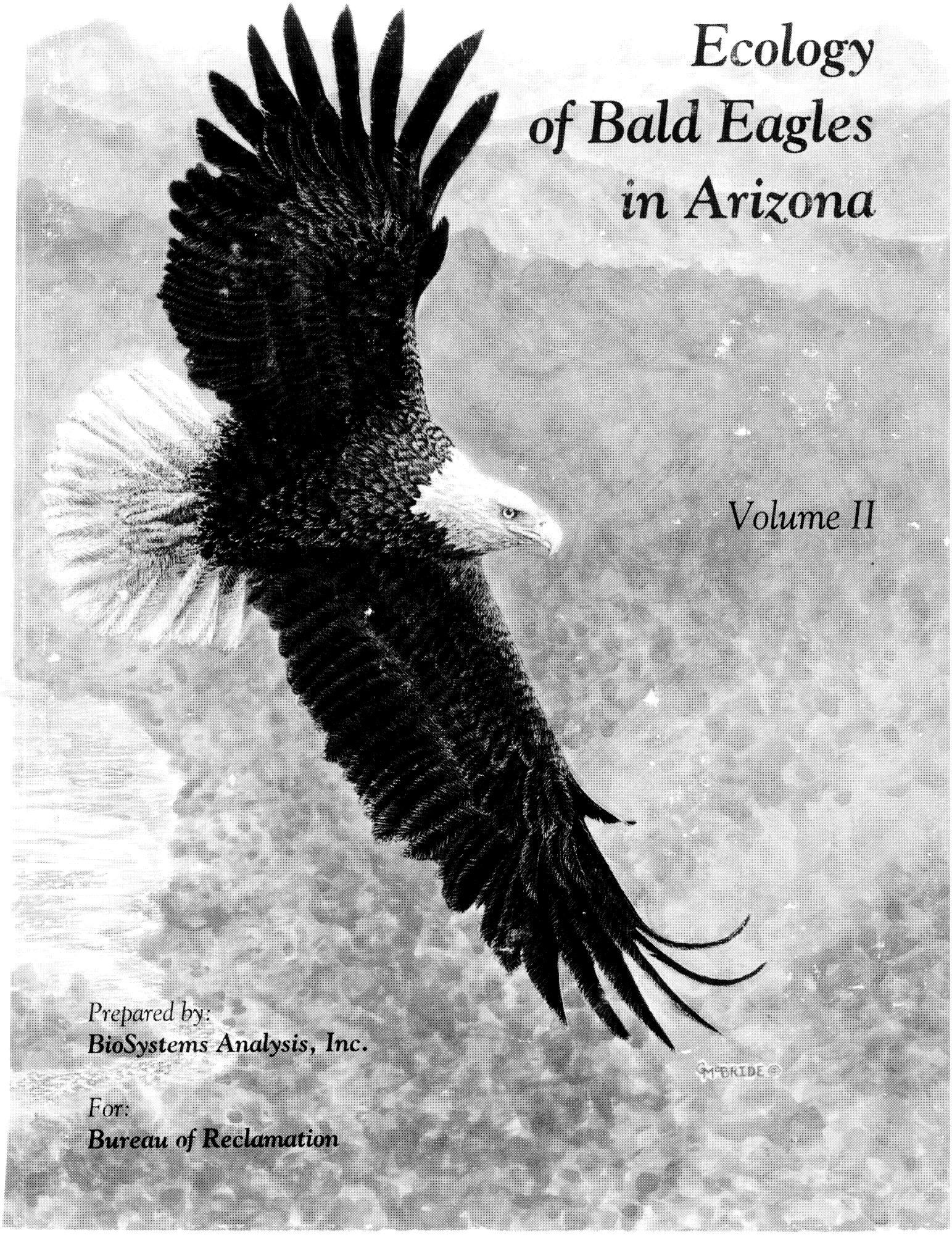
Ecology of Bald Eagles in Arizona

Volume II



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Part B

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B1 INTRODUCTION

This part of the report describes field studies by BioSystems at seven bald eagle breeding areas in Arizona, including Bartlett, Blue Point, Ladders, East Verde, Horseshoe, Pinal/Pinto, and Cliff (Figure B1.0-1). Several criteria guided the agencies' selection of the territories. Foremost was the need for a comprehensive understanding of the ecology of the Arizona population to be used in assessing the impacts of existing and future water projects. Among these was a plan, now abandoned, to build Cliff Dam on the Verde River downstream of Horseshoe Reservoir, a project which might have affected three to five pairs of bald eagles. Proximity to this project, and to others involving dam modifications and water diversions, therefore guided the choice of territories to some extent. However, the desire for a population view ultimately influenced the final selection of the seven territories, thus permitting a comparison of the ecologies of eagles in river habitat settings ranging from relatively undisturbed to completely regulated. Moreover, a favorable redundancy existed in this sampling scheme, so that generalizations suggested in one territory were reinforced or contradicted by findings in the similar habitat setting of another.

The distinction between habitats occupied by eagles in Arizona has largely to do with flow regulation and reservoir characteristics. Thus, the Bartlett (Section B4.1) and Blue Point (Section B4.2) pairs exploit a totally controlled aquatic environment, the components being a regulated river reach and a reservoir fed by regulated flows. During spring and summer, the rivers emerging from the dams at Bartlett and Blue Point are cooler than unregulated reaches of similar flow because the dam releases originate from the insulated depths of the reservoirs. We will show that these temperature differences are important in influencing the species composition and availability of prey fish populations in the rivers, and that the reservoirs themselves are important foraging areas.

Two other selected bald eagles territories, Ladders (Section B4.3) and East Verde (Section B4.4), are located on the free-flowing Verde river many kilometers upstream of the reservoirs. We found that the similarity of habitat shared by these pairs is reflected in their diets and in seasonal patterns of movements within home ranges. These and other findings differed from those obtained at Bartlett and Blue Point, not only because of the difference of flow regulation, but because of the absence of reservoirs, the presence of substantial tributaries, the occurrence of high and turbid spring flows in some years, and the effects of sediment transport on stream habitat.

Of course, we cannot suggest that the ecologies of the Ladders and East Verde eagles are similar to those that might have inhabited Arizona rivers in pristine times. For one thing, prey fish species composition in these free-flowing reaches has been significantly altered. Moreover, flow and turbidity regimes are doubtlessly far less stable and of greater amplitude than those in pre-Columbian Arizona because of the enormous impact of domestic grazing on soils, a factor which continues to reduce the formerly extensive riparian plant and animal communities (see Section D2.6).

The third set of bald eagle territories we studied with common habitat attributes was Horseshoe (Section B4.5) and Pinal/Pinto (Section B4.6). It was tempting to consider these breeding areas as intermediate habitat because, like Ladders and East Verde, they contain free-flowing reaches, and, like Bartlett and Blue Point, there are reservoirs present. While some similarities did exist, we also found eagle foraging ecology at Horseshoe and Pinal/Pinto to be unique among the seven territories studied. In these areas where free-flowing rivers enter the reservoirs, the eagles exploited an estuarine type of richness, a transition of shallows, temperature gradients, and edge-effects that offered both live prey and carrion.

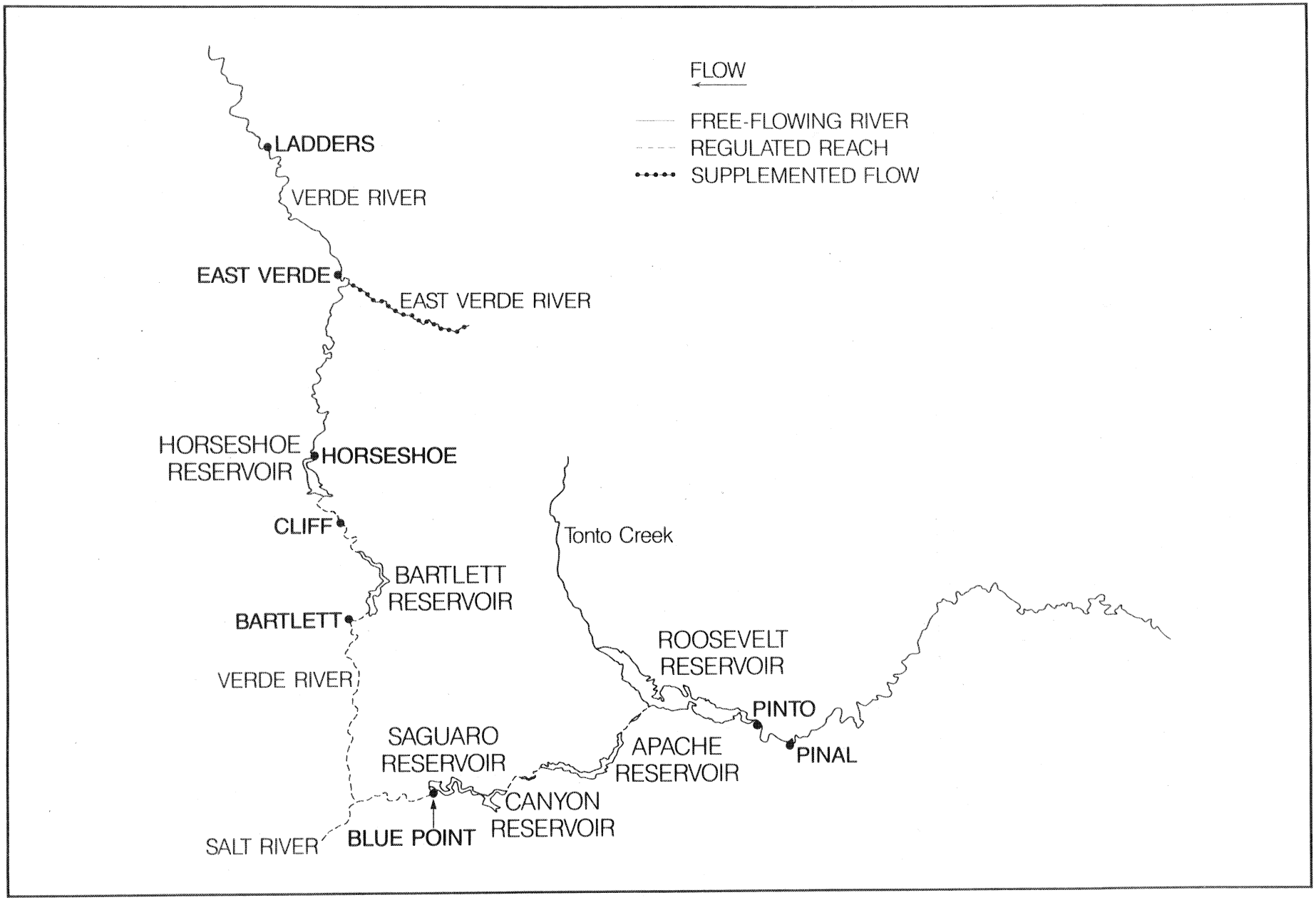


Figure B1.0-1. Eight bald eagle breeding areas where BioSystems conducted telemetry studies.

The seventh selected territory, Cliff (Section B4.7), was located on a regulated river between two dams. Unlike the regulated reaches at Bartlett and Blue Point, the river at Cliff is relatively warm because of the water volume and mode of regulation of Horseshoe Reservoir just upstream. Although the pair did not successfully nest in the year we studied it, and so did not demonstrate extensive foraging for which data could be collected, we did obtain useful information on habitat and prey use.

In summary, the rationale behind these in-depth studies of nesting bald eagles was not only that they needed for local management decisions but were essential in the development of an understanding of the ecology and status of the entire population. Thus we sought to find common features among the Arizona breeding areas that would provide the needed population perspective.

However, during our investigations we found that biotic, physiographic, and human factors affecting food and habitat availability for bald eagles were more diverse than expected, both within and between bald eagle territories. For example, in addition to the habitats described above for the seven studied territories, there were other habitat regimes occupied by nesting bald eagles that we did not study intensively. Several pairs nested on tributaries of varying size, including Tonto Creek and Canyon Creek. Others, such as Alamo and Pleasant, nested on reservoirs lacking substantial perennial flows into them. Horse Mesa was situated near a dam between two narrow reservoirs, with a very short, regulated, hypolimnetic riverine section, from which water was alternately pumped back into the upstream reservoir. The pair at Fort McDowell exploited a regulated river section without access to a reservoir. These variations, and those we encountered in our intensive studies of the seven territories, rendered a somewhat diffuse picture of the ecology of this highly adaptable predator, but one which nonetheless highlighted many interesting and useful facts.

The next section (B2) contains an explanation of our general approach in studying the seven pairs. More specific methods are given in Section E8. For a general description of habitats occupied by nesting bald eagles in Arizona, we refer the reader to Section D2 which also discusses the history of human influence on the Arizona landscape. Section E1 further outlines the historical changes in Arizona habitat with emphasis on how bald eagle prey populations have been affected. Sections D3, D4, and D5 review published and unpublished reports on nesting in Arizona, and provide an account of the habitat setting, history, and demographics for all 28 breeding areas that are known to have been occupied. We urge the reader of the present material to consult the appropriate sections of Parts C (Population Ecology) and D (Breeding Ecology) to obtain a fuller understanding of the dynamics of the studied territories and of the population as a whole.

B2 OVERVIEW OF APPROACH AND METHODOLOGY

Perspective

For the agencies and others concerned with the well-being of Arizona's native bald eagles, the ultimate consideration is demographics. If the population is going to survive into the future, the rate of recruitment to the breeding population must equal or exceed that of mortality. In Part C of this report, we give an overview of the demographics of the Arizona bald eagle population by first assessing occupancy and reproduction, and then describing the known factors which act to reduce the overall numbers of eagles. While some of these diverse mortality agents are human-related and others are phenological or biotic, the majority operate in a relatively simple way; that is, most eagle deaths are circumstantial rather than systematic in cause.

Conversely, the myriad factors that increase bald eagle populations are rooted in the evolutionary adaptations of both eagles and their prey. Eagles must extract energy from the environment, use it to amass bodily and experiential resources, and transfer this energy to their offspring so as to maximize the quantity of their eventual descendants. An eagle must find and successfully defend a volume of habitat sufficient in its elements to provide the needed energy. It must cooperate with another similarly prepared eagle to construct a huge nest, the most critical requisite of which is isolation from predators. Meanwhile, it must obtain the bodies of animals, many or most of which derive from an altogether different life zone (water).

The requisites of a breeding area which enable a pair of bald eagles to reproduce, and coincidentally, to counter demographic loss, lie largely in its potential for efficient energy extraction. This energy is sometimes available as abundant carrion, and the eagles may obtain it in the simple way herbivores acquire food. But in most cases, prey is not directly available to nesting bald eagles, but rather must be acquired at differing times and under varying circumstances, depending on prey life history strategies, food distribution for prey populations, and ambient environmental patterns and events. There may be a score of prey species present in a territory, and the availability to eagles of each species may be controlled by a different set of evolutionary and environmental conditions. Some of these species and habitat conditions are endemic, while others are entirely new to Arizona and to bald eagles.

To understand bald eagle predation on fish, it is necessary to consider species composition and the relative abundance and life-history of each species, especially spawning chronology, migrations, mortality agents, and feeding behavior. Eagle foraging opportunities in riverine conditions may depend on the type of flow, whether natural or resulting from dam regulation, and on differences in stream habitats, substrate, turbidity, temperatures, and sediment loads. Reservoir foraging is affected by water elevation and stratification, the distribution of shallow water, and the type of inflow.

In this part of the report, we consider each of these factors specifically in the light of the movements and activities of the seven studied pairs of bald eagles. The rationale behind doing these studies during the nesting season is partly one of efficiency. When there are nestlings to feed, bald eagles are most active, and they demand much more from the environment than at other times. But more importantly, the nesting season is the time when the energy extracted by bald eagles from the environment most directly

relates to demographics. In our study of the seven bald eagle territories, *energy extraction* equates to *foraging ecology*, and the latter constitutes our focus throughout those sections of this report.

Overview of Methods

To obtain the needed knowledge on foraging ecology, we determined the ranges of the foraging adults and the kinds of prey taken. We estimated prey size to calculate the value of each species to the eagles. To determine the conditions of prey vulnerability, we identified and measured the habitat present at the exact locations where we observed eagles catching prey. We soon found that these locations, and indeed the foraging ranges of the birds themselves, varied from month to month over the breeding season. The variation in areas used often corresponded to changes in the species of fish taken or to changes in microhabitat at foraging sites. To clarify how the locational changes related to apparent differences in prey availability we employed fisheries techniques to study the distributional, life-historical, and behavioral aspects of the fishes that related to their vulnerability to eagles.

Eagle Movements. The foraging ranges of bald eagles during the nesting season are often so large, it is virtually impossible to determine their size by visual observation alone. However, because the birds are largely oriented to water courses, the overall numbers of square kilometers used by a pair for foraging is far smaller than the range of a golden eagle, for example, whose food is more dispersed in the landscape. A bald eagle ranging 10 km from its nest might enact 98 percent of its foraging within less than 20 square kms, while the foraging locations of a golden eagle, traveling the same distance, might encompass some 60 square kms.

However, with visual methods alone, even a foraging range of 20 square kms would require very many observers stationed along the river to produce a proportional estimate of habitats used by the eagles, one that would not be biased by observer location. It was for this reason that previous studies of bald eagle movements in Arizona tended to underestimate the distances traveled and to overlook some of the important foraging areas.

The way around the problem of keeping track of eagle movements is to use radio telemetry (see Section E8 for techniques). Unlike visual surveys, where knowledge of the whereabouts of the eagle is entirely dependant on observer location (and alertness), a few strategically-placed biologists with telemetry receivers, directional antennas, and two-way communication radios can almost always approximate the location of a radio-tagged eagle, even when it is impossible to find it visually. The great advantage of this is that the eagle's position in the landscape can be known over long, uninterrupted periods of the day and for days on end. Thus, a sound estimate can be made of the relative contribution of each part of the home range in sustaining the eagles.

As in many other species of raptors, the male bald eagle is usually the main provider for the family until the young are at least half grown and so his activities are the most expressive of the pair's specific requirements of habitat and prey. Therefore, because of the difficulty and time involved in capturing adult bald eagles for radio-tagging, we always attempted to catch the male rather than the female.

Previous studies of home range in Arizona used observations of eagles flying in and out of defined quadrats to estimate patterns of habitat use within breeding areas. The resulting home range maps were expressed as a series of "hot squares" or as home range polygons. The problem with this approach is that flying and soaring eagles are often not hunting, but rather using thermals and terrain features to

obtain lift so they can to travel to distant foraging locations or to patrol their territories. In our experience, the distribution of perching events is a better measure of an eagle's range and of preferred foraging locations within it. Because a perched eagle is often hunting, the perch location itself is suggestive that a potential foraging site is nearby.

The following factors support our assumption that eagles perching outside the nest area are probably engaged in foraging. First, we argue that there is a potential cost of perching outside the nest area—for example, the danger of nest predation or the arrival of a territorial usurper. Such risk would not as strongly involve a soaring eagle, since the nest area may remain visible during such activity. More compelling, however, is the fact that the vast majority of foraging events we observed were preceded by perching events. In 532 (80%) of 665 foraging events for which such data was recorded, the eagle perched within sight of the foraging location just before the event. In 465 cases (70%), the eagle appeared to have seen the prey before leaving the perch. In general, where eagles perched repeatedly, they also tended to forage, though not necessarily in connection with every perching event.

Our approach, therefore, was to assume that if an eagle perched at a particular location it had selected that location on the basis of its quality as foraging habitat. Each time an eagle traveled to a location and perched or foraged, the location received a score of one point. If the eagle left the location and traveled 100 m or so along the river, but then returned to the original location, the latter received another point to its accruing "visitation score." Thus, locations that were repeatedly revisited took on significance in our habitat appraisal.

We recorded eagle locations along the river, using topographical maps on which the river centerlines (and those of major tributaries) were indexed per kilometer (and one-tenth km), proceeding upstream from the mouth (see River Map Atlas, Section E12). The resulting river kilometer segments are referred to as "Km" throughout this report (airline kilometers are "km"). Similarly, we indexed the reservoir shorelines (at standard water surface elevations) with one kilometer graduations, going counter-clockwise around the reservoir from the dam. We referred to these shoreline kilometers as "SKm."

The data we obtained on eagle location varied in precision, depending on the circumstances. Naturally, it was most useful to see the eagle, in which case we coded its location to the nearest 0.1 Km. In situations where we could identify the eagle's location only on the basis of telemetry, we were often able to ascribe its location only to a full Km, or, in the least precise case, to a "zone," encompassing several Kms, chosen on the basis of its inclusion within recognizable landmarks.

One difficulty with this technique was that the very large number of nest visitations tended to overshadow point scores of other locations. Because the nest vicinity was often an important foraging area, it would have been inappropriate to exclude it from our analysis. To solve the problem we consulted our foraging data to estimate what percentage of all recorded forages by the eagle were made in the nest vicinity, then weighted the array of visitation scores correspondingly.

Prey Selection. We approach the problem of determining the diets of the eagles in several ways. Since bodily materials from prey animals typically accumulate in and around an active nest, these can be collected and compared with a reference collection. Not only is species identification possible in almost all cases, but the sizes and weights of prey can be calculated from the sizes of specific body parts. Many of these are actually components from the same animals but by matching up parts of similar size, duplicates can be virtually eliminated from the data set. The result can not only be used to estimate the

number and size of each prey item brought to the nest, but by combining the calculated weights of individuals (biomass), an approximation can be made of the relative contribution of each species in sustaining the eagles.

There are certain biases associated with prey remains analyses that blur the picture of eagle prey selection. Some prey animals have bones and other body parts that persist in the nest longer than the parts of species with more delicate bone structures. Some prey items are completely consumed in the nest, leaving no record of their occurrence, while others tend to be delivered headless by the eagles, thus depriving the researcher of the most useful information. Perhaps the most disagreeable feature of depending entirely on prey remains data is the impossibility of learning anything about when and where the prey was taken, and the circumstances of its acquisition by the eagle.

For such reasons, we set up observation posts near and above the studied nests and watched prey being delivered by the adults. Observers were instructed not to guess the identities of prey items, but simply to describe and draw what they saw, so that a knowledgeable person viewing the data could deduce each prey item's identity and size on the basis of the described and depicted characters. This technique is virtually the same as that used by the classical microscopists.

The prey delivery observers remained in radio contact with the several trackers dispersed within the eagles' home range, and all kept records of the timing of events. Because the telemetered eagle's location was known in the minutes prior to delivery, the location of the foraging event was also known, even if the actual attack was not seen. In this way, we accumulated information on the geography of foraging. The technique allowed us to match up particular prey species with specific locations and habitats. As different species of prey became available over the season, foraging distribution patterns changed.

Another benefit of the nest delivery observations was that it was often possible to determine whether prey had been taken alive or as carrion. Prey recently taken alive appeared colorful, limp, and sometimes even exhibited muscle movement, while carrion items were stiff and dully colored. A difficulty arose, however, in that some fish judged to have been alive when taken were actually dying at the water's surface, often as a result of spawning stress.

We were later able to contrast the prey delivery data with the prey remains analyses (Section B5) at four nests where both kinds of data were available. This comparison allowed us to evaluate and weigh the conclusions of a larger series of prey remains analyses conducted throughout the Arizona nesting population, an analysis which revealed the probable direction of bias in estimating the dietary contributions of various prey taxa.

Foraging Habitat Selection. The goal of the trackers was to constantly know where the eagle was and to witness as many foraging events as possible. This knowledge enabled us to determine what specific habitat features were responsible for rendering the prey vulnerable. As soon as possible after observing a foraging event, but without disturbing the eagle, we went to the location and recorded *macrohabitat* characteristics, specifically river habitat (i.e., run, riffle, pool, or pocket water), type of perch, distance from perch to strike point, distance from strike point to shore, and shoreline characteristics. We also recorded the method of attack, the size and type of the prey, whether it appeared to have been taken alive or as carrion, and what the eagle did with it. We measured *microhabitat* features at the exact strike point, including water depth, water temperature, clarity, stream velocity, surface condition, stream substrate, and submerged vegetation. If the exact strike point was not observed, we were still able to

estimate conditions such as depth and surface turbulence if these were homogeneous over wide areas. We looked for evidence to identify the prey species caught, but often obtained this information later from the nest observer.

Prey Studies. Because of the preponderance of fish in the diet of most pairs (at least 75% of the state-wide estimate of biomass), bald eagle foraging ecology in Arizona is largely a function of the ecology of fish. To learn the many details necessary to such an understanding, we first focused on the environmental characteristics in the studied territories that might influence fish populations, such as river flows and reservoir elevations. Next were questions about the kinds of prey fish occurring in the eagles' territories (see Section E2). Beginning with the literature (Section E3), we used a variety of field methods, including netting, seining, and visual surveys. The latter were especially advantageous, not only in permitting us to cover wide areas, but in providing direct knowledge of fish behavior and occurrence in shallows where they were vulnerable to eagles.

We soon found that factors causing fish to enter shallow water (or to become available as carrion) were often related to life history events such as spawning. We consulted the literature on the life-histories of each fish species (see Section E3), and obtained field data on spawning cycles and factors which influence them. Stream habitat, including riffles, runs, pools, and pocket water, also influenced prey distribution and vulnerability to eagles. We measured the distribution of these habitats in selected territories for a comparison with the distributions of eagles.

Data Presentation. In preparing this report, we assembled data from diverse sources within the total field effort, including telemetric and visual observations of eagles, prey identification, flow and habitat measurements, and surveys of the ecology and natural history of fish populations. We were able to compare and contrast findings between territories because conditions varied markedly between them. For the same reason, we found it difficult and unnecessary to standardize the contents of each chapter merely for the sake of consistency. Instead, in trying to obtain an overall picture of foraging ecology, we present a variety of data, much of which was collected with no assurance that they would bear on our eventual conclusions. In presenting our findings in detail, we hope to provide a foundation to aid in clarifying yet unresolved questions. At this point, we regard this document as a momentary view of a fairly complex system.

B3 STUDY REGION OVERVIEW

All seven pairs of bald eagles we studied intensively with telemetry during 1987-1989 lived on the Salt and Verde rivers in central Arizona (see Figure A2.4-1). To a large extent, the ecologies of these pairs depended on their nest placement within the geography of the drainages and on the natural and man-made features occurring along them. To orient the reader to this larger setting, we will now briefly describe these drainages. In doing so, we refer often to our River Map Atlas, which provides a simple way to locate geographical and topographical features referred to throughout this report. We urge the reader to consult this atlas in order to fully understand the locational aspects within and between eagle territories. Sections B4 and D4 provide habitat characterizations of the home ranges of each pair. Section D2 gives a statewide view of bald eagle habitat in Arizona, a chronicle of man's influence on these habitats, and a history and description of water projects. Section E1 discusses the histories of prey fish populations and their habitats in Arizona.

Verde River Drainage

The Verde River drains north-central Arizona, flowing from the Flagstaff and Williams area south to Phoenix. Substantial tributaries include the East Verde River, West Clear Creek, Oak Creek, and Sycamore Creek. Horseshoe and Bartlett reservoirs also occur on the drainage. From the bridge crossing at Highway 89, the river courses over 300 river kilometers (Km) to its confluence with the Salt River, east of Phoenix.

After flowing through several narrow canyons from Km 293 to around Km 234 at Clarkdale, it opens into the Verde Valley which contains the communities of Clarkdale, Centerville, Cottonwood, Bridgeport, Middle Verde, and Camp Verde. Mean monthly flows of the Verde River at the Camp Verde USGS gaging station (Km 185) during 1987-1989 ranged from 23 to 1,144 cfs. Below Camp Verde, West Clear Creek enters the Verde River at Km 175. The Verde enters a narrow canyon a short distance downstream, and it is here that the Ladders bald eagle breeding area (Section B4.3) is located, the northernmost of the territories we studied.

For the next 150 Kms, there is only one small human settlement: at Childs Powerplant at Km 142. Not far downstream is the East Verde bald eagle breeding area (Section B4.4), near where Fossil Creek (Km 136) and the East Verde River (Km 130) enter the mainstem. This part of the drainage is designated wilderness and is administered by the U.S. Forest Service. The East Verde River (ca. 15-200 cfs, mean monthly) drains 320 mi^2 of the Mogollon Rim region and is currently supplemented with water imports from East Clear Creek.

Below its confluence with East Verde River, the Verde River flows some 50 Kms to Horseshoe Reservoir, passing the Table Mountain bald eagle territory (not studied) situated about half way to the reservoir. Mean monthly flows during the years of our study at the USGS gaging station at Km 90 varied from 114 to 2,177 cfs.

The Verde River enters Horseshoe Reservoir at about Km 85. Depending on rainfall and dam operation, Horseshoe Reservoir varies from being full to being entirely riverine in character. The Horseshoe bald eagle breeding area (Section B4.5) is located in the inflow area of the reservoir.

Horseshoe Dam (Km 73) regulates the Verde River as it continues southward into Bartlett Reservoir at about Km 58. Between Horseshoe Dam and Bartlett Reservoir is the Cliff bald eagle breeding area (Section B4.7). Bartlett Reservoir is more apt to be full than Horseshoe Reservoir, but during the 1989 drought its surface area was much reduced. On the regulated river downstream of Bartlett Dam is the Bartlett bald eagle breeding area (Section B4.1). From there, the river continues some 35 Kms to the Salt River confluence, passing two more bald eagle breeding territories (Ft. McDowell and Orme), neither of which we studied intensively.

Salt River Drainage

The Salt River originates in the White Mountains in east central Arizona and flows west through Phoenix to its confluence with the Gila River. The Salt River itself begins at the point at which the White River joins the Black River at Km 247. The main tributaries include Carrizo, Cibecue, Canyon, Ash, Cherry, Pinal, and Tonto creeks. Four reservoirs occur on the drainage: Roosevelt (the largest), Apache, Canyon, and Saguaro.

From the confluence of the Black and White rivers, the Salt flows westward almost 150 Kms through a rugged canyon, forming the boundaries of the Fort Apache Indian Reservation to the north and the San Carlos Indian Reservation to the south. Seven bald eagle breeding areas occur in this remote reach. Some (Lone Pine, Cedar Basin, Mule Hoof, Cibecue, and Redmond) occur on the mainstem, and two (Canyon and Ash) are on tributaries. None of these territories were studied intensively.

At Km 112, where the river opens up into the Tonto Basin, Pinal Creek enters from the south. Nearby is the Pinal bald eagle breeding area (Section B4.6). Mean monthly flows in the Salt River at this location ranged from 114 to 2,685 cfs during 1987-1989. A few kilometers downstream near the Salt's inflow into Roosevelt Reservoir is the territory of the Pinto adult female bald eagle who, during our study, shared the attentions of the Pinal adult male. We therefore included the Pinto female in our study of the Pinal pair.

Roosevelt Reservoir, created by Theodore Roosevelt Dam at Km 79, backs up the Salt River to the east (Salt Arm)(where the Pinal/Pinto breeding areas are located) and Tonto Creek to the north (Tonto Arm). Upstream on Tonto Creek are two bald eagle breeding areas, Sheep and "76," neither of which were selected for study.

Below Roosevelt Dam, the regulated Salt River flows through a narrow canyon and soon enters Apache Reservoir, created by Horse Mesa Dam which is at Km 52. The Horse Mesa bald eagle territory (not studied) is in the vicinity of the dam. Below Horse Mesa Dam, the Salt River flows through a narrow canyon and enters Canyon Reservoir, created by Mormon Flat Dam which is at Km 36. Below a short riverine section is Saguaro Reservoir, created by Stewart Mountain Dam at Km 21, near which is the Blue Point bald eagle breeding area is nearby (Section B4.2).

The regulated Salt River below Stewart Mountain Dam contains highly variable flows, ranging from 0–2,124 cfs (mean monthly) during 1987–1989. Downstream, the river passes Bulldog Cliffs and flows through open country until it joins the Verde River at Km 5.5. Then the Salt River continues to Granite Reef Dam, where it is diverted into canals.

B4 FIELD STUDIES AT SEVEN NESTING AREAS

The following sections describe specific studies of bald eagle foraging ecology, habitat use, disturbance, and relationships to water projects at each of seven nesting areas: Bartlett, Blue Point, Ladders, East Verde, Horseshoe, Pinal/Pinto and Cliff.

In interpreting our conclusions, we remind the reader that our data reflect the conditions prevailing during the years of field study: 1987, 1988, and 1989. Table B4.0-1 shows that April and May flows in unregulated sections of the Verde River were much lower in 1989 than in any other year listed. Similarly, spring flows in the Salt River upstream of Roosevelt Reservoir declined from 1987, when rates approximated the 15-year mean, to 1989 when the lowest values for April and May were recorded for the 20-year period. Rainfall (recorded at Phoenix) was lower than average in 1988 and 1989.

Some of the maximum temperatures for March, April, and May measured at Phoenix during 1988 and 1989 were higher than any for the twenty-year period (Table B4.0-2). Not shown in the table were particularly high afternoon temperatures during mid-May 1988 which endured for nearly a week and may have accounted for several nest failures (see Section C3.5). These temperatures were the highest on record for that time in the Julian cycle, as were some of the 1989 April temperatures.

Whether or not the differing flows, amount of rainfall, or the range of temperatures occurring during our study affected the behavior of eagles, their foraging opportunities, and therefore our results, is unknown. Our opinion is that there was little effect on our conclusions because a highly variable array of such conditions over the years has been the rule in Arizona. Further data on the monthly flows and reservoir elevations specific to each of the studied bald eagle breeding areas are given toward the beginning of each section.

B4.1 BARTLETT BREEDING AREA

The Bartlett breeding area is located 54 km northeast of Phoenix, on the regulated Verde River downstream of Bartlett Reservoir (Figure B4.1-1). Bartlett is within the Lower Sonoran Life Zone (C. H. Merriam 1890, 1898; in Lowe 1964), and surrounding habitat is of the Sonoran Desertscrub Biome, which contains species of the Paloverde–Cacti–Mixed Scrub Series (Brown and Lowe 1980, Brown 1982). The riparian habitat includes Fremont cottonwood, Goodding willow, mesquite spp., tamarisk, and some emergent vegetation along scattered cutbanks and cliffs. A single line of cottonwoods grows in the mesquite bosque immediately below Bartlett Dam, although trees are scarce from the nest vicinity to Needle Rock. The upper portion of Bartlett Reservoir contains some promontory cliffs; however, most of the reservoir is devoid of bald eagle perching habitat, with steep desert slopes to the east and more open country to the west. The two current nests are on a cliff on the right bank of the regulated river a few kilometers downstream of Bartlett Dam (Figure B4.1-1).

We were directed to study the Bartlett pair because dam repair projects are pending at the site (see below), and because the territory sustains some of the greatest levels of public use of any bald eagle breeding area in Arizona, a matter confirmed by our research. During the past five nesting seasons, at least three different adult males have attended the site (one and probably two of these birds died); moreover, two broods failed during incubation, most likely as a result of public disturbance.

Table B4.0-1. Monthly averages of mean daily flows in cubic feet per second (cfs) on the Verde River (Tangle Creek Gaging Station) and the Salt River (Salt River at Roosevelt Gaging Station) during 1975–1989. Data supplied by Salt River Project. Rainfall data were obtained from U.S. Dept. of Commerce Environmental Data Service and the Office of The State Climatologist, Tempe, AZ.

	Verde River Entering Horseshoe Reservoir			Salt River Entering Roosevelt Reservoir			Total Precipitation Phoenix, Jan.–May
	March	April	May	March	April	May	
1975	901	1,329	223	2,144	2,968	1,750	1.6
1976	719	1,113	274	574	1,204	872	2.6
1977	226	228	168	241	608	322	1.1
1978	10,418	646	210	10,386	3,081	1,035	6.9
1979	3,793	1,865	321	5,053	6,281	2,960	4.8
1980	3,499	1,532	342	2,701	3,848	2,742	5.2
1981	408	455	175	763	1,280	580	3.0
1982	4,410	619	229	2,642	1,945	1,210	3.3
1983	4,384	2,079	485	5,229	4,265	3,208	5.2
1984	260	247	189	815	922	575	1.4
1985	2,302	742	264	5,155	3,361	2,147	1.8
1986	1,560	566	157	2,380	1,715	609	2.9
1987	2,177	545	197	2,685	3,104	1,339	3.1
1988	605	1,892	263	1,125	1,785	1,215	2.4
1989	437	201	146	1,158	583	232	2.4
Means	2,407	937	243	2,870	2,463	1,386	3.2

Table B4.0-2. Temperatures (°F) recorded at Phoenix Sky Harbor Airport during 1970–1990 (data from U.S. Department of Commerce, Environmental Data Services Administration and Arizona Office of the State Climatologist, Tempe).

	Minimum		Maximum		
Year	January	February	March	April	May
1970	26	32	84	91	108
1971	19	31	95	94	97
1972	26	31	95	94	100
1973	31	35	75	98	105
1974	30	33	91	95	110
1975	27	31	85	91	102
1976	26	40	90	96	106
1977	31	34	89	99	108
1978	35	37	91	94	108
1979	29	36	83	97	105
1980	38	35	79	102	104
1981	38	35	89	100	99
1982	34	37	83	97	102
1983	34	41	90	93	113
1984	36	38	89	101	113
1985	33	28	88	100	105
1986	44	37	98	97	105
1987	29	38	86	100	102
1988	34	44	100	100	107
1989	33	33	95	105	110
Mean	31.7	35.3	88.7	97.2	105.4

From a biological standpoint, the Bartlett breeding area is interesting because, like Blue Point, the aquatic environment is entirely controlled by humans. The foraging range includes a reservoir and a regulated river section which derives its water from deep within the impoundment. Flow and temperature cycles are determined almost entirely by dam operations. Fish fauna in the territory include both exotic and native species.

During the course of this investigation, there were differences in reservoir elevation, flow patterns, and water temperatures between the 1988 and 1989 study years. River flows and reservoir levels were generally higher in the 1988 nesting season than in 1989. Water temperatures were higher in 1989 than in 1988. In both years, air temperatures were above normal. It is possible that the conditions prevailing

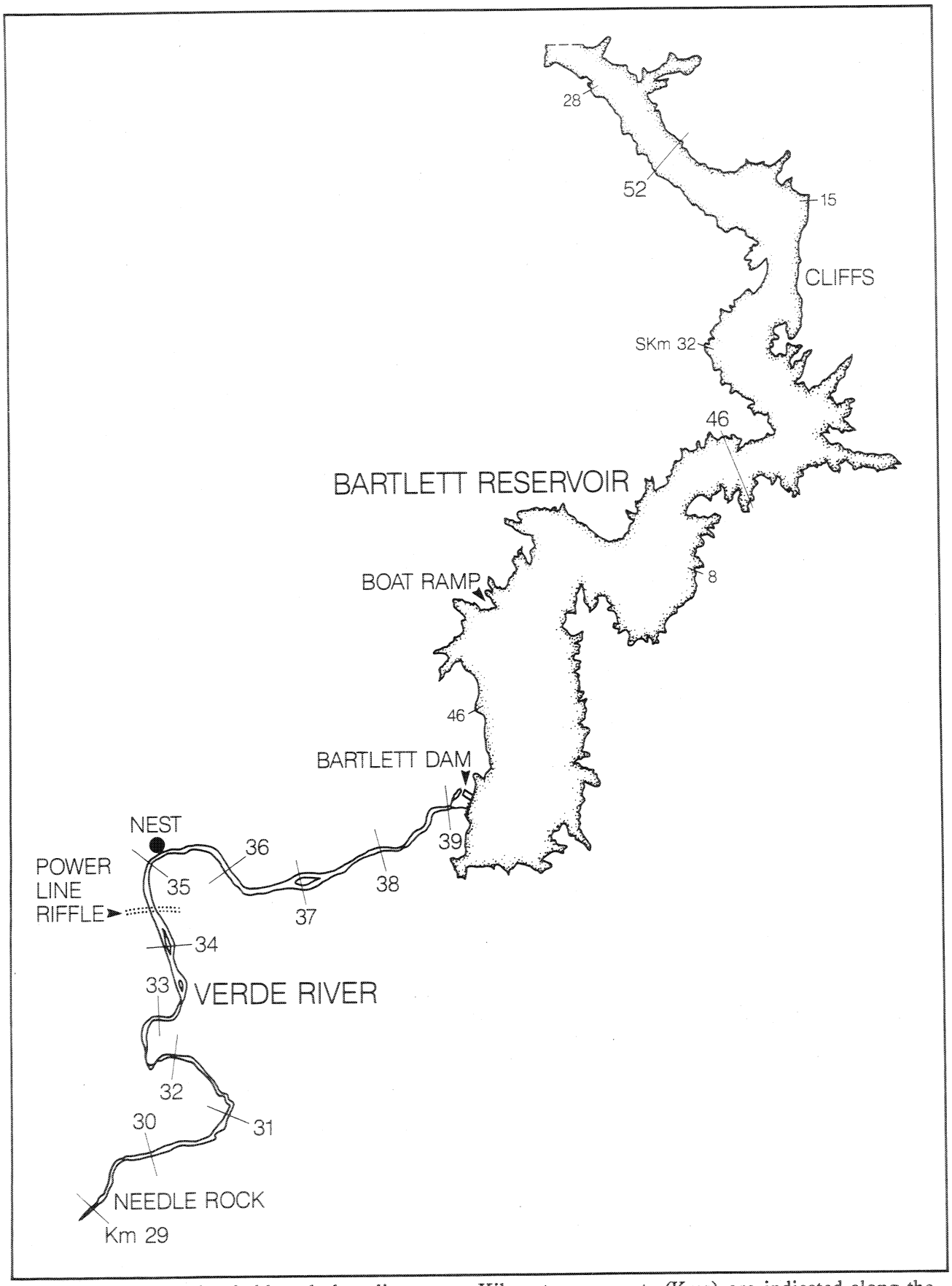


Figure B4.1-1. Bartlett bald eagle breeding area. Kilometer segments (Kms) are indicated along the river, and shoreline kilometers (SKms) along the reservoir (lines across reservoir indicate river Kms).

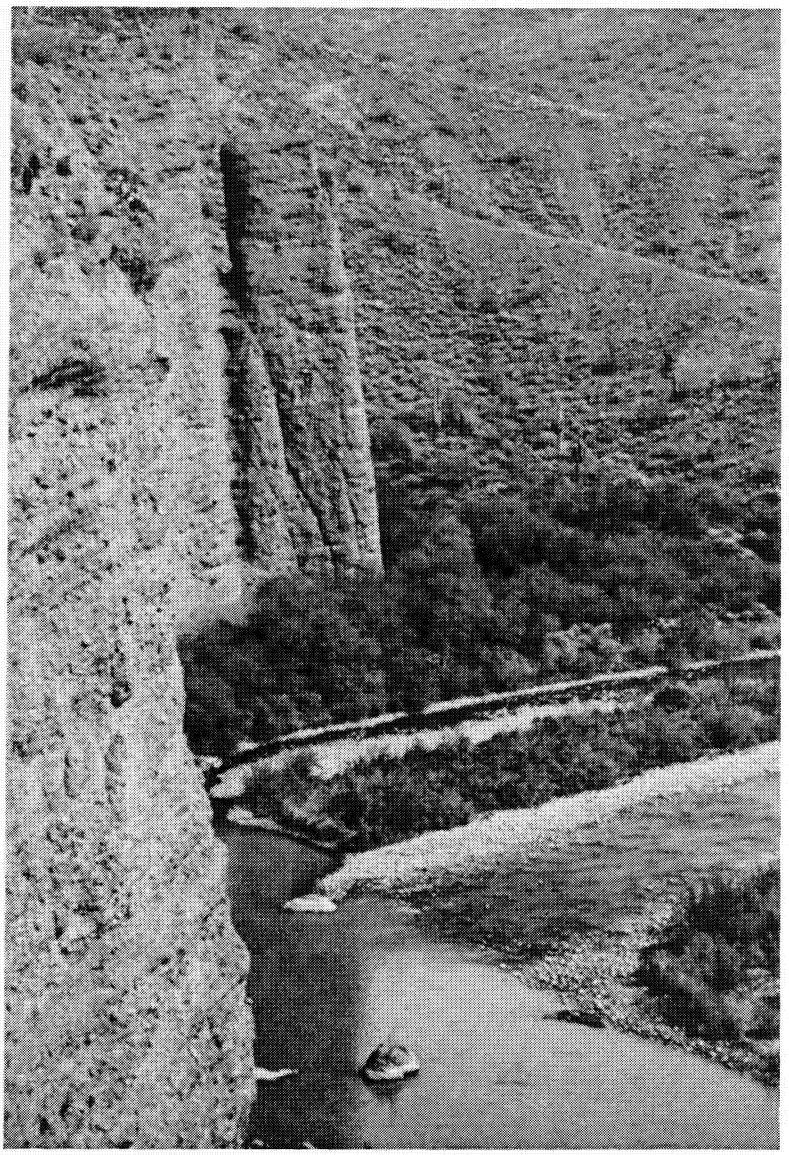


Plate B1. Bartlett nest cliff along the regulated Verde River, April 1990 (photo by D. Driscoll).

during the study caused the eagle's foraging patterns to differ from years with other flow and temperature regimes. However, these yearly differences in flows and reservoir elevations, and the higher-than-average air temperatures in both years, did not prevent the Bartlett pair from successfully fledging young in both years of study.

History of Reproduction

The Bartlett breeding area was first known to be occupied in the 1940s (Phillips *et al.* 1964), but there are no productivity data for this period. Two cliff nests currently exist at the site, both located on the regulated river reach below Bartlett dam. Two young hatched in 1964, but both died after the shooting

of one adult and possible abandonment by the other. One eaglet fledged in 1966, and eggs were laid in 1967, but the nest was not checked for young (Rubink and Podborny 1976). Since 1970, adults at the Bartlett breeding area have laid at least 44 eggs, failing seven years and fledging 20 young in the other 14 years. See Section D4.3.3 for details on annual productivity and mortality at Bartlett.

Water Projects

Plan 6 water project impacts in the vicinity of the Bartlett breeding area would have included the building of Cliff Dam upstream of Bartlett Reservoir, but Cliff Dam plans have been deleted from Plan 6.

Since Cliff Dam will not be built, Horseshoe and Bartlett dams will have to be renovated under "Safety of Dams" considerations. The dam, currently a concrete-arch structure with a single spillway, will be modified with an additional spillway (Alternative A), or with overtopping protection (Alternative B)(U.S. Bureau of Reclamation 1990). Environmental effects of these modifications have previously been addressed in the Biological Opinion prepared by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1989b), and the Biological Assessment prepared by the Bureau of Reclamation (U.S. Bureau of Reclamation 1989c). Possible impacts to eagles from these repairs may include construction, disturbance, loss of riparian habitat, adverse changes in flows, and/or water temperatures below the dam. In Section B4.1.6 we discuss measures to minimize or prevent these impacts.

Bartlett Reservoir

In 1939, the Bureau of Reclamation completed Bartlett Dam, which is about 15 airline miles downriver from Horseshoe Reservoir. Bartlett Reservoir is managed primarily for irrigation storage. Surface acreage of the reservoir averages 2,770 acres with a hydraulic height of 188 ft; maximum capacity is 178,490 acre-ft of water. The multiple-arch dam is concrete-lined, and its spillway has a flow capacity of 175,000 cfs. Water levels typically fluctuate between 40 and 70 vertical ft annually; maximum water level is 1798 ft msl. The drainage area of Bartlett Reservoir covers 6,160 square miles.

In 1987 and 1988, mean monthly water elevation levels in the reservoir were similar (Figure B4.1-2).

Mean water elevations from January to December of 1987 and 1988 were 1792 ft and 1791 ft, respectively. Minimum level in 1987 was 1777 ft in December and maximum was 1798 ft in April and May. The range of daily elevations in 1988 was 1775 ft in January, to 1798 ft in April. Water elevations in both years remained fairly stable from late winter to early fall, with a slight peak in spring. In the fall through winter of 1987 and 1988, water elevations steadily dropped in the reservoir to provide storage for anticipated spring runoff.

In 1989, the reservoir was managed differently, as water elevations did not increase during February and March as in two previous years (Figure B4.1-2). Rather, maximum water elevation occurred in January 1989 (1787 ft) and mean monthly water elevation from February–May fluctuated between 1782 ft and 1774 ft. In 1987 and 1988, reservoir elevations in February–May had been 16–24 ft higher.

Verde River (Bartlett Territory)

Typically, water is released into the Verde River from the bottom of the Bartlett Reservoir via two steel pipe outlets that have a capacity of 4,000 cfs. In emergency situations, such as valve replacement or

floods, water is released over the spillway. In many years, the outlet valves have been routinely shutoff for up to two weeks, so that no water is released into the river. When this happens, large areas of the Verde River dry up, forcing aquatic species into isolated pools.

In 1987 and 1988, discharge into the Verde River was fairly uniform overall, with some variation in peak flow (Figure B4.1-3). Average flow was 513 cfs in 1987 and somewhat higher, at 553 cfs, in 1988. Mean monthly discharge rates ranged from 86 cfs (January) to 2810 cfs (March) in 1987; and 93 cfs (September) to 5230 cfs (April) in 1988. In the first six months of 1989, mean monthly flow was only 359 cfs, with a low of 3 cfs (June), and high of 1290 cfs (March).

Mean monthly flows in the river were also similar in 1987 and 1988 (Figure B4.1-3). Generally, flow increased in the early part of the year and peaked in spring. However, flows in 1987 and 1988 differed slightly in the timing and magnitude of the peak flow. The main flow peak, in 1987, occurred in March when a discharge rate of 2810 cfs was recorded. In 1988, the peak flow was observed in April (5230 cfs)(Figure B4.1-3). Flows in 1989 differed greatly from previous years, in that: (1) no high flow was recorded during the spring, and (2) the mean monthly flows for April, May, and June were significantly lower (Figure B4.1-3).

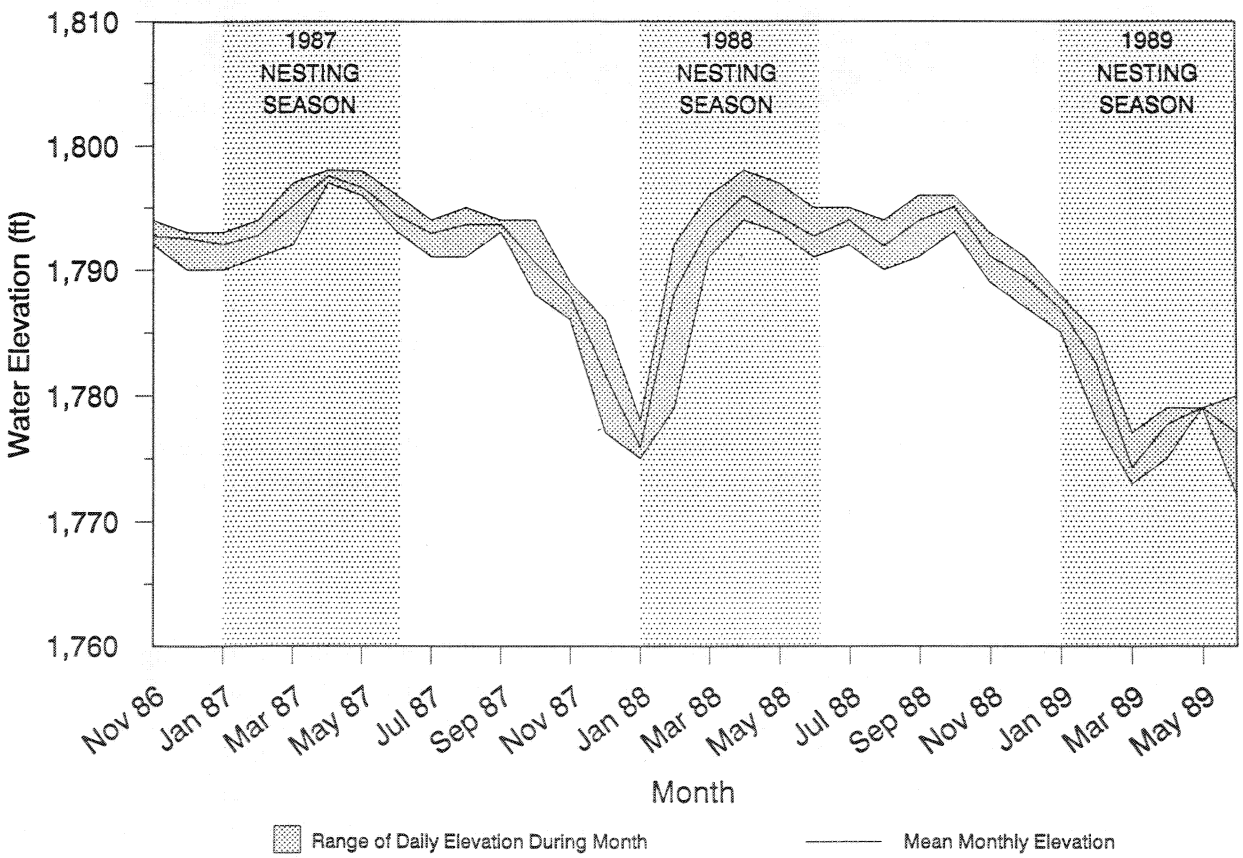


Figure B4.1-2. Mean monthly elevation and range of daily elevations in Bartlett Reservoir, 1986–1989.

Plate B2. Bartlett Dam and Reservoir. Note the tunnel (arrow) which regulates flow into the lower Verde River. The tunnel near the base of the dam releases cool water into the river from the hypolimnion of the reservoir, February 1989 (photo by D. Driscoll).

Flow patterns can also be described in terms of mean daily flows. Mean daily flow patterns for 1988 generally fluctuated from 164 cfs to 856 cfs; however, a significant change in flow occurred in late April,

when flows increased to 5230 cfs. Similarly, in 1989, mean daily flows patterns ranged from 254 cfs to 857 cfs, for the period December 1988 to June 1989. Unlike 1988, flow significantly decreased during the first week in June 1989, when only 3 cfs was released. In subsequent weeks, flows returned to normal (mean 385 cfs).

Schedule of Study

We telemetered the Bartlett adult male AM04 on 28 March 1988 and conducted tracking operations during four periods that year: 29 March–7 April, 16–20 April, 26 April–5 May, and 12–15 May. The adult female CF01 was not telemetered. The next year (1989), we tracked AM04 during 28 February–9 March, 14–23 March, 28 March–6 April, 11–20 April, 25 April–4 May, and 9–18 May. We also obtained limited information on his movements from 10 May until the telemetered juvenile migrated on 14 July. An observer, placed about 120 m from the nest, recorded prey deliveries in both years, while telemetry trackers, communicating with hand-held radios, stationed themselves at strategic points to record foraging events and other activities. In April and May 1989, we used a motor boat to track AM04's movements on the reservoir. In general, eagle visitation data in 1988 were less precise

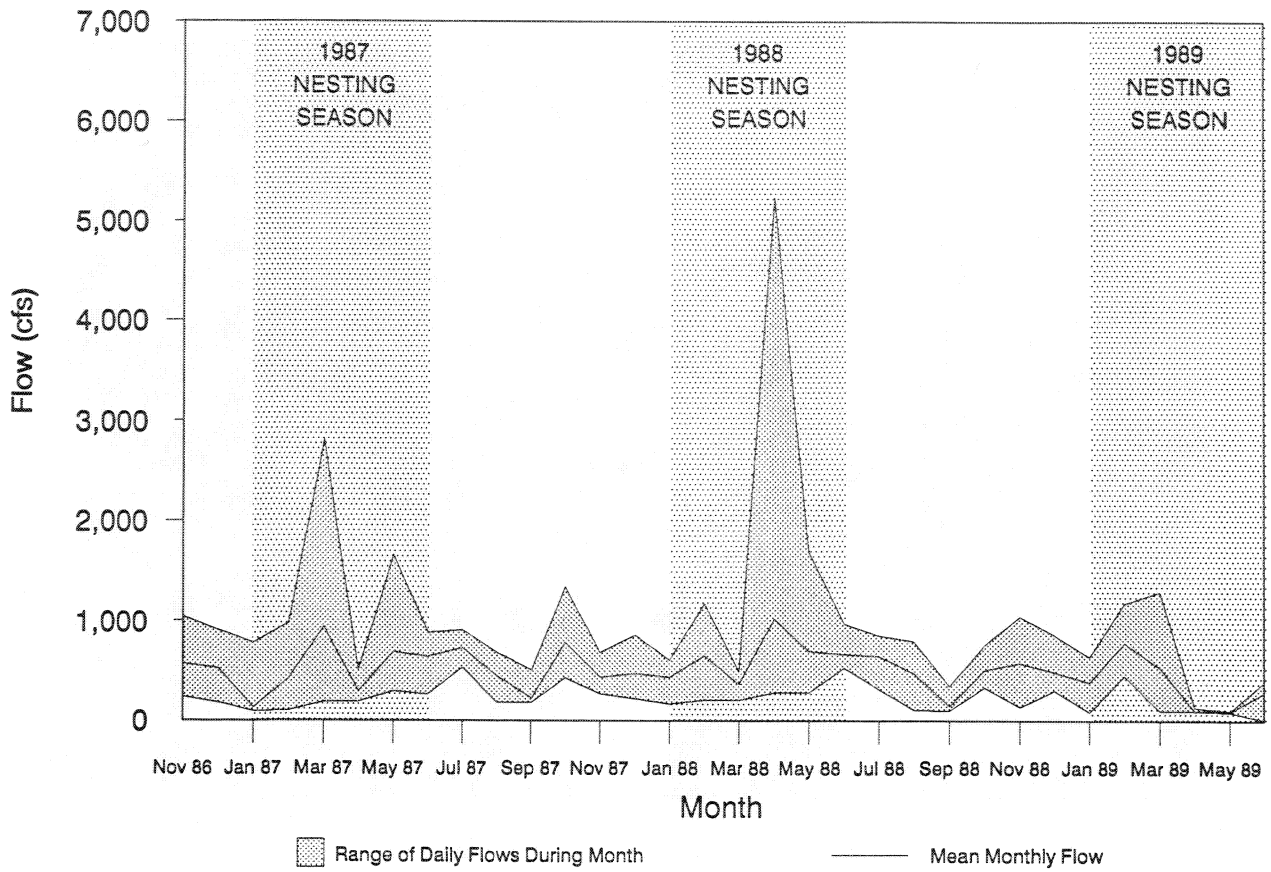


Figure B4.1-3. Mean monthly flows and range of daily flow in the Verde River below Bartlett Dam from November 1986–June 1989. Flows measured at USGS Gaging Station located at river kilometer 35.7.

than in 1989, when more trackers were available. In 1988 we were able to assign eagle locations to zones (see glossary), while in 1989, we were usually able to narrow them to Kms or one-tenth Kms.

B4.1.1 Home Range

Previous knowledge of the home range of the Bartlett pair was based on visual observations (Hildebrandt and Ohmart 1978, Hildebrandt 1981, Haywood and Ohmart 1981, Haywood and Ohmart 1982, Haywood and Ohmart 1983, Grubb *et al.* 1983, Grubb 1984, Grubb 1986a). The "best estimate" home range, based on observed flights of adults, by Sell (1982) is close to the actual home range we recorded with telemetry data during 1988 and 1989.

During the 1988 and 1989 breeding seasons, we located AM04 perching from Km 25.9 on the Verde River to Km 53 on Bartlett Reservoir, a span of 27 Kms (Figure B4.1-4). AM04 often soared over land adjacent to the river or reservoir, but within the end-points of the home range as determined by perching data. AM04 rarely perched away from the river environs, and there is no indication that he foraged away from the river to any significant extent.

Plate B3. The Bartlett male (AM04), captured 28 March 1988, was banded as a nestling in 1984 at the Blue Point breeding area. Note the brown eye-stripe and crown-ring typical of near-adult (4-year-old) bald eagles. AM04 raised two young in 1988 and three in 1989 (see Section D4.3 or details)(photo by D. Driscoll).

AM04 ranged widely during the early part of the breeding season in 1989. He perched for one-half hour each at both extremes of his home range during late February and March. His range narrowed at the end of March and beginning of April, when he perched and foraged close to the nest area. The eagle ranged further from the nest during the late breeding season as his use of Bartlett Reservoir increased.

Perching locations for AM04 were concentrated in four distinct areas, but use of these areas changed throughout the breeding season. The areas of use were: Needle Rock area, nest area, Bartlett Dam area, and Km 50 on Bartlett Reservoir. Throughout the season, most of AM04's visits and time were spent near the nest in Km 34 and Km 35. He often perched near and foraged in the riffle at Km 34.5 (the "powerline riffle").

Early in the nesting season, AM04 frequented the Needle Rock area between Km 29–31 on the Verde River. AM04 made several forages from a small cliff in a super-riffle at Km 30.3. In late February and early March, about 15 percent of AM04's visitations and time were spent at the Needle Rock area. Use of this area dwindled during each successive study period, and after the first part of May, AM04 no longer visited Needle Rock.

As AM04's use of downstream areas diminished, he increased his visits and time spent on Bartlett Reservoir. In February and March, AM04 spent about 10 percent of his time on the reservoir, but this increased to 42 percent by late April and early May. Few prominent bald eagle perch sites were available

on Bartlett Reservoir, except for a cliff bordering the eastern shoreline between Km 49 and 51 which provided a good view of the water below.

B4.1.2 Foraging Studies

We investigated bald eagle foraging at the Bartlett breeding area from 29 March–21 May 1988, and from 28 February–18 May 1989. In these two years, we obtained 332 observations relating to foraging: 87 in 1988 and 245 in 1989. These included both direct observations of forage attempts and observations of prey delivered to the nest. We made 196 observations for the Bartlett male, AM04. Of these observations, 137 were prey deliveries, 37 in 1988 and 100 in 1989. Total observations relating to foraging for the two years were 54 and 142, respectively. The total number of observations for the female, CF01, was 133; there were 32 in 1988 and 101 in 1989. In 1988, 30 of these observations were of prey deliveries, and in 1989, 67 were of prey deliveries.

B4.1.2.1 Prey Selection. During the periods of intensive study at Bartlett in 1988, we found both male (AM04) and female (CF01) bald eagles preying primarily on fish (Tables B4.1-1 and B4.1-2). Most prey items were delivered to the nest. We observed about 25 Kg of biomass actually brought into the nest by the pair in 1988. For both eagles, 92 percent of their delivered biomass was fish. Suckers dominated the deliveries in 1988, followed by centrarchids by AM04, and catfish by CF01. Non-fish species utilized in 1988 included rabbits and wood rats.

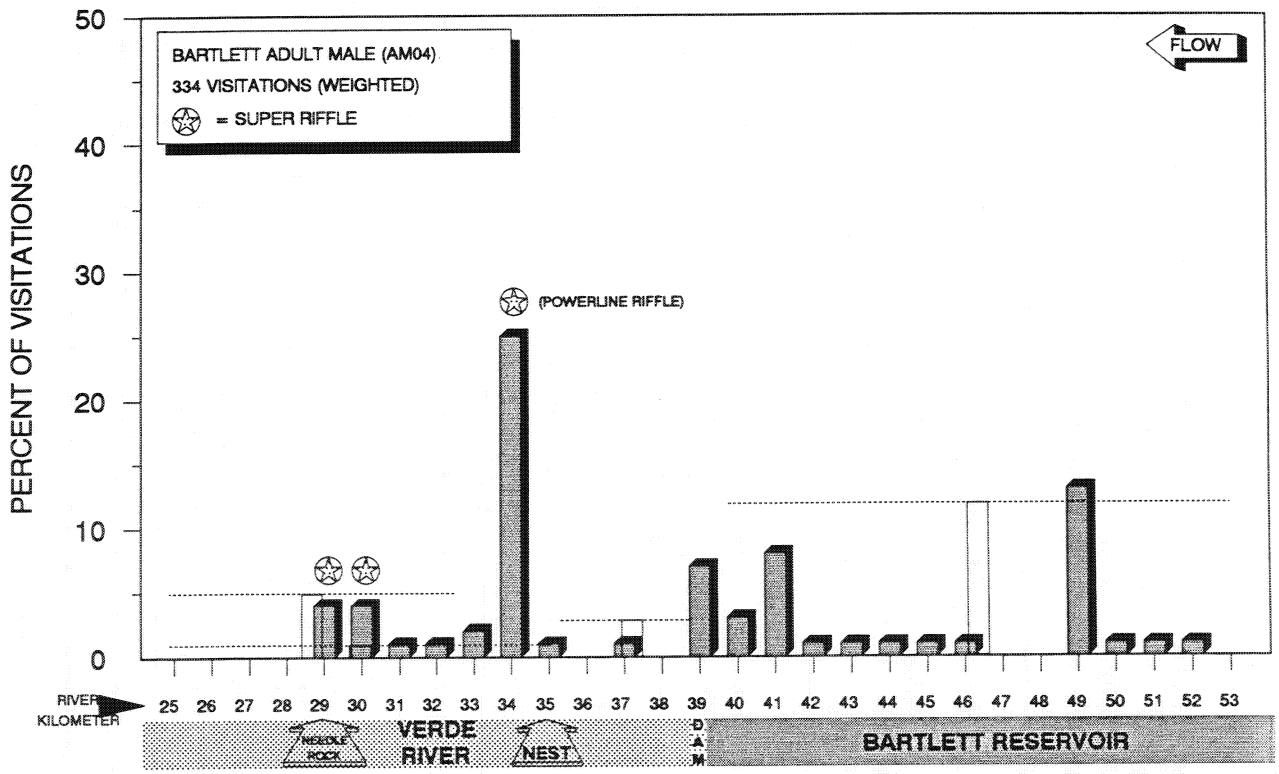


Figure B4.1-4. The home range of the telemetered Bartlett adult male (AM04) during 29 March to 15 May 1988 and 26 February to 18 May 1989. The bars represent percentages among a total of 334 visitations. Visitation percentages at Kms 34 and 35 (nest vicinity) were weighted according to the proportion of total prey deliveries by the male from these segments. Open bars indicate cases when trackers could not precisely locate the eagles and the dotted lines extending laterally from those bars indicate zones of eagle occupancy for the imprecise locations.

Table B4.1-1. Prey taken and prey delivered to nest by the male bald eagle (AM04) from Bartlett breeding area in 1988. Column A indicates number of prey from observed forages plus prey deliveries to nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass of prey (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals						B. Whole Biomass (grams)						C. Biomass Delivered to Nest (grams)								
	28-Day Period:						28-Day Period:						28-Day Period:								
Species	3/27/88–4/23/88		4/24/88–5/21/88		Total		3/27/88–4/23/88		4/24/88–5/21/88		Total		3/27/88–4/23/88			4/24/88–5/21/88			Total		
Fish Species																					
Sucker	16	67%	7	41%	23	56%	4,185	52%	2,986	54%	7,171	53%	3,669	*(15)	74%	2,491	(7)	55%	6,160	(22)	65%
Probable Sucker	2	8%			2	5%	309	4%			309	2%	36	(1)	1%				36	(1)	0%
Flathead Catfish			1	6%	1	2%			948	17%	948	7%				948	(1)	21%	948	(1)	10%
Black Crappie	1	4%	1	6%	2	5%	430	5%	250	4%	680	5%	430	(1)	9%	200	(1)	4%	630	(2)	7%
Largemouth Bass			1	6%	1	2%			204	4%	204	1%				122	(1)	3%	122	(1)	1%
Smallmouth Bass	1	4%			1	2%	124	2%			124	1%	124	(1)	2%				124	(1)	1%
Unknown Bass			1	6%	1	2%			275	5%	275	2%				275	(1)	6%	275	(1)	3%
Lepomis spp.			4	24%	4	10%			348	6%	348	3%				348	(4)	8%	348	(4)	4%
Unknown Fish	1	4%	2	12%	3	7%	512	7%	549	10%	1,061	8%				128	(1)	3%	128	(1)	1%
Subtotal	21	88%	17	100%	38	93%	5,560	69%	5,560	100%	11,120	82%	4,259	(18)	86%	4,512	(16)	100%	8,771	(34)	92%
Other Species																					
Jackrabbit	1	4%			1	2%	1,536	19%			1,536	11%	384	(1)	8%				384	(1)	4%
Wood Rat	1	4%			1	2%	281	3%			281	2%	281	(1)	6%				281	(1)	3%
Unknown Mammal	1	4%			1	2%	695	9%			695	5%	50	(1)	1%				50	(1)	1%
Subtotal	3	12%			3	7%	2,512	31%			2,512	18%	715	(3)	14%				715	(3)	8%
TOTAL	**24**	**100%**	**17**	**100%**	**41**	**100%**	**8,072**	**100%**	**5,560**	**100%**	**13,632**	**100%**	**4,974**	**(21)**	**100%**	**4,512**	**(16)**	**100%**	**9,486**	**(37)**	**100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

Table B4.1-2. Prey taken and prey delivered to nest by the female bald eagle (CF01) from Bartlett breeding area in 1988. Column A indicates number of prey from observed forages plus prey deliveries to nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass of prey (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

Species	A. Number of Individuals 28-Day Period: 3/27/88–4/23/88		4/24/88–5/21/88		Total		B. Whole Biomass (grams) 28-Day Period: 3/27/88–4/23/88		4/24/88–5/21/88		Total		C. Biomass Delivered to Nest (grams) 28-Day Period: 3/27/88–4/23/88		4/24/88–5/21/88		Total	
Fish Species																		
Sucker	12	92%	12	63%	24	75%	5,750	95%	6,087	55%	11,837	69%	5,750 *(12)	95%	4,855 (10)	50%	10,605 (22)	67%
Channel Catfish			1	5%	1	3%			935	8%	935	5%			935 (1)	10%	935 (1)	6%
Flathead Catfish			2	11%	2	6%			1,896	17%	1,896	11%			1,896 (2)	19%	1,896 (2)	12%
Largemouth Bass			1	5%	1	3%			585	5%	585	3%			585 (1)	6%	585 (1)	4%
Unknown Bass			1	5%	1	3%			585	5%	585	3%			585 (1)	6%	585 (1)	4%
Subtotal	12	92%	17	89%	29	91%	5,750	95%	10,088	92%	15,838	93%	5,750 (12)	95%	8,856 (15)	90%	14,606 (27)	92%
Other Species																		
Cottontail Rabbit			1	5%	1	3%			650	6%	650	4%			650 (1)	7%	650 (1)	4%
Wood Rat	1	8%			1	3%	281	5%			281	2%	281 (1)	5%			281 (1)	2%
Unknown Mammal			1	5%	1	3%			281	3%	281	2%			281 (1)	3%	281 (1)	2%
Subtotal	1	8%	2	11%	3	9%	281	5%	931	8%	1,212	7%	281 (1)	5%	931 (2)	10%	1,212 (3)	8%
TOTAL	**13**	**100%**	**19**	**100%**	**32**	**100%**	**6,031**	**100%**	**11,019**	**100%**	**17,050**	**100%**	**6,031 (13)**	**100%**	**9,787 (17)**	**100%**	**15,818 (30)**	**100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

We observed the Bartlett pair more extensively in 1989, and numbers of prey captures and nest deliveries increased accordingly. Again, the majority of observed prey captures were delivered to the nest; we estimated over 50 Kg of biomass in those prey deliveries. AM04 delivered 100 prey items in 1989 (Table B4.1-3). CF01 delivered fewer items than her mate (n = 67, Table B4.1-4). Interestingly, CF01 almost equaled AM04 in the estimated amount of total biomass delivered to the nest in 1989; the female brought fewer but larger prey items to the nestlings.

The Bartlett eagles utilized a greater proportion of fish species in 1989 compared to 1988; biomass of fish delivered increased to 93 percent and 98 percent for AM04 and CF01, respectively. The pair captured mostly suckers again. Secondarily, the female took mostly catfish, and the male mostly centrarchids, a trend we also observed in 1988. While both members of the Bartlett pair captured suckers in near-equal percentages in 1988, CF01 took a larger percentage of suckers than her mate in 1989. Overall, 81 percent of the prey delivered by the female was suckers. In contrast to the male, CF01 took only one crappie from the reservoir which no doubt reflected her tendency to forage closer to the nest (see Section B4.5 which shows a sex difference in home range of a telemetered pair). During the entire study (1988–1989) only two carp were taken by eagles in the Bartlett breeding area. Rabbits and a rock squirrel were included in the non-fish prey for 1989. We did not collect prey remains from the Bartlett nest during the study due to problems climbing the nest pinnacle; however, prey items identified in the remains collected from territory perches are included in Section B5.1.2

The Bartlett eagles supplemented a sucker diet mainly with centrarchids and catfish, and there were seasonal differences in the use of these taxa. In 1988, we observed almost total utilization of suckers during early April (95% of delivered biomass, Table B4.1-5) and mid-April (75% of biomass delivered) followed by less sucker use from late April through May (approximately 50%). The decline in suckers corresponded with an increased reliance on centrarchids and catfish during the latter portion of the 1988 observations. This trend, although present, is less noticeable in the 1989 data. In early March 1989, suckers accounted for one-half of the biomass delivered; carp, centrarchids, and mammals accounted for the remainder. Sucker utilization jumped dramatically in mid- to late March (98% of biomass delivered). Suckers remained relatively important in April and May (ranging from 49–77% of biomass delivered); however, catfish, crappie, and bass utilization increased. Crappie were taken only from late March through May 1989. Catfish utilization peaked during mid-April, while bass were taken throughout the nest observation period. Non-fish prey were not delivered to the nest during May 1989.

B4.1.2.2 Geography of Foraging. We identified and quantified the use of foraging areas by the Bartlett eagles based on: (1) direct observation of the foraging birds; (2) visual and telemetric knowledge of the whereabouts of eagles in the minutes preceding prey delivery; and (3) visitation scores per location. The results of all three methods showed that the eagles' choice of areas varied in both space and time. Reasons for variations in habitat selection included: (1) heterogeneity of habitat and prey distributions within the home range; (2) the effects of flows, reservoir elevations, and temperatures on habitat; and, (3) life history events affecting the availability of prey.

Shift from River to Reservoir. Our data clearly show that both river and reservoir habitats were important to the foraging eagles at Bartlett breeding area. Seven of eight fish species comprising the diet of the adult male (telemetered) in 1988 and 1989 were taken exclusively from either the Verde River or Bartlett Reservoir (Table B4.1-6). Only channel catfish were taken in both riverine (n = 4) and lacustrine habitat (n = 3). Species taken exclusively in the Verde River included suckers (n = 65), smallmouth bass (n = 1), flathead catfish (n = 1), and carp (n = 1). Fish captured only in Bartlett

Table B4.1-3. Prey taken and prey delivered to nest by the male bald eagle (AM04) from Bartlett breeding area in 1989. Column A indicates number of prey from observed forages plus prey deliveries to nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass of prey (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

Species	A. Total Number of Individuals 28-Day Period: 2/26/89 3/25/89		3/26/89–4/22/89		4/23/89–5/20/89		Total		B. Whole Biomass (grams) 28-Day Period: 2/26/89–3/25/89		3/26/89–4/22/89		4/23/89–5/20/89		Total	
Fish Species																
Sucker	14	50%	24	46%	14	39%	52	45%	4,426	46%	11,473	59%	5,592	40%	21,491	50%
Probable Sucker	1	4%			4	11%	5	4%	163	2%			1,179	9%	1,342	3%
Carp	1	4%					1	1%	1,651	17%					1,651	4%
Flathead Catfish	1	4%					1	1%	1,120	12%					1,120	3%
Channel Catfish			4	8%	3	8%	7	6%			585	3%	836	6%	1,421	3%
Unknown Catfish			1	2%			1	1%			199	1%			199	0%
Black Crappie			6	12%	4	11%	10	9%			2,492	13%	1,553	11%	4,045	9%
Largemouth Bass	1	4%	4	8%	3	8%	8	7%	726	8%	1,460	8%	1,183	9%	3,369	8%
Unknown Bass	2	7%	2	4%	2	6%	6	5%	166	2%	305	2%	979	7%	1,450	3%
Bluegill Sunfish	1	4%	3	6%			4	3%	103	1%	381	2%			484	1%
Green Sunfish	1	4%					1	1%	24	0%					24	0%
Lepomis spp.	2	7%	1	2%			3	3%	24	0%	46	0%			70	0%
Unknown Fish	2	7%	3	6%	6	17%	11	9%	45	0%	803	4%	2,514	18%	3,362	8%
Soft-shelled Turtle			1	2%			1	1%			220	1%			220	1%
Subtotal	26	93%	49	94%	36	100%	111	96%	8,448	88%	17,964	93%	13,836	100%	40,248	94%
Other Species																
Rock Squirrel	1	4%					1	1%	817	9%					817	2%
Cottontail Rabbit			1	2%			1	1%			650	3%			650	2%
Unknown Mammal	1	4%					1	1%	281	3%					281	1%
Subtotal	2	7%	1	2%	0	0%	3	3%	1,098	12%	650	3%	0	0%	1,748	4%
Unidentified Carrion			1	2%			1	1%			399	2%			399	1%
Unidentified			1	2%			1	1%			399	2%			399	1%
Subtotal	0	0%	2	4%	0	0%	2	2%	0	0%	798	4%	0	0%	798	2%
TOTAL	**28**	**100%**	**52**	**100%**	**36**	**100%**	**116**	**100%**	**9,546**	**100%**	**19,412**	**100%**	**13,836**	**100%**	**42,794**	**100%**

Table B4.1-3. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 2/26/89 3/25/89			3/26/89–4/22/89			4/23/89–5/20/89			Total		
Fish Species												
Sucker	3,924	*(14)	55%	9,867	(22)	58%	3,590	(11)	43%	17,381	(47)	53%
Probable Sucker	164	(1)	2%							164	(1)	1%
Carp	545	(1)	8%							545	(1)	2%
Flathead Catfish	336	(1)	5%							336	(1)	1%
Channel Catfish				585	(4)	3%	579	(3)	7%	1,164	(7)	4%
Unknown Catfish				199	(1)	1%				199	(1)	1%
Black Crappie				2,492	(6)	15%	1,553	(4)	19%	4,045	(10)	12%
Largemouth Bass	726	(1)	10%	1,391	(4)	8%	1,183	(3)	14%	3,300	(8)	10%
Unknown Bass	166	(2)	2%	305	(2)	2%	979	(2)	12%	1,450	(6)	4%
Bluegill Sunfish	103	(1)	1%	161	(2)	1%				264	(3)	1%
Green Sunfish	24	(1)	0%							24	(1)	0%
Lepomis spp.	24	(2)	0%	46	(1)	0%				70	(3)	0%
Unknown Fish	45	(2)	1%	803	(3)	5%	419	(1)	5%	1,267	(6)	4%
Soft-shelled Turtle				220	(1)	1%				220	(1)	1%
Subtotal	6,057	(26)	85%	16,069	(46)	94%	8,303	(24)	100%	30,429	(96)	93%
Other Species												
Rock Squirrel	817	(1)	11%							817	(1)	3%
Cottontail Rabbit				650	(1)	4%				650	(1)	2%
Unknown Mammal	281	(1)	4%							281	(1)	1%
Subtotal	1,098	(2)	15%	650	(1)	4%	0		0%	1,748	(3)	5%
Unidentified Carrion										0		0%
Unidentified				399	(1)	2%				399	(1)	1%
Subtotal	0		0%	399	(1)	2%	0		0%	399	(1)	1%
TOTAL	**7,155**	**(28)**	**100%**	**17,118**	**(48)**	**100%**	**8,303**	**(24)**	**100%**	**32,576**	**(100)**	**100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

Table B4.1-4. Prey taken and prey delivered to nest by the female bald eagle (CF01) from Bartlett breeding area in 1989. Column A indicates number of prey from observed forages plus prey deliveries to the nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals					B. Whole Biomass (grams)				
	28-Day Period:					28-Day Period:				
Species	2/26/89–3/25/89	3/26/89–4/22/89	4/23/89–5/20/89	5/21/89–6/17/89	Total	2/26/89–3/25/89	3/26/89–4/22/89	4/23/89–5/20/89	5/21/89–6/17/89	Total
Fish Species										
Sucker	15 88%	20 65%	27 77%	1 50%	63 74%	6,358 80%	11,598 71%	11,515 81%	87 17%	29,558 76%
Probable Sucker			3 9%		3 4%			1,016 7%		1,016 3%
Carp	1 6%				1 1%	1,424 18%				1,424 4%
Channel Catfish		5 16%	1 3%		6 7%		2,209 14%	128 1%		2,337 6%
Black Crappie		1 3%			1 1%		828 5%			828 2%
Largemouth Bass		1 3%			1 1%		275 2%			275 1%
Unknown Centrarchid		1 3%			1 1%		51 0%			51 0%
Bluegill Sunfish			1 3%		1 1%			58 0%		58 0%
Unidentified Fish		2 6%	3 9%	1 50%	6 7%		692 4%	1,454 10%	419 83%	2,565 7%
Subtotal	16 94%	30 97%	35 100%	2 100%	83 98%	7,782 98%	15,653 96%	14,171 100%	506 100%	38,112 98%
Other Species										
Cottontail Rabbit		1 3%			1 1%		650 4%			650 2%
Unidentified Snake	1 6%				1 1%	190 2%				190 0%
Subtotal	1 6%	1 3%			2 2%	190 2%	650 4%			840 2%
TOTAL	**17 100%**	**31 100%**	**35 100%**	**2 100%**	**85 100%**	**7,972 100%**	**16,303 100%**	**14,171 100%**	**506 100%**	**38,952 100%**

Table B4.1-4. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 2/26/89–3/25/89			3/26/89–4/22/89			4/23/89–5/20/89			5/21/89–6/17/89		Total		
Fish Species														
Sucker	6,332	*(15)	82%	8,956	(18)	70%	7,424	(19)	98%			22,712	(52)	81%
Probable Sucker														
Carp	1,424	(1)	18%									1,424	(1)	5%
Channel Catfish				1,772	(5)	14%	128	(1)	2%			1,900	(6)	7%
Black Crappie				828	(1)	6%						828	(1)	3%
Largemouth Bass				275	(1)	2%						275	(1)	1%
Unknown Centrarchid				51	(1)	0%						51	(1)	0%
Bluegill Sunfish							58	(1)	1%			58	(1)	0%
Unidentified Fish				299	(2)	2%						299	(2)	1%
Subtotal	7,756	(16)	100%	12,181	(28)	95%	7,610	(21)	100%	0	(0)	27,547	(65)	98%
Other Species														
Cottontail Rabbit				650	(1)	5%						650	(1)	2%
Unidentified Snake	0	**(1)										0	(1)	
Subtotal	0	(1)	0%	650	(1)	5%	0	(0)	0%	0	(0)	650	(2)	2%
TOTAL	**7,756**	**(17)**	**100%**	**12,831**	**(29)**	**100%**	**7,610**	**(21)**	**100%**	**0**	**(0)**	**28,197**	**(67)**	**100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

** Snake escaped from the nest after delivery.

Table B4.1-5. Summary of estimated biomass (grams) of prey delivered to the Bartlett breeding area bald eagle nest in 1988 and 1989 by both male and female adults. Numbers in parentheses refer to number of individuals delivered to nest. Some species are grouped for analysis. Percentages expressed as percent of column total rounded to nearest whole number.

	OBERSERVATION PERIOD/DAYS OBSERVED										
Species	3/27–4/9/88 9 days	4/10–4/23/88 5 days	4/24–5/7/88 9 days	5/8–5/21/88 3 days	2/26–3/11/89 9 days	3/12–3/25/89 9 days	3/26–4/8/89 9 days	4/9–4/22/89 9 days	4/23–5/6/89 9 days	5/7–5/20/89 8 days	Total 79 days
Fish Species											
Sucker sp.	6,047 95% (24)	3,408 74% (4)	5,641 53% (13)	1,705 46% (4)	4,108 49% (11)	6,311 98% (19)	7,980 65% (21)	10,843 61% (19)	8,908 77% (25)	2,106 49% (5)	57,057 66% (145)
Carp					1,969 23% (2)						1,969 2% (2)
Catfish sp.			1,883 18% (2)	1,896 51% (2)	336 4% (1)		841 7% (4)	1,715 10% (6)	621 5% (3)	86 2% (1)	7,378 9% (19)
Crappie sp.		430 9% (1)	200 2% (1)				1,055 9% (3)	2,265 13% (4)	873 8% (2)	680 16% (2)	5,503 6% (13)
Bass sp.		124 3% (1)	1,445 14% (3)	122 3% (1)	791 9% (2)	101 2% (1)	647 5% (4)	1,324 7% (3)	776 7% (2)	1,386 32% (3)	6,716 8% (20)
Other Centrarchids			348 3% (4)		103 1% (1)	48 1% (3)	109 1% (2)	149 1% (2)		58 1% (1)	815 1% (13)
Unknown Fish			128 1% (1)		45 1% (2)		893 7% (4)	209 1% (1)	419 4% (1)		1,694 2% (9)
Subtotal	6,047 95% (24)	3,962 86% (6)	9,645 91% (24)	3,723 100% (7)	7,352 87% (19)	6,460 100% (23)	11,525 95% (38)	16,505 93% (35)	11,597 100% (33)	4,316 100% (12)	81,132 94% (221)
Other Species											
Rabbits		384 8% (1)	650 6% (1)				650 5% (1)	650 4% (1)			2,334 3% (4)
Other Mammals	331 5% (2)	281 6% (1)	281 3% (1)		1,098 13% (2)						1,991 2% (6)
Reptiles						0 0% (1)		220 1% (1)			220 0% (2)
Unknown Carrion								399 2% (1)			399 0% (1)
Subtotal	331 5% (2)	665 14% (2)	931 9% (2)	0 0% (0)	1,098 13% (2)	0 0% (1)	650 5% (1)	1,269 7% (3)	0 0% (0)	0 0% (0)	4,944 6% (13)
TOTAL	**6,378 100% (26)**	**4,627 100% (8)**	**10,576 100% (26)**	**3,723 100% (7)**	**8,450 100% (21)**	**6,460 100% (24)**	**12,175 100% (39)**	**17,774 100% (38)**	**11,597 100% (33)**	**4,316 100% (12)**	**86,076 100% (234)**

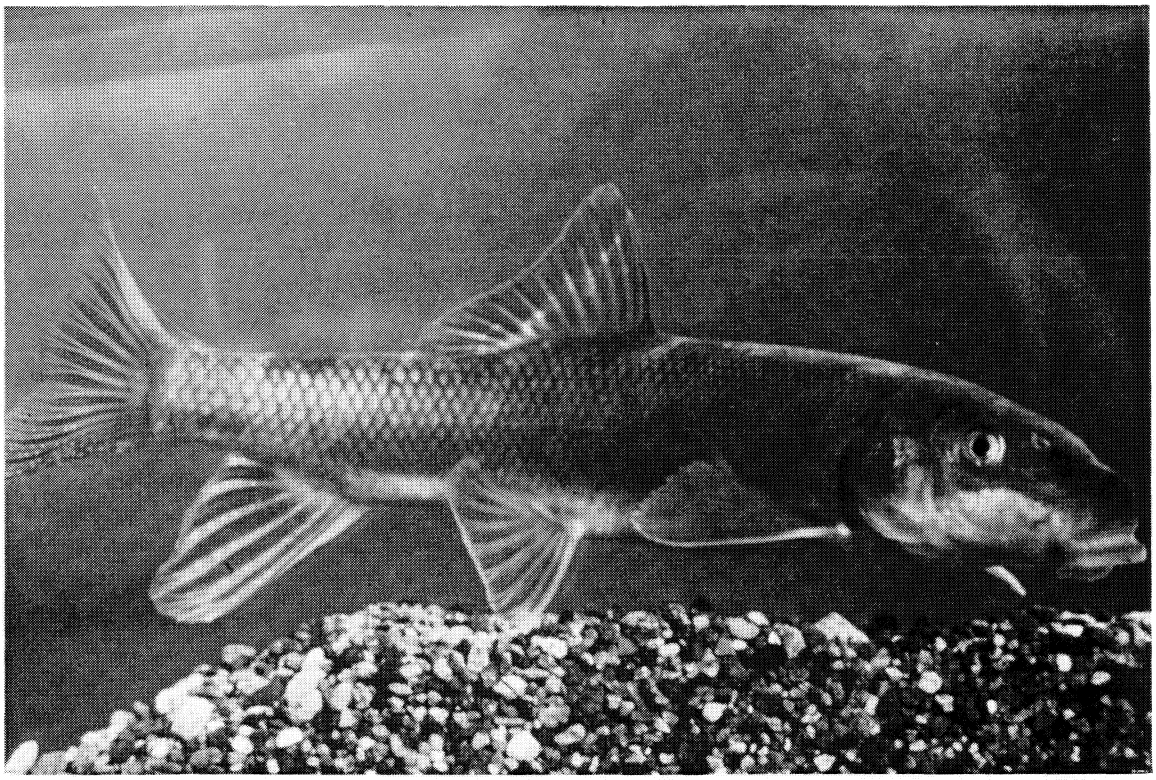


Plate B4. Sonora suckers were an important prey fish of the Bartlett eagles (photo by M. Jakle).

Reservoir included black crappie (n = 12), largemouth bass (n = 11), bluegill (n = 4) and *Lepomis* spp. (n = 5). Five prey deliveries could only be classified as unknown bass, of which three were from the reservoir and two from the river.

In both 1988 and 1989, foraging by the male eagle (AM04) shifted over the spring from the river to the reservoir (Table B4.1-6). In 1988, only one of 21 (5%) of the fish taken from 27 March to 23 April were from the reservoir, while at least seven of 17 (41%) were captured from the reservoir during 24 April to 21 May ($\chi^2 = 5.46$, df = 1, $p < 0.05$). Similarly, in 1989, the percent of fish known to be taken from the reservoir increased from 15 percent (4 of 26) in March to at least 39 percent (33–34 of 84) in April and May combined ($\chi^2 = 4.07$, df = 1, $p < 0.05$).

Interestingly, in the early to mid-April period of 1988 (March 27–April 23), the male eagle foraged almost exclusively in the river, while during the same period in 1989, his foraging was divided between the reservoir and river ($\chi^2 = 7.7$, df = 1, $p < 0.01$). In explaining this, it may be pertinent to note that mean daily flows averaged 500 cfs (SD +/− 139 cfs) in the early to mid-April period of 1988, compared with 115 cfs (SD +/− 40 cfs) during the same period of 1989. Reservoir elevations were also higher in late March and April of 1988 (1794–1798 ft), than in the same period of 1989 (1774–1779 ft).

Overall, water temperatures recorded in 1989 were higher than those recorded in 1988, probably a result of both reduced flows and a lower reservoir elevation in 1989. In 1988, most recorded temperatures were below 14°C compared to 1989 when temperatures rose above 14°C on several days from mid-

Table B4.1-6. Origin of prey taken by the telemetered male bald eagle (AM04) in Bartlett Territory in 1988 and 1989.

Date *Km*	Species	Number Taken	Reservoir 39.3–56.0	River Upstream of Nest Area 35.4–39.0	Nest Area 34.2–35.3	River Downstream of Nest Area 35.2–*Downstream*	Downriver 32.5–*Downstream*	Unknown
03/27/88–04/23/88	Sucker	16	—	—	12	3	1	—
	Probable Sucker	2	—	—	2	—	—	—
	Black Crappie	1	1	—	—	—	—	—
	Smallmouth Bass	1	—	—	1	—	—	—
	Unknown Fish	1	—	—	1	—	—	—
	Woodrat	1	—	—	—	—	—	1
	Jackrabbit	1	1	—	—	—	—	—
	Unknown Mammal	1	1	—	—	—	—	—
	Total	24	3	0	16	3	1	1
	Percent	—	13%	0%	67%	13%	4%	4%
04/24/88–05/21/88	Sucker	7	—	—	3	3	1	—
	Black Crappie	1	1	—	—	—	—	—
	Largemouth Bass	1	1	—	—	—	—	—
	Lepomis spp.	4	4	—	—	—	—	—
	Unknown Bass	1	—	—	1	—	—	—
	Flathead Catfish	1	—	—	—	—	—	1
	Unknown Fish	2	1	—	—	1	—	—
	Total	17	7	0	4	4	1	1
	Percent		41%	0%	24%	24%	6%	6%

Table B4.1-6. (Page 2 of 3)

Date *Km*	Species	Number Taken	Reservoir 39.3–56.0	River Upstream of Nest Area 35.4–39.0	Nest Area 34.2–35.3	River Downstream of Nest Area 35.2–*Downstream*	Downriver 32.5–*Downstream*	Unknown
02/26/89–03/25/89	Sucker	14	—	1	2	5	5	1
	Probable Sucker	1	—	—	1	—	—	—
	Largemouth Bass	1	1	—	—	—	—	—
	Bluegill	1	1	—	—	—	—	—
	Green Sunfish	1	—	—	—	—	—	1
	Lepomis spp.	2	—	—	—	—	—	2
	Unknown Bass	2	1	—	—	—	1	—
	Flathead Catfish	1	—	—	—	—	—	1
	Carp	1	—	1	—	—	—	—
	Unknown Fish	2	1	—	1	—	—	—
	Rock Squirrel	1	—	—	—	—	—	1
	Unknown Mammal	1	—	—	—	—	—	1
	Total	28	4	2	4	5	6	7
	Percent		14%	7%	14%	18%	21%	25%
03/26/89–04/22/89	Sucker	24	—	2	9	9	2	2
	Black Crappie	6	6	—	—	—	—	—
	Largemouth Bass	4	4	—	—	—	—	—
	Bluegill	3	3	—	—	—	—	—
	Lepomis spp.	1	1	—	—	—	—	—
	Unknown Bass	2	2	—	—	—	—	—
	Channel Catfish	4	2	—	1	1	—	—
	Unknown Catfish	1	1	—	—	—	—	—
	Unknown Fish	3	2	—	—	1	—	—
	Turtle sp.	1	1	—	—	—	—	—
	Cottontail Rabbit	1	—	—	—	—	—	1
	Unknown	2	1	—	—	—	—	1
	Total	52	23	2	10	11	2	4
	Percent		44%	4%	19%	21%	4%	8%

Table B4.1-6. (Page 3 of 3)

Date *Km*	Species	Number Taken	Reservoir 39.3–56.0	River Upstream of Nest Area 35.4–39.0	Nest Area 34.2–35.3	River Downstream of Nest Area 35.2–*Downstream*	Downriver 32.5–*Downstream*	Unknown
04/23/89– 05/20/89	Sucker	14	—	1	10	3	—	—
	Probable Sucker	4	—	—	4	—	—	—
	Black Crappie	4	4	—	—	—	—	—
	Largemouth Bass	3	3	—	—	—	—	—
	Unknown Bass	2	2	—	—	—	—	—
	Channel Catfish	3	1	—	2	—	—	—
	Unknown Fish	6	3	—	3	—	—	—
	Total	36	13	1	19	3	0	0
	Percent		36%	3%	53%	8%	0%	0%

March through June (Figure B4.1-5). During spring 1989, flows in the Verde River averaged below 100 cfs, compared to 1988 when flows were almost always greater than 300 cfs. On 3–5 June, 1989, flows were reduced to 3–5 cfs, and temperatures subsequently rose as high as 24.4°C, exemplifying the effects of reduced flow in the rapid heating of river water.

Increased dam releases do not always result in lower temperatures in the river. In 1988, temperatures increased slightly during 27–29 April when flows increased to 5230 cfs (Figure B4.1-5). On those dates, warmer water from the epilimnion spilled over the dam, increasing, rather than decreasing, temperatures in the river.

Lower reservoir elevations probably contributed to the higher temperatures in 1989 to some extent. In 1989, the mean reservoir elevation from January to June was 1780 ft, down from 1790 ft in 1988. As the volume of Bartlett Reservoir decreased, the remaining water heated up faster leading to warmer water in the hypolimnion.

Thermal increases in the Verde River in 1989 was most pronounced during periods of low flow and high ambient temperatures (Table B4.1-7). For example, on 5 March 1989, when mean daily flow was 1,180 cfs, we observed a difference of only 2.4°C between the nest area (Km 34–35.9) and the area downstream near the Verde River mouth (Km 0.2–4.3). However, on 1 April, when flow was 94 cfs, the difference in upstream and downstream river temperatures was 8°C (Table B4.1-7). Similarly, when flows were 97 cfs on 17 April, the river temperature near the confluence was as high as 26.7°C, compared to 15.6° at the nest area, a difference of 11.1°C. Other dates on which this effect was observed are summarized in Table B4.1-7.

Warming of water appears to occur more rapidly from its release at Bartlett Dam to Needle Rock, than between Needle Rock and the confluence area. On 1 April, the temperature from the nest area to Needle Rock increased an average 0.6°/Km (from 14.8–18.9°C over 7.3 Km), compared to an average increase of only 0.1°C/Km from Needle Rock to the confluence area (from 18.9–22.8°C over 28.4 Km). On 17 April, we observed a similar pattern: an average increase of 0.7°C/Km was noted from the nest area to Needle Rock (from 15.6–20°C over 6.4 Km), compared to only 0.2°C/Km from Needle Rock to the confluence (from 20–26.7° over 28.9 Km).

Interestingly, based on a temperature suitability curve we developed for spawning suckers in the Verde and Salt rivers (Section E2), temperatures within the nest area (Km 34.0–35.9) remained suitable for sucker spawning (14–18.5°) from mid-March through June, whereas temperature in downstream reaches were probably too warm by early March.

We hypothesize that the sudden flow changes in Verde River below Bartlett Dam in mid-March 1989, rapidly increased water temperatures in the lower reaches above the preferred spawning temperatures of the suckers. Gravid suckers probably responded to these temperature conditions by migrating upriver to the nest area, resulting in a concentration of spawning suckers there.

In April 1989, the suckers had finished spawning in the Needle Rock Area by the first week in April, although peak spawning near the nest occurred in mid-April. In 1988, the cooler water would have caused the sucker spawn to peak later in April. This hypothesis may explain the apparent difference in eagle foraging pattern between the two years.

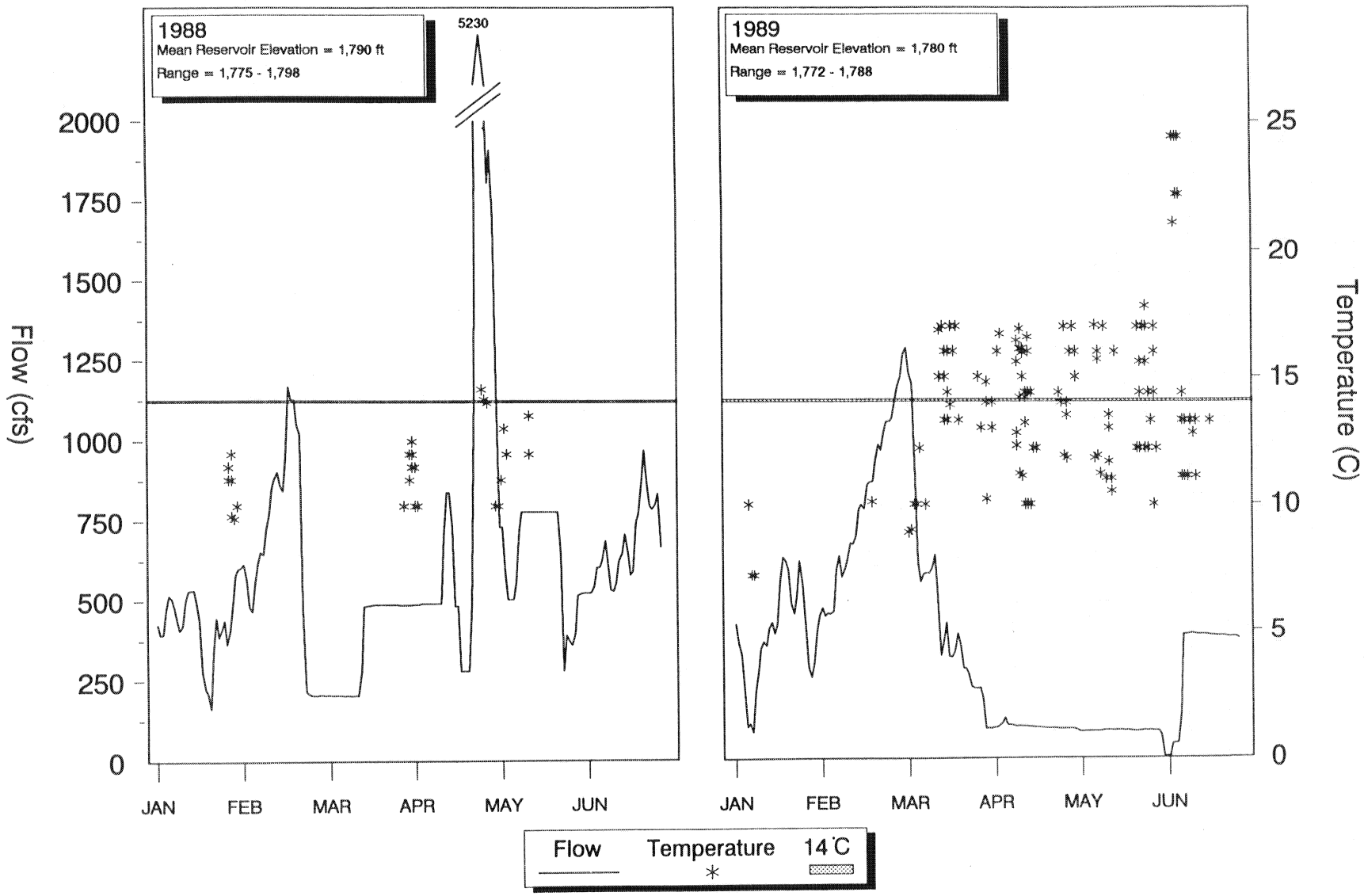


Figure B4.1-5. Mean daily flow and temperature measurements in the Verde River below Bartlett Dam (Km 34.0–35.9) from January–June 1988 and 1989. Means and ranges of Bartlett Reservoir elevations are also provided for these months.

Table B4.1-7. Summary of dates where temperatures (°C) within the same time period were recorded on two or more Km segments of the Verde River. This demonstrates the effects of thermal loading from upstream to downstream locations.

Date	Time Period	Flow (cfs)	Nest Area 34.0–35.9	Needle Rock 29.1–31.6	Fort McDowell 13.2–17.3	Near Confluence 0.2–4.3
09 Feb 89	1326–1528	596			11.9	12.4
05 Mar 89	1523–1718	1,180	12.0		14.0	14.4
06 Mar 89	740–825	929		10.0		8.6
07 Mar 89	1258–1309	613	10.0	13.0		
19 Mar 89	1430–1700	317	17.0	18.0		
01 Apr 89	1100–1214	94	14.0	15.9		
	1642–1700		14.8	18.9	21.7	22.8
12 Apr 89	1000–1200	100	12.8	15.6		
13 Apr 89	1200–1230	99	12.8	16.5		
14 Apr 89	800–820	99	11.1	13.4		
	1200		14.4	17.8		
15 Apr 89	800	98	10.0	14.4		
	1200		13.3	17.2		
	1700		14.4	17.8		
16 Apr 89	800	97	10.0	15.0		
	1200		14.4	15.6		
	1700		16.7	20.0		
17 Apr 89	720–800	97	10.0	14.4	17.7	
	1150–1200		14.4	16.1	22.0	
	1700		15.6	20.0	23.8	26.7
18 Apr 89	1200	96	12.2	16.1		
28 Apr 89	1200–1224	91	14.0	15.0		
11 May 89	1023–1200	83	16.0	18.7		

Another possible explanation is that dead or moribund, post-spawn crappie may have been less available on the reservoir in 1988. In that year, only two crappie were identified in prey deliveries by the male, while he brought ten crappie in 1989. Warmer water in the reservoir may have increased crappie spawning in 1989, or there may have simply been more crappie present in appropriate age classes.

Black crappie have high post-spawning mortality, especially among the older age categories, and bald eagles take them as they lay dead or dying on the water surface in late spring. Many fish species that suffer high post-spawning mortality have cyclical populations. Therefore, in some years, large numbers of 3–4-year-old fish spawn and die, while in other years, there are relatively few large spawners in this age category. Changes in the timing of sucker spawning, especially in downstream sections of the river, may have caused eagles to switch to upstream foraging areas in April 1989 (rather than in May, as was the case in 1988). However, fisheries biologist James Warnecke (AGF) advises us that, compared to other reservoirs with more cyclic age-class distributions, Bartlett Reservoir (and Roosevelt Reservoir) tends to consistently support sizeable populations of spawning crappie from year to year.

Macro-Habitat Selection on the Reservoir. Unlike eagle foraging in Saguaro Reservoir (Blue Point) where we also studied foraging eagles, the geography of AM04's visitations to Bartlett Reservoir shown in Figure B4.1-6 does not appear to correspond very well to the distribution of shallow water. There are, in fact, few extensive areas of shallow water in this reservoir. On the basis of our observations of eagles perching and foraging on the reservoir (see below), we believe that the distribution is related to: (1) the somewhat random distribution of carrion; (2) the availability of suitable perches, especially those offering a view of the water; and, (3) the avoidance of areas of human disturbance. Eagles perched most often at the cliffs along Skm 14 (reservoir shoreline kilometer 14), an area where the water is deep along shore.

In comparing habitat availability with use, 24 (67%) of the SKms around Bartlett Reservoir contain no cliffs or trees, while 11 Skms (33%) were scored as suitable for perching. About 89 percent of the reservoir within 6 m of shore is greater than 200 cm deep at reservoir elevations prevailing during our study. The other 11 percent (5 Skms) of Bartlett's shores are 60 to 200 cm deep.

About 95 percent of all perching events on the reservoir occurred in areas where the reservoir depth was more than 2 m. Since the majority of the reservoir fits this criterion, perch locations are probably random with respect to water depth. About 40 percent (n = 97) of all perching events on the reservoir occurred in Skm 14, the only area on the reservoir with a substantial set of cliffs. These cliffs overlook a section of reservoir greater than 200 cm deep (not good habitat for catching live fish) and have no passive disturbance (e.g., roads, campgrounds, etc.). The latter may be a factor in perch choice; 85 percent of all perches (excluding the Km 14 cliffs) occurred in areas of no passive disturbance, but 70 percent of the Skms are characterized as having no passive disturbance within them. However, AM04 did not appear to avoid perching in the vicinity of public users (active disturbance) along the reservoir; he occasionally perched near the boat ramp and the dam (see Figure B4.1-6).

Shifts Along the River. In addition to shifting foraging from the river to the reservoir in the late spring, the male eagle's foraging pattern on the river itself changed during the nesting season (Table B4.1-6). During 26 February–25 March 1989, 62 percent of the fish taken from the river by the telemetered male came from downstream of the nest area, specifically 31 percent below Km 32.5, and 31 percent below Km 33.9. During the same time, AM04 caught only 12 percent of fish from the nest area. During the next study period (26 March–22 April), AM04 foraged with almost equal success at the nest area and downstream sites (25% and 29% respectively). After 22 April (23 April–20 May), the male eagle took only 8 percent of his fish downstream of the nest, compared to 56 percent in the nest area.

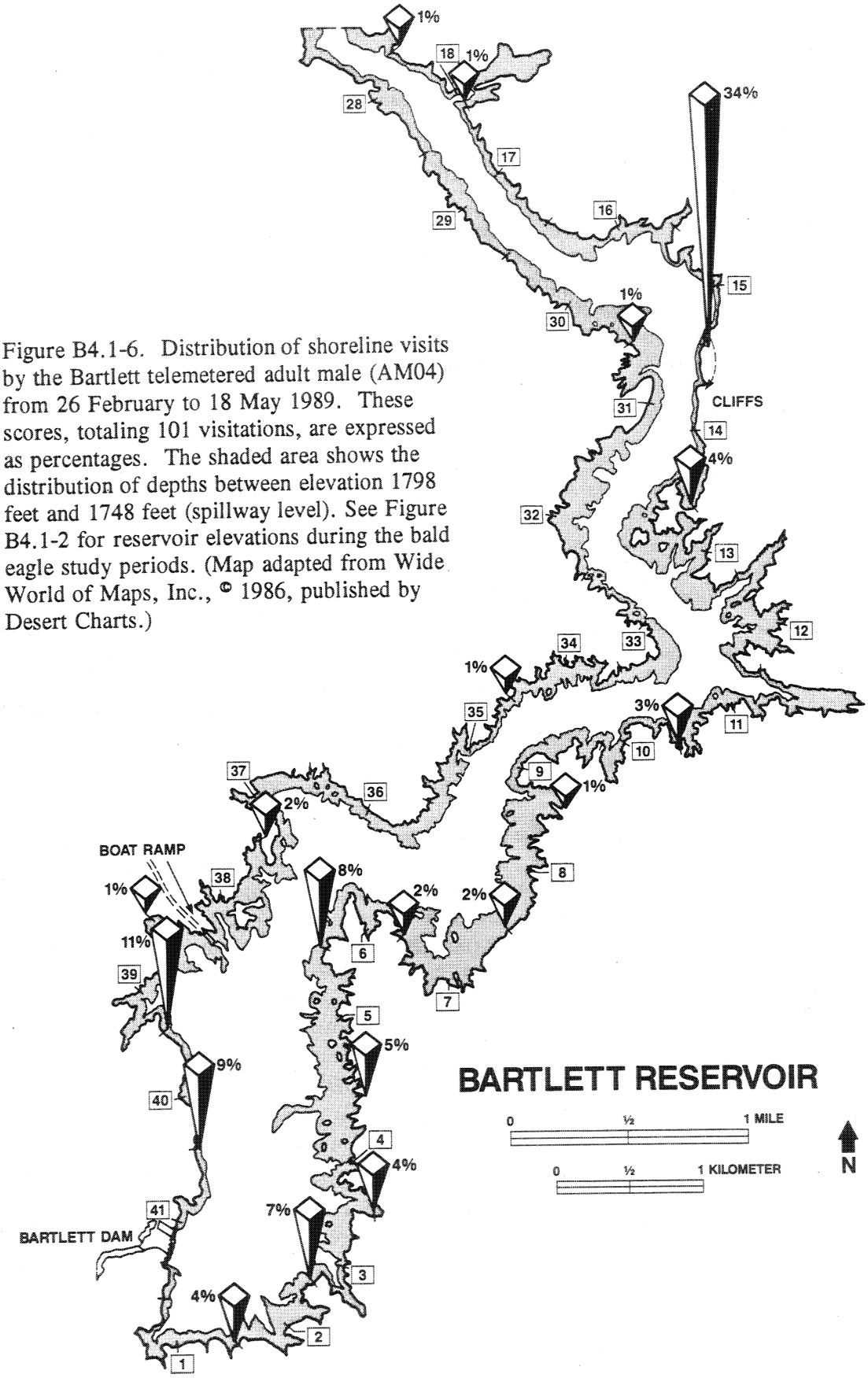


Figure B4.1-6. Distribution of shoreline visits by the Bartlett telemetered adult male (AM04) from 26 February to 18 May 1989. These scores, totaling 101 visitations, are expressed as percentages. The shaded area shows the distribution of depths between elevation 1798 feet and 1748 feet (spillway level). See Figure B4.1-2 for reservoir elevations during the bald eagle study periods. (Map adapted from Wide World of Maps, Inc., © 1986, published by Desert Charts.)

These changes in distributional patterns of foraging are supported by the telemetry visitation data shown in Figure B4.1-7 (compare with Table B4.1-6). The 1989 telemetry data reveals that the eagle visited the Needle Rock Area (Km 32.0–25.0) during 26 February–25 March, 37 percent of total visitations for the period. Percent of visitations to the area dropped steadily in subsequent study periods from 14 percent in April to only 4 percent in May. During the same study periods, percent visitations to the nest area (Km 33.0–35.0) and the reservoir (Km 39.0–53.0) increased from March to May (see above). Percent of visitations to the nest area specifically for foraging increased from 14 percent in March to 17 percent in April, and 33 percent in May. Percent visitation to the reservoir changed slightly during the spring from 48 percent in March to 60–65 percent in April and May.

Our fisheries data (Section B4.1.3) will show that the pattern of foraging in downstream areas early in the nesting season, also observed at the Blue Point breeding area (in a similar habitat setting), is easily explained by changes in the distribution of spawning suckers responding to shifting zones of water temperature as a function of distance from the dam. In early spring, hypolimnetic water may be too cool for suckers to spawn near the dam, but as the water flows downstream, it warms to appropriate sucker spawning temperatures. Later in spring, with increases in air temperature (and that of the hypolimnion), the zone of optimum sucker spawning temperature moves closer to the dam.

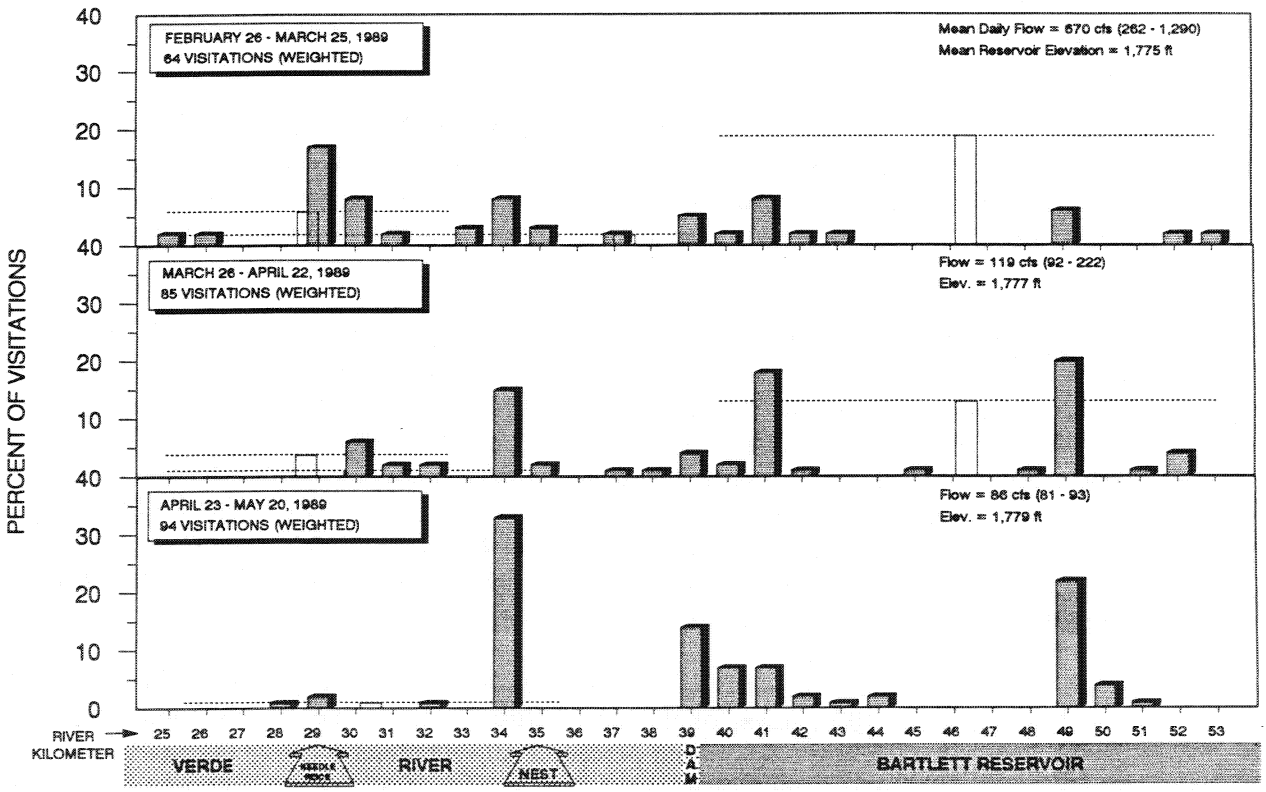


Figure B4.1-7. Seasonal changes in the distribution of visitations by the telemetered Bartlett adult male (AM04) during 26 February to 18 May 1989. Visitation percentages at Kms 34 and 35 (nest vicinity) were weighted according to the proportion of total prey deliveries by the male from those segments during each period. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from those bars indicate zones of eagle occupancy for the imprecise locations.

A matter complicating the "shifting sucker spawn hypothesis" as the sole explanation of the observed patterns of habitat selection by AM04 is the matter of increasing public disturbance in the Needle Rock area in April and May. Although we did not quantify the number of public users there, it was our impression that disturbance levels there increased in each spring month, possibly discouraging the eagle's use of the downstream area.

Macro-Habitat Selection on the River. We mapped instream habitat in the Bartlett Breeding area from the Needle Rock area to the Dam (Km 29.0–38.3) on 12–13 April, 1989. Mean daily flow in the river was 100 cfs during the survey. Pools and runs accounted for 93 percent of the total habitat area in the river (64% and 29%, respectively)(Figure B4.1-8). Normal riffles and super-riffles accounted for four percent and three percent of the total habitat area, respectively. Cascades and backwaters made up less than 1 percent of the total area. Most of the river (approximately 56%) was shallow (less than 0.6 m deep)(Figure B4.1-9). Low flows during the survey resulted in an abundance of shallow water.

A summary of lengths, widths, area, substrate type, and depth ranges for each habitat type in the Verde River is summarized in Table B4.1-8. We compared normal riffles to super-riffles to record possible habitat difference. We found that super-riffles were significantly shorter and wider than normal riffles (t-test, $p < 0.05$), but similar in average area (t-test, $p < 0.05$). Smaller substrate was found in super-riffles compared to normal riffles; in super-riffles, approximately 83 percent of the total area was composed of sand and gravel (22% and 62%, respectively), while in normal riffles, 81 percent of total area was made up of gravel and rubble (41% and 40%, respectively). Depths in both habitat types were similar (Table B4.1-8).

We hypothesize that super-riffles provide more spawning habitat for suckers than normal riffles due to the relatively large width to length ratio. Since the majority of suckers that we observed spawning were at the upstream edge of riffles, it appears this portion of the riffle is preferred. We also observed this pattern of habitat selection by Sacramento suckers and chinook salmon in the Mokelumne River in California.

Distribution of Visitations. The Bartlett Breeding area includes a 10 Km reach (Km 29–38) which received the majority of eagle visitations to the river (Figure B4.1-4). The hypothesis that visitations were randomly distributed over the entire 10 Km was rejected by Chi-Square. We next attempted to compare visitation scores to specific habitat characteristics per Km segment. Habitat characteristics included in this analysis were distance from nest, quality of perch sites, and the abundance of various riverine habitats (i.e., pools, runs, riffles and super-riffles)(Table B4.1-9). We calculated a Spearman's Rank Correlation coefficient (Snedecor & Cochran 1980) of visitations versus these habitat characteristics (except for super-riffles because only 3 Kms contained them). There were no significant correlations with distance from nest, perch quality, or abundance of pools, runs, or riffles.

It is notable that 85 percent of all visitations to the river were to three Km segments (Kms 29, 30 and 34). These 3 Kms contained 100 percent of the super-riffle habitat in the eagle's home range and 69 percent of all riffle habitat (by area). Sixty-four percent of all visitations occurred in one of these Kms (Km 34), and this segment contained the largest super-riffle habitat area (2,980 m^2 out of 7,266 m^2 for the entire reach). It was also within sight of the nest at Km 35.2. The second- and third-ranked kilometer segments for eagle visitations (Kms 29 and 30) contained the remaining super-riffles.

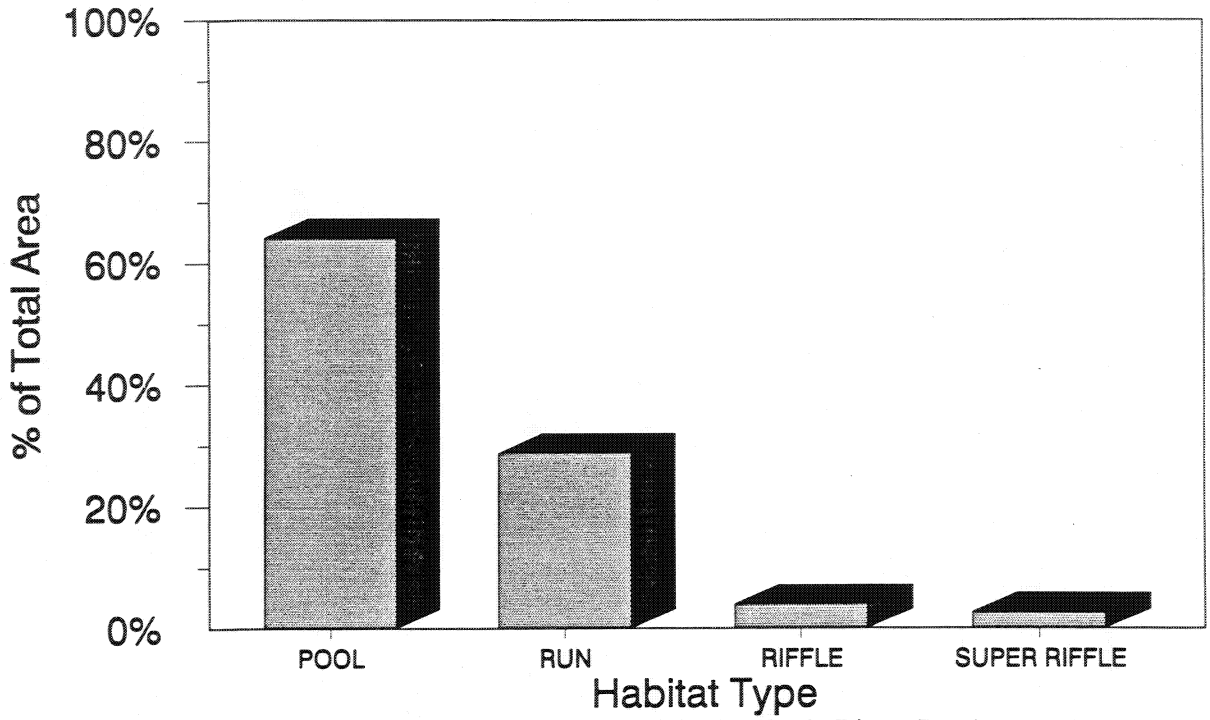


Figure B4.1-8. Summary of habitat abundance (by area) in the Verde River (Bartlett Territory) between Km 29.0–38.3 at approximately 100 cfs. Cascade and backwaters are not shown as they cumulatively made up less than 1% of the habitat area.

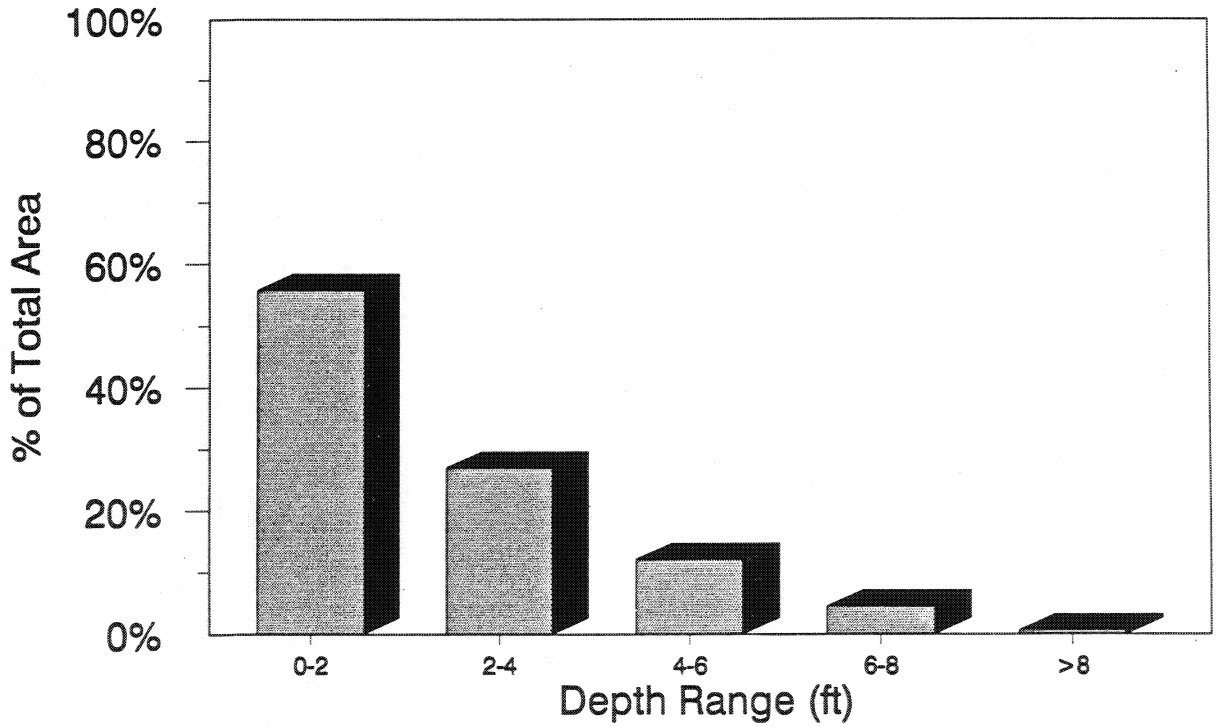


Figure B4.1-9. Summary of depth distribution (by area) in the Verde River (Bartlett Territory) between Km 29.0–38.3 at approximately 100 cfs.

Table B4.1-8. Summary of lengths, widths, areas, substrate type, and depth ranges for each habitat type in the Verde River from the Needle Rock area to the Dam (Km 29.0–38.3). Habitat surveys were conducted at approximately 100 cfs (12–13 April 1991).

Habitat	Length (m)	Width (m)	Area (m²)	Percentage of Area with Substrate Type						Percentage of Area with Depth Ranges (m)			
				Mud	Sand	Gravel	Rubble	Boulder	Bedrock	0–0.6	0.6–1.2	1.2–1.8	>1.8
RIFFLE (n = 9)													
Total	680		12,506	0.0%	15.6%	41.2%	40.1%	3.1%	0.0%	99.4%	0.6%	0.0%	0.0%
Mean	76	21	1,390										
Std. Dev.	45	8	762										
SUPER-RIFFLE (n = 6)													
Total	146		8,215	0.0%	21.7%	61.2%	17.1%	0.0%	0.0%	98.8%	1.2%	0.0%	0.0%
Mean	24	59	1,369										
Std. Dev.	16	21	848										
RUN (n = 25)													
Total	4,063		92,191	0.0%	29.2%	38.3%	27.8%	4.6%	0.1%	66.9%	27.0%	6.1%	0.0%
Mean	163	20	3,688										
Std. Dev.	107	11	3,227										
BACKWATER (n = 1)													
Total	70		1,175	0.0%	40.0%	50.0%	10.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
Mean		17											
Std. Dev.													
CASCADE (n = 2)													
Total	77		1,116	0.0%	16.5%	32.9%	37.1%	13.5%	0.0%	100.0%	0.0%	0.0%	0.0%
Mean	38	15	558										
Std. Dev.	4	8	223										
POOL (n = 20)													
Total	5,067		205,925	0.5%	39.7%	36.6%	19.7%	1.2%	2.2%	46.2%	29.8%	16.2%	7.9%
Mean	253	36	10,296										
Std. Dev.	129	20	9,825										
TOTAL RIVER (n = 63)													
Total	10,103		321,128	0.3%	35.2%	37.9%	22.8%	2.3%	1.4%	55.8%	27.0%	12.2%	5.1%
Mean	160	29	5,097										
Std. Dev.	128	19	6,963										

Table B4.1-9. Summary of visitations, distance from nest, perch score, and habitat abundance in ten-kilometer segments (Km 29–38) within the Bartlett breeding area.

Segment	Weighted Visitation Percentage	From Nest (km)	Perch Score*	Pool	Run	Riffle	Super Riffle	Total All Riffles
29	4	6	5	41,136	0	0	2,830	2,830
30	4	5	5	32,777	1,602	1,138	1,456	2,594
31	1	4	5	12,221	12,527	0	0	0
32	1	3	3	10,012	9,517	3,235	0	3,235
33	2	2	4	8,852	5,084	1,442	0	1,442
34	25	1	5	17,288	11,480	5,285	2,980	8,265
35	1	0	5	12,820	13,958	0	0	0
36	0	1	2	17,171	19,505	0	0	0
37	1	2	2	45,418	2,254	0	0	0
38	0	3	5	16,851	16,381	1,423	0	1,423

* Perches were scored as follows:
5 = Large promontory cliff or large snag near shore;
4 = Small cliff, cut bank, or large snag within 25 m of water or small snag in water;
3 = Large live tree with perch branch within 25 m of water;
2 = Cut bank < 10 m high, small snag, or large live tree 25–50 m of water.

Figure B4.1-4 clearly shows that eagles were attracted to river kilometers containing super-riffles. In the 8 Km from Km 29 to Km 37 (excluding the nest Km), there were 3 Kms containing super-riffles (38%), and 5 Km containing no super-riffles (62%). Visitations scores totaled 108 points for Kms with super-riffles (87.8%), and 15 points (12.2%) to those without super-riffles. If Km visitation were random with respect to super-riffle occurrence, then we would expect roughly 46 visitations to the super-riffle Kms, a hypothesis rejected by Chi Square ($\chi^2 = 11.06$, df = 1, $p < 0.001$). Excluding Km 34, which may have been favored because it was near the nest (Km 35), the visitation scores are 25 points (62.5%) to super-riffle Kms and 15 points (37.5%) to Kms without super-riffles. Again, selection of super-riffles by the eagles is strongly suggested by Chi-Square ($\chi^2 = 8.40$, df = 1, $p < 0.005$).

We conclude that, for this territory, eagles concentrated foraging activities in segments of the river containing super-riffle habitat. Foraging close to the nest appeared to be preferable; however, eagles would apparently travel several Kms to forage in an area containing super-riffles, by-passing other habitat types.

B4.1.2.3 Observations of Foraging on the River (Fish). Direct observations of foraging on both the river and the reservoir yielded information on the use of specific kinds of macro- and microhabitats by the eagles (see B3.3.3, Methods). Because the river from Km 34.0 to Km 36.3 was entirely visible to the nest observer (recording prey deliveries), data on observed foraging in this area represent the actual

Plate B5. Km 34.5 "Powerline" super-riffle below the Bartlett nest cliff. The photo, taken on 8 April 1990 at flows of 50 cfs, shows how the riffle will grow larger at higher flows (photo by D. Driscoll).

distribution of events, and therefore we are able to compare them with the distribution of habitat variables. Such a comparison is far more useful than using foraging observations outside these Kms to obtain a geography of habitat selection, because of chance factors in observer location.

We observed a total of 119 forages in the river between Kms 34.0–36.3 in 1988 and 1989, in which we were able to identify the specific location (habitat) of prey capture. A comparison of habitat availability in this river reach (Km 34.0–36.3) to the distribution of eagle foraging by habitat is quite informative

Plate B6. Super-riffle at Km 29 in Bartlett breeding area. Note that the super-riffle extends completely across the river, even at flows of 750 cfs pictured here on 21 August 1991 (photo by D. Driscoll).

(Figure B4.1-10); obviously eagle foraging was not random in this reach. Rather, the eagles preferentially foraged in super-riffles and to some extent in normal riffles, an observation that independently supports the larger-scale visitation data comparison described above.

River Foraging Microhabitat by Prey Species. The Bartlett eagles took prey fish species in differing macrohabitats (riffles, runs, pools, etc.) and microhabitats (substrate and vegetation, water temperature, depth, velocity, etc.). Sucker species were by far the most common prey in the Bartlett breeding area, and there were very few microhabitat data obtained at strike points for fish other than suckers.

Sucker species. We observed 71 forages for fish identified as sucker species, two forages for desert sucker, and one for a Sonora sucker. We obtained microhabitat measurements at 59 strike points, although we could not obtain complete data at all points (Table B4.1-10). Most suckers taken during observed forages (68 of 71 observations) were alive when captured. The status of two was not determined, and only one was positively identified as carrion.

Riffles were the most frequently observed habitat for sucker forages by eagles (46 of 71 forages for all sucker spp.; see Table B4.1-10). Runs were the next most important category of habitat, with nine observed forages. One forage was noted in a pre-riffle, and some of the other forages listed as occurring

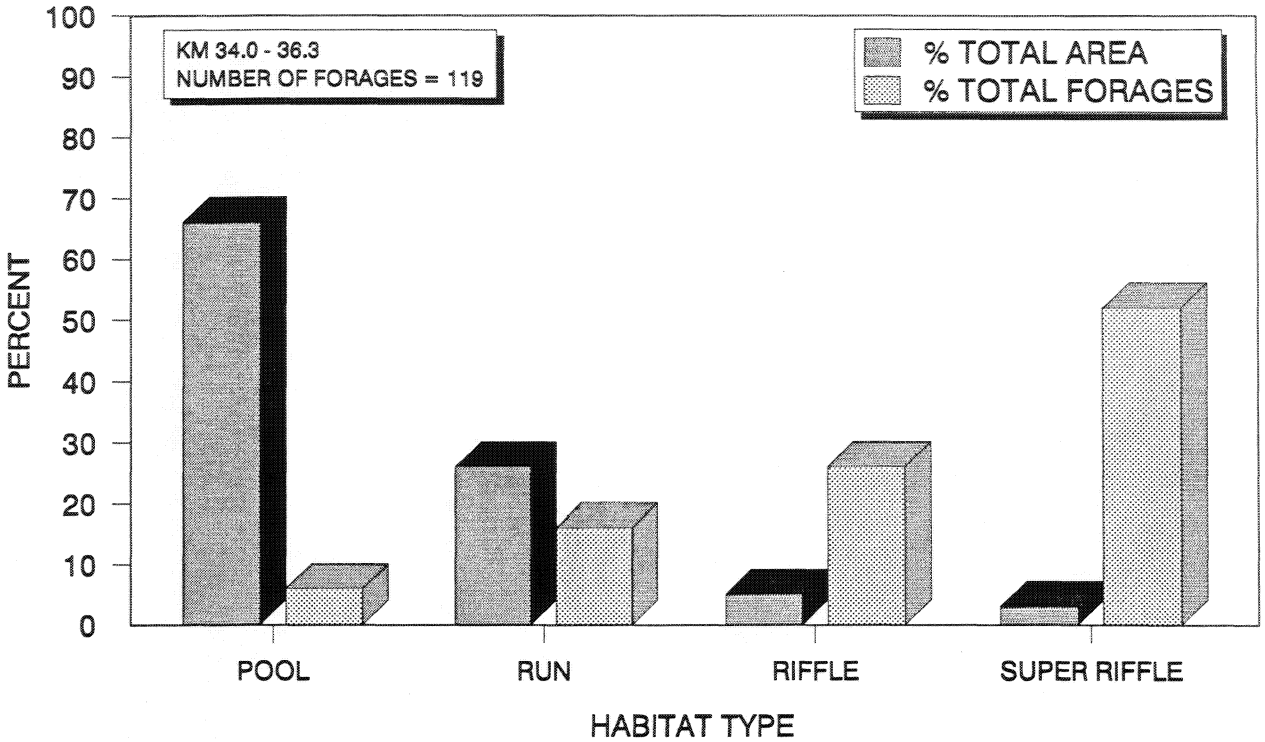


Figure B4.1-10. A comparison of habitat availability (by percent area) and total forages by habitat type in the Verde River (Km 34.0–36.3).

in runs may have been in pre-riffles. Depths in the runs where suckers were taken ranged from 13 to 80 cm, with an average of 35 cm (n = 9). However, six of the nine depths were less than 40 cm. Thus, many of the forages in runs took place either at shallow side areas or ends.

Consistent with the large number of eagle forages in riffles, suckers were taken in generally shallow water (Figure B4.1-11). Water temperatures ranged from 10–17°C, averaging 14°C, and most water velocities at the strike points were less than 0.33 m/sec. (Figures B4.1-12, B4.1-13 and B4.1-14). Substrate at the strike points was usually either 2–5-cm pebbles (21 observations) or rocks (27 observations), with a mossy coating of algae observed at 37 strike points (Table B4.1-10). Turbidity was measured as clear to the bottom at 58 of 59 strike points, with one measurement of 80 cm.

River habitat and microhabitat at observed strike points for the prey category termed "probable suckers" were generally similar to those for fish positively identified as suckers (Table B4.1-10). Eight depth measurements at strike points showed depths of 4 cm (n = 1), 10 cm (n = 5), and 13 cm (n = 2).

Other Species. Not counting piracies, we observed eagles take three channel catfish, one smallmouth bass, and two unidentified bass from the river in Bartlett breeding area. River habitat was either run or pool, with one cascade. No microhabitat measurement appeared unusual in this small sample. (See Table B4.1-10, Figure B4.1-13). Measurements of depth and velocity at channel catfish forages showed depths of 60 and 84 cm, and water velocities between 0.0 and 0.19 m/sec. Data from the bass forage

Table B4.1-10. River habitat, substrate, and submerged vegetation at all observed forage points on the Verde River, Bartlett territory. Observations are for all eagles in 1988 and 1989, but primarily for the adult male AM04 and the adult female CF01 in 1988 and 1989. The data do not include piracies.

Species	River habitat	No.	Substrate	No.	Vegetation	No.
Sucker spp.	Riffle	45	Gravel & sand	1	None	16
	Pre-riffle	1	Coarse gravel	5	Grassy bottom	1
	Run	9	Pebbles (<2 cm)	5	Mossy coating (algae)	35
	Pool	5	Pebbles (2–5 cm)	20	Algae mat	5
	Pocket water	5	Rocks	26	Other	1
	Cascade	1				
	Other	3	Other	1		
Desert sucker	Riffle	1	Pebbles (2–5 cm)	1	Mossy coating (algae)	1
	Pool	1				
Sonora sucker	Pocket water	1	Rocks	1	Mossy coating (algae)	1
Probable sucker	Riffle	2	Pebbles (2–5 cm)	3	Mossy coating (algae)	8
	Pre-riffle	1	Rocks	5		
	Run	2				
	Pool	2				
	Pocket water	2				
	Back-water	1				
Channel catfish	Run	2	Coarse gravel	2	None	1
	Pool	1			Mossy coating	1
Bass spp.	Run	1	Rocks	2	None	1
	Cascade	1			Grassy bottom	1
Smallmouth bass	Pool	1				
Unidentified fish	Riffle	19	Gravel & sand	1	None	5
	Run	5	Coarse gravel	1	Mossy coating (algae)	21
	Pool	2	Pebbles (<2 cm)	4	Algae mat	1
	Pocket water	4	Pebbles (2-5 cm)	12		
			Rocks	9		

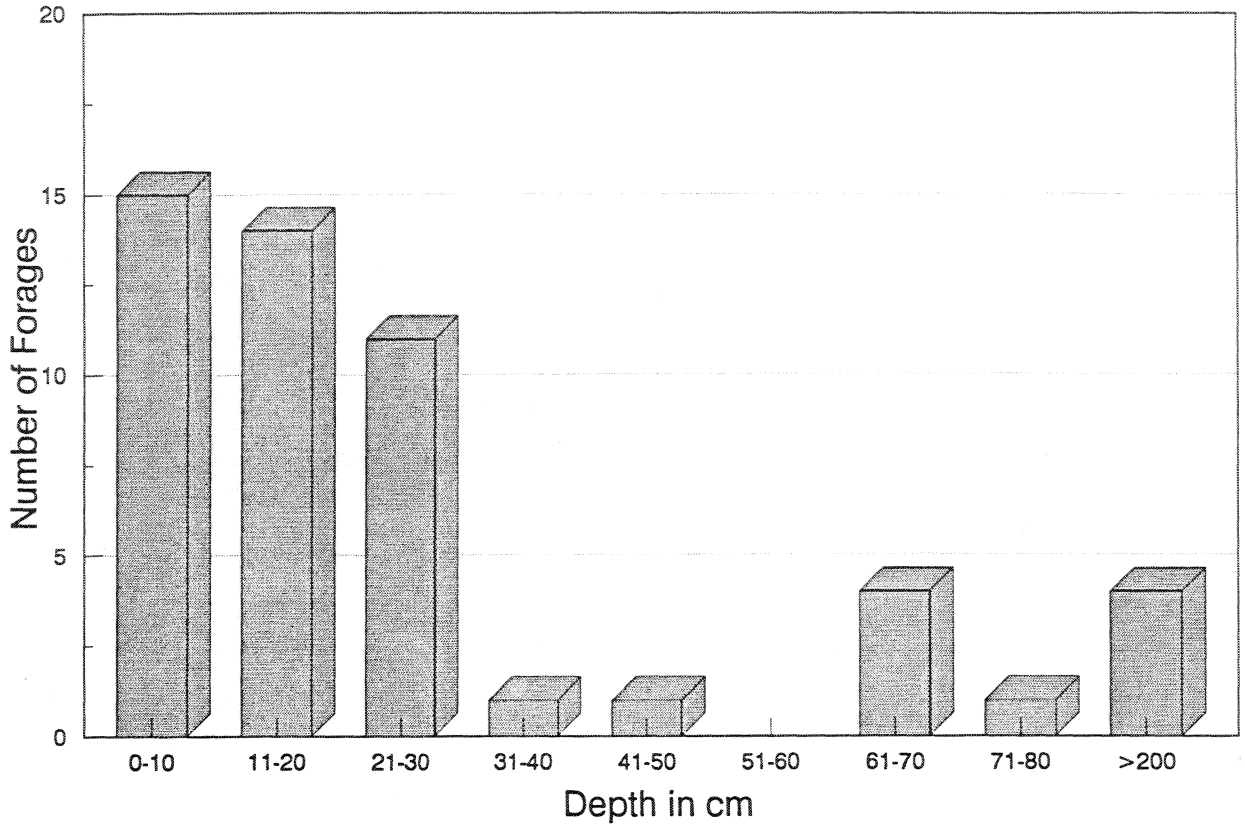


Figure B4.1-11. Profiles of depths at observed strike points for sucker spp. (including identified desert and Sonora suckers) on the Verde River, Bartlett territory. Data do not include piracies.

points showed depths of 15 and 77 cm, and one water velocity of 0.25 m/sec (these measurements are from forages for unidentified bass).

Unidentified Fish. Nineteen of 30 river habitat records for unidentified fish were at riffles, and microhabitat data for this category does not appear very different from that for sucker species (Table B4.1-10, Figure B4.1-13). Since the pattern of forages for these fish does not appear to be different from that of observed forages for fish generally, and since most identified fish were sucker species, it is probable that most were suckers.

Foraging Perches on the River. On this section of the Verde River, eagles rarely used vegetation for their foraging perches. In 79 observed forages where eagles flew directly to the river surface to forage, the forage originated from vegetation only once, when an eagle foraged from a cottonwood tree. Forty-eight forages originated from cliff faces, seven from boulders, six from cliff tops and five from pinnacle tops, with six originating from the nest itself. The remaining forages originated from the river shore once, sand bars twice, and once from the water.

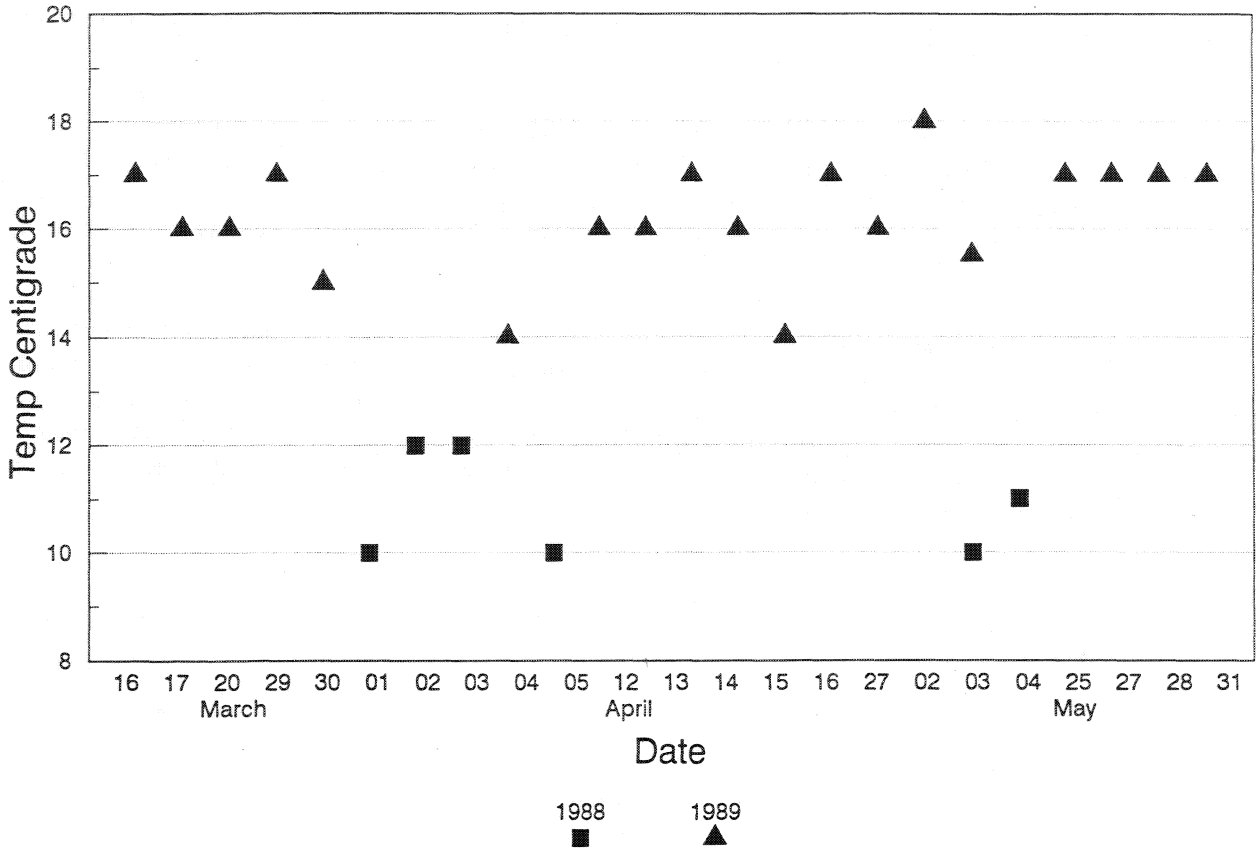


Figure B4.1-12. Water temperatures at observed strike points in the Km 34.5 riffle, Bartlett territory.

Distance from perch to the attack point varied widely, but the distance was short in most instances. Of 81 observed forages where eagles flew directly to strike points at the river surface, 61 covered a distance of 50 m or less. Eleven covered between 51 and 100 m, three were between 101 and 200 m, and six were over 200 m. Sixty-one of these 81 forage attempts were successful (75%).

River Piracies. In six piracies on the river in Segments 30 or 34, eagles pirated prey from three ospreys, two great blue herons, and one raven. In one attack, both the male and female eagles harassed an osprey until it dropped its prey. The prey species pirated were four suckers (unidentified to species), one channel catfish, and one unknown. The attack distance was as short as 15 m, but one distance was 800 m and two were over 1000 m.

B4.1.2.4 Observations of Foraging on the Reservoir (Fish). We observed 20 forages on Bartlett Reservoir. Distribution of these forages (not including piracies) is shown in Figure B4.1-15.

Reservoir Foraging Habitat. Table B4.1-11 shows microhabitat for 15 observed forages on the surface of Bartlett Reservoir. All but one on these forages was in deep water. Generally speaking, if wind or water currents carried carrion fish far from their habitat, then the measurements taken at the strike points may not accurately reflect the habitat of the fish. The sample from this reservoir is small, and thus it is impossible to say if this bias is present. Only two largemouth bass (live) and one bluegill (live) could

be identified as living or carrion; however, the designation as carrion did not preclude their being injured or moribund prior to capture.

During observed forages on the reservoir, eagles used boulders as forage perches five times, cliff faces twice, a cliff top, and the shoreline once each. No vegetation was utilized as a forage perch. As with river forages, the distance from the forage perch to the strike point was quite variable. Of 10 recorded distances, the shortest was 10 m, and three were over 1000 m. Three live fish were taken in forages of 100 and 600 m, while a forage of greater than 1000 m was for carrion.

Reservoir Piracies. We observed eagles displace other species from carrion four times on the reservoir. We saw no piracies of recently-taken prey such as we saw on the river. Turkey vultures were displaced on two occasions, ravens on one, and once a mixed group of ravens and turkey vultures was displaced. The carrion species were identified as one black crappie, one bass (unidentified to species), one unknown fish, and one totally unidentifiable item. As with the piracies on the river, the attack distances were quite variable, ranging from 1 m to over 1000 m.

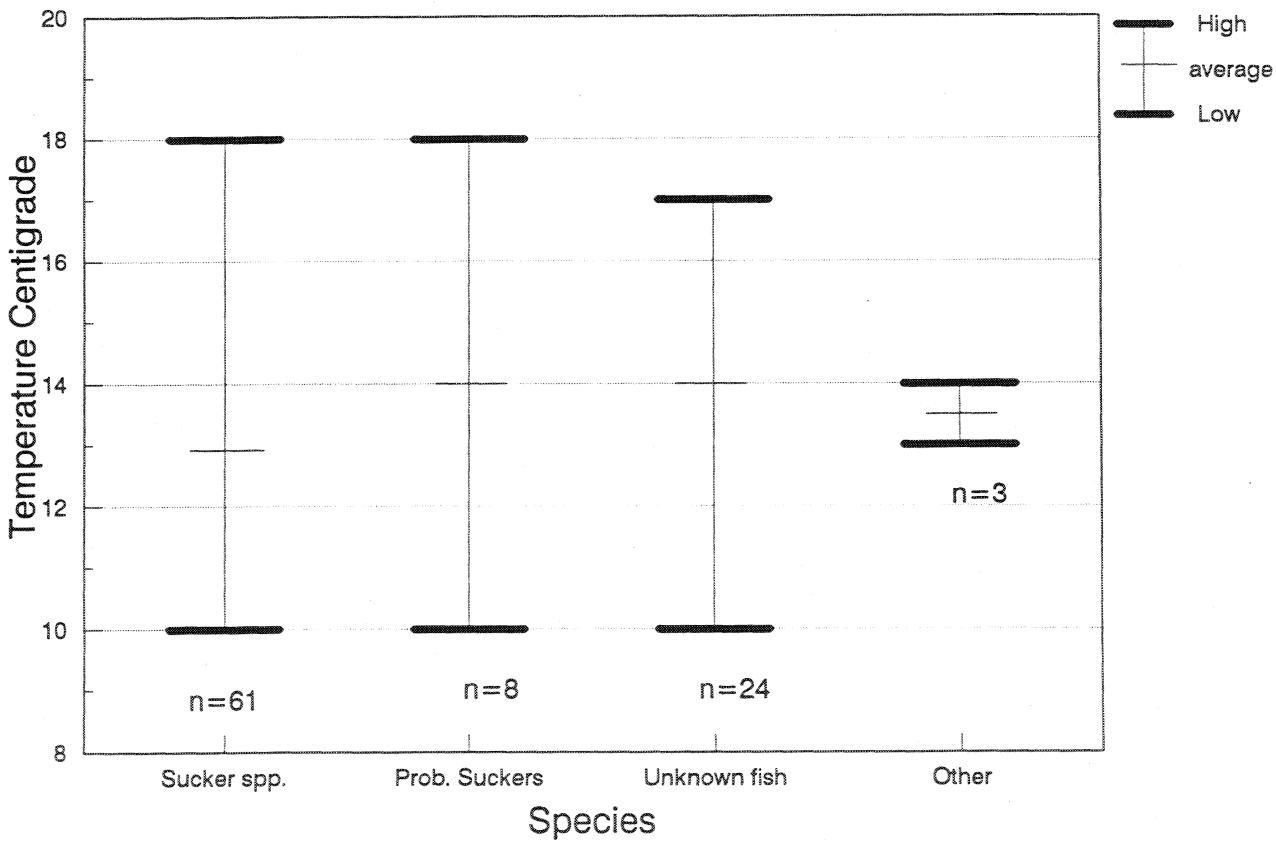


Figure B4.1-13. Water temperatures at observed forage points on the Verde River, Bartlett territory. Data do not include piracies. Species categories are sucker spp. (including identified desert and Sonora suckers), fish identified as probable suckers, unidentified fish, and others (including channel catfish, unidentified bass, and smallmouth bass; see text).

B4.1.3 Prey Population Studies

During our investigations of fish and other prey in the Bartlett breeding area we attempted to identify: (1) relative abundance of potential prey fish in the Verde River and Bartlett Reservoir, (2) seasonal and diel changes in distribution and abundance of prey vulnerable to eagles (i.e., in shallow water), (3) life-history influences on prey availability, and (4) effect of water management on prey availability.

Table B4.1-11. Dates and habitat data for observed forages on Bartlett Reservoir in 1989 (there were no observed forages in 1988). Data do not include piracies.

Species	Date	Status (live/carrion)	Depth	Turbidity	Velocity	Shore distance	Temperature (°C)
Ch. Catfish	5/14/89	U	>200 cm	CTB	—	40 m	—
Bluegill	4/16/9	A	5 cm	60 cm	—	10 m	20°
Largemouth bass	4/19/89	A	>200 cm	180 cm	NMC	35 m	20°
	4/29/89	U	>200 cm	CTB	NMC	30 m	20°
	5/02/89	A	>200 cm	CTB	—	50 m	23°
Unidentified fish	4/15/89	U	>200 cm	—	NMC	10 m	—
	4/18/89	U	—	—	—	20 m	22°
	4/19/89	U	>200 cm	180 cm	NMC	35 m	20°
	4/27/89	U	>200 cm	CTB	—	—	20°
	5/04/89	U	>200 cm	CTB	—	20 m	21°
	* 4/19/89	U	>200 cm	—	NMC	10 m	—
	* 5/01/89	U	>200 cm	CTB	—	100 m	21°
	5/01/89	U	>200 cm	CTB	—	100 m	21°
	5/01/89	U	>200 cm	CTB	—	100 m	21°
	5/01/89	U	>200 cm	CTB	—	100 m	21°

Turbidity: CTB = clear to bottom. Velocity: NMC = no measureable current.

* These were entered as unidentified prey; assume fish because on open water; the last four entries were for a series of forages within a few minutes.

Relative Abundance of Fish in Bartlett Reservoir. Bluegills were by far the most abundant fish collected during AGF surveys in Bartlett Reservoir (1984-85), making up over 69 percent of fish captured. Only three other potential prey species were abundant in the reservoir: black crappie (6.2%), largemouth bass (14.4%) and carp (4.1%). Species collected, but comprising less than 3 percent of the fish community, included goldfish, flathead catfish, channel catfish, smallmouth bass, and green sunfish. The abundance of black crappie, which utilize the pelagic zone of the reservoir, was probably under-represented in the AGF surveys due to greater sampling effort along the shallow margins of the reservoir. Jim Warnecke (AGF) noted that large spawning populations of 3–4 year-old black crappie typically inhabit Bartlett Reservoir.

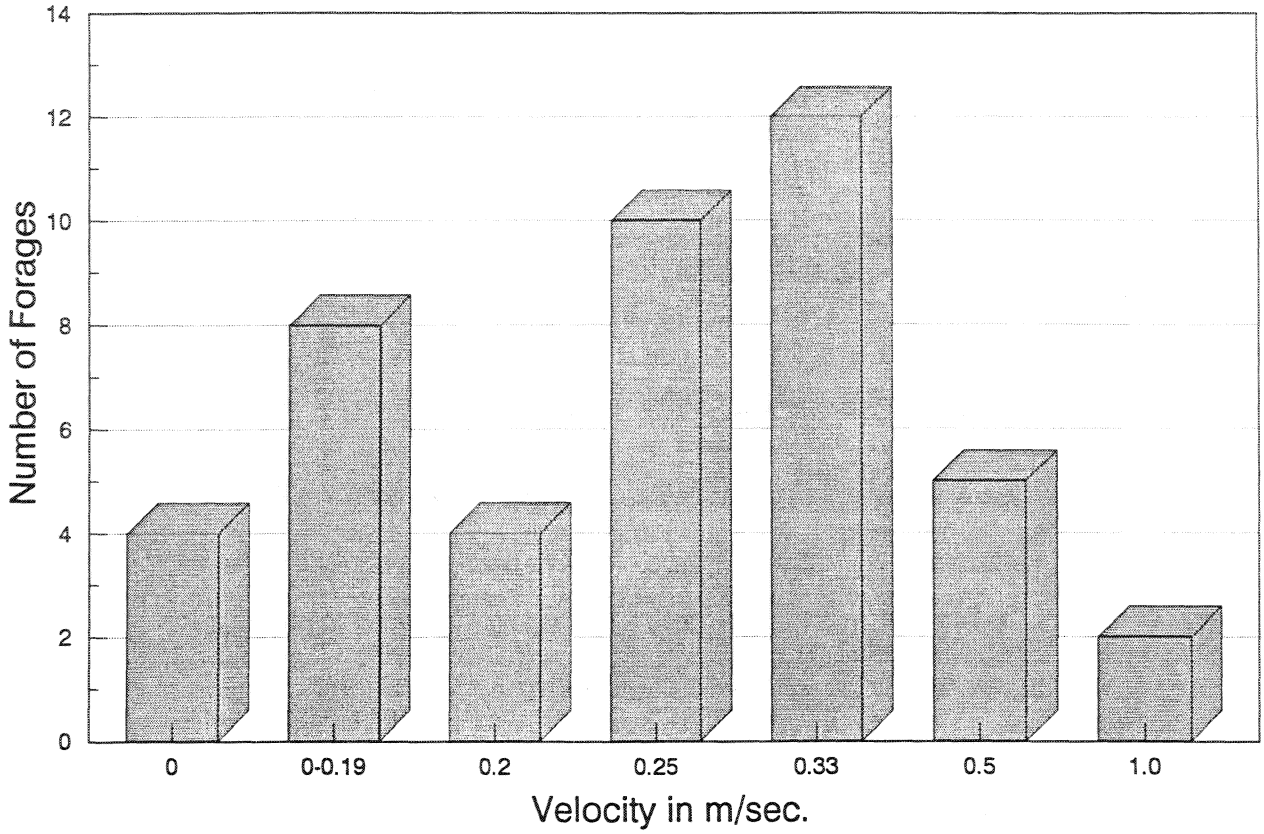


Figure B4.1-14. Profiles of water velocities at observed strike points for sucker spp. (including identified desert and Sonora suckers) on the Verde River, Bartlett territory. Data do not include piracies.

Relative Abundance of Fish in the Verde River (Bartlett Breeding Area). In 1973, the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1976) conducted fisheries surveys in the Verde River from Bartlett Dam to the Salt River confluence. They used a combination of techniques, including electroshocking, gill-netting, and seining. They reported that suckers comprised about 50 percent of the potential prey fish present in the Verde River from Bartlett Dam to its confluence with the Salt River. Desert sucker were more abundant than Sonora sucker at that time (41.5% to 8.6%, respectively). Carp and catfish (primarily yellow bullheads) had almost equal abundance constituting 24 percent and 23 percent of the prey fish present. Only two other species, largemouth bass (6%) and green sunfish (3.5%) accounted for more than one percent of prey fish recorded.

In 1989, we collected 467 fish in gill nets set overnight in pools and floated through riffle and run habitats in the daytime. Our sampling efforts were concentrated between Kms 36.0 and 29.0, although we also sampled habitats between Km 29.0 and the Verde River mouth (Km 0.0). Desert sucker and Sonora sucker accounted for 94 percent of the fish collected (55% and 39%, respectively). Roundtail chub, largemouth bass, green sunfish, carp, rainbow trout and flathead catfish cumulatively accounted for only 6 percent of fish collected. To summarize the differences in results between our surveys and those conducted in 1973, there was (1) a greater proportion of desert sucker (41.5% in 1973 to 55% in 1989); (2) a very large increase in the proportion of Sonora sucker (8.6% to 39%); and, (3) fewer carp and catfish.

These dissimilarities may have resulted from differences in sampling techniques or may have reflected actual changes in the fish community. Visual surveys we conducted in 1988 and 1989 from Km 38.0 to the mouth, also indicated that suckers were by far the most abundant fish and that carp were relatively rare. Since we documented that bald eagles at Bartlett took 75 suckers but only one carp in the river during 1988–1989, the species composition determined from our surveys is probably representative of current conditions.

Size and Sex Distribution of Suckers. Desert sucker collected in gill nets appeared to separate bimodally into size classes, ranging from 200–310 mm and from 320–470 mm (Figure B4.1-16). The largest desert sucker collected in this territory was 465 mm total length (TL). Similarly, Sonora sucker collected could be separated into two size classes ranging from 200–270 mm TL and from 370–560 mm TL (Figure B4.1-16). The largest Sonora sucker collected was 558 mm TL. Over 32 percent of Sonora sucker collected were larger than the largest desert sucker netted. The bimodality of the length frequency histograms for desert and Sonora suckers suggest two dominant year classes. Fish smaller than 200 mm TL of both species are under-represented in our data due to gear selectively; however, since the majority of suckers taken by bald eagles were greater than 200 mm TL (75 of 75), our data is representative of prey availability. One hundred and sixty-four desert sucker collected in gill nets in 1989 were sexed. Eighty were females (49%) and 84 were males (51%). Of the 146 Sonora sucker sexed, 96 were females (66%) and 50 were males (34%).

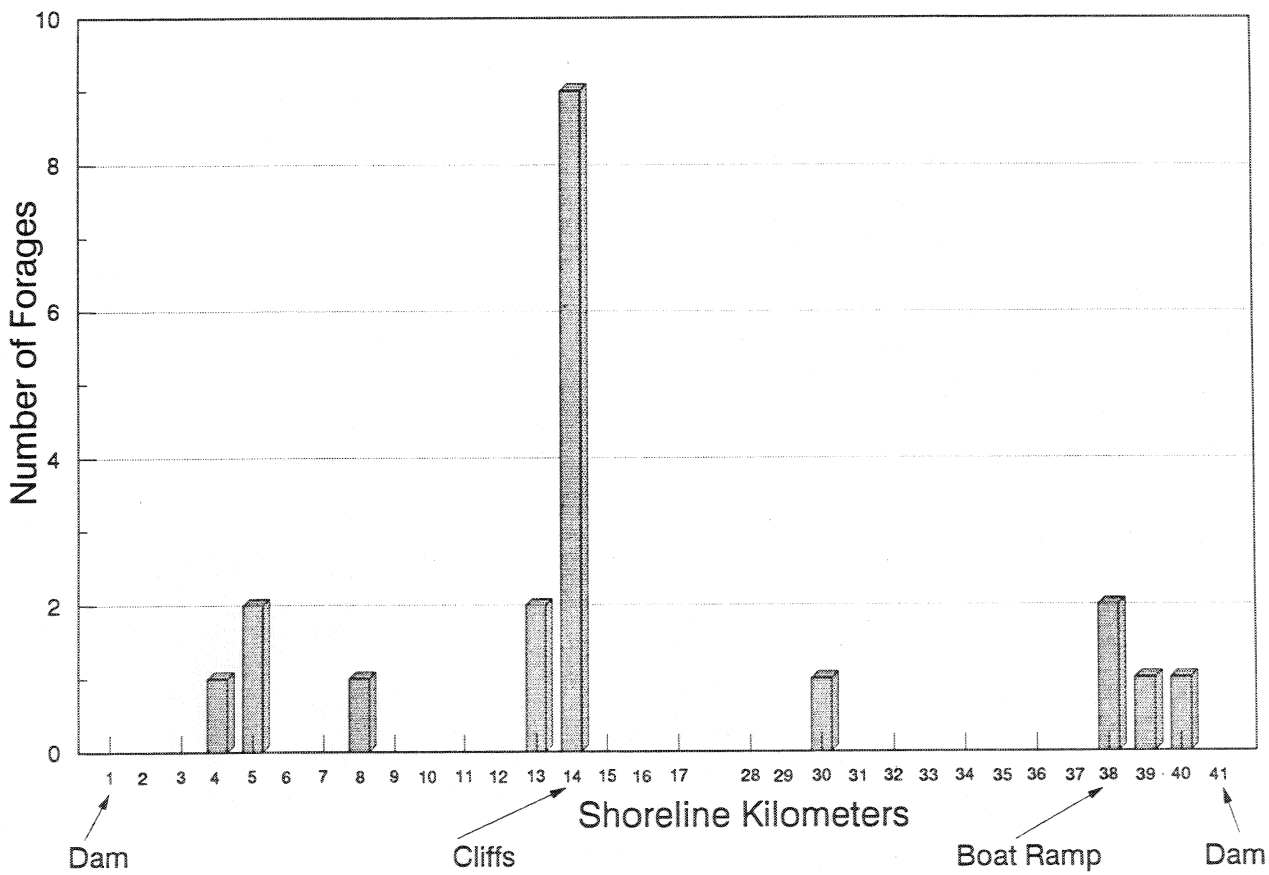


Figure B4.1-15. Distribution of observed forages on Bartlett Reservoir, by shore kilometer (see B4.1-6 for geography of SKm locations). Data do not include piracies.

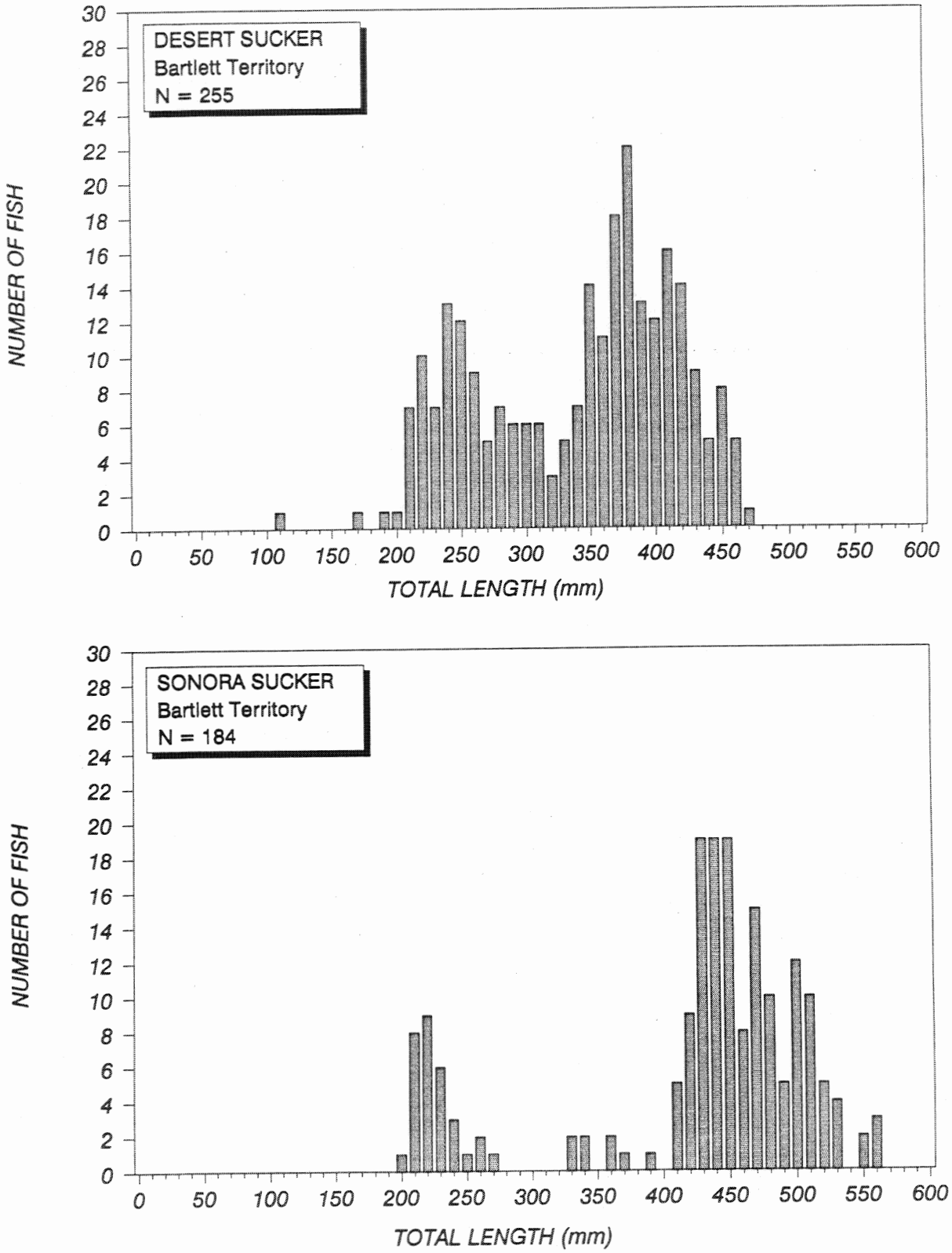


Figure B4.1-16. Size distribution in samples of desert suckers and Sonora suckers in the Verde River, Bartlett Territory (1989).

Spawning Chronology. Sucker activity in the Verde River (Kms 28.0–38.0) in 1989 is summarized in Figure B4.1-17. To highlight differences within the breeding area, we separated the area into two reaches: an upstream reach (Kms 34.0–38.0) and a downstream reach (Km 28.0–33.0)(the nest is at Km 35.2). Our first visual survey of the downstream reach occurred in early March, at which time we observed hundreds of suckers in shallow water exhibiting intense courtship activity but only occasional spawning. Peak spawning in this downstream reach occurred in mid-March, but ceased by 1 April. Thousands of sucker fry were observed along the river margin during our 1 April survey; their occurrence was consistent with a March spawning period. We observed no spawning, and only occasional courtship by suckers in this reach on 12–14 April 1989.

We examined 15 adult desert sucker and 14 Sonora sucker collected in the downstream reach between 14–18 April 1990 to further assess reproductive status. Twenty-five of 29 adult suckers were completely spawned-out, one was releasing milt and three contained non-ripe eggs. We also collected suckers and assessed their reproductive status at several locations downstream of the Bartlett territory (between Km 20.6 and Km 3.1) on 14–18 April 1990. All the desert sucker examined (n = 23) were spawned-out at that time. Similarly 17 of 18 Sonora sucker examined were spawned-out.

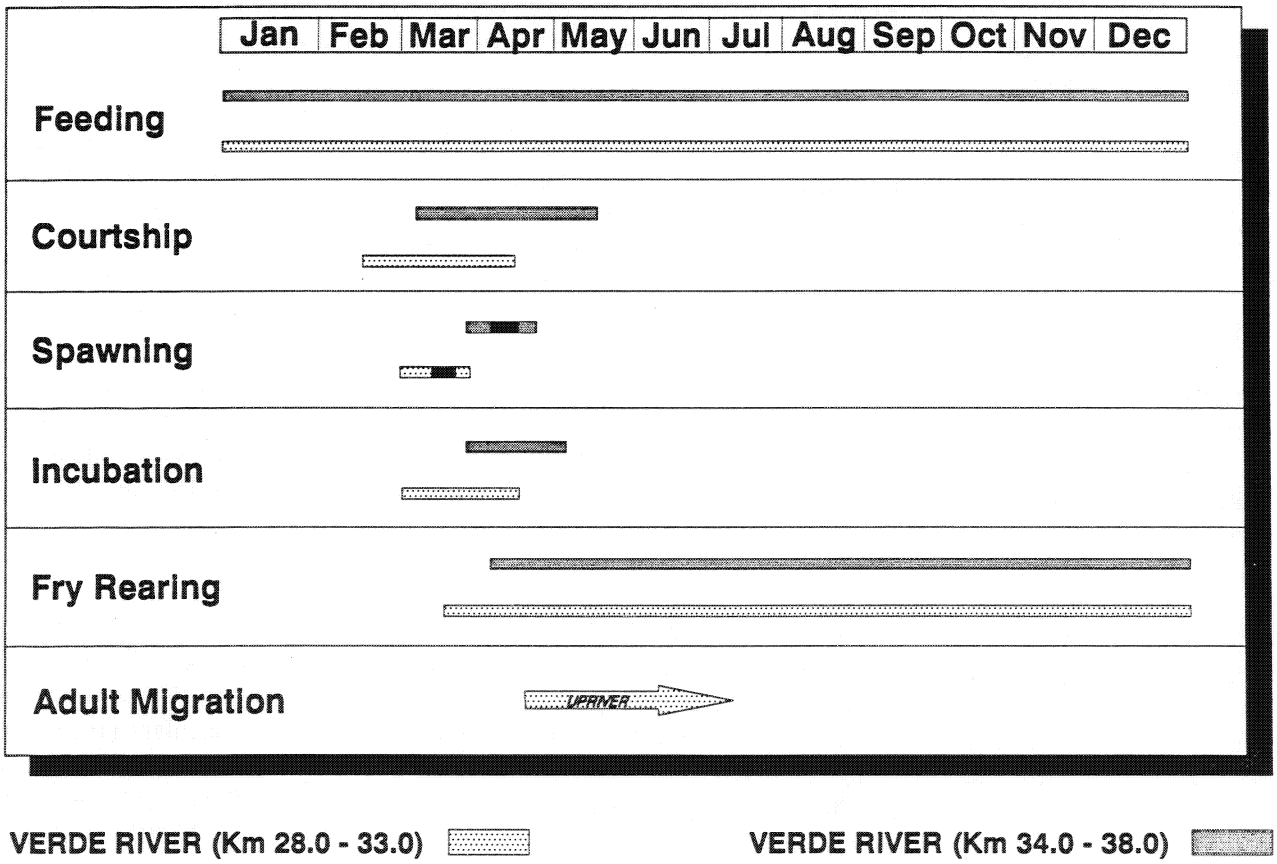


Figure B4.1-17. Sucker activity in two reaches of the Verde River within the Bartlett eagle territory in 1989. Activity of desert and Sonora suckers are not differentiated in this figure.

Two visual surveys conducted on the downstream reach on 28 April and 10 May reach revealed few adult suckers, and no courtship or spawning activity. Juvenile suckers were by far the most abundant size class observed in the downstream reach at this time. Additional visual surveys at several locations from Km 20.6 to the confluence verified that adult suckers, although abundant earlier in the nesting season, were now relatively scarce in the lower Verde River. We hypothesize that the adults migrated upstream in late April as water temperatures in the river increased. All desert sucker (n = 34) and Sonora sucker (n = 35) examined in the downstream reach between 28 April and 12 May 1990 were spawned-out.

In the upstream reach (Km 34.0–38.0), peak courtship and spawning activity by suckers occurred later than in the downstream section (Figure B4.1-17). During our first survey in late February, we observed no courtship or spawning activity by suckers. Intense courtship was first observed in mid-March in the upstream reach, but the peak in sucker spawning was delayed until mid-April, almost one month later than at downstream areas. Sucker fry were first observed at the upstream sites on 12 April, suggesting that some spawning occurred in late March.

We examined 15 desert suckers and four Sonora suckers collected in the upstream reach on 3 March to verify our visual observations. The majority of desert sucker were ripe at this time (12 of 15) but no trend was evident for Sonora sucker (1 with developing eggs, 2 ripe, 1 spawned-out). A total of 38 desert sucker were examined from 1–18 April, of which seven contained developing eggs, 30 were ripe, and one was spawned-out. Sixteen Sonora sucker were ripe at this time, six contained developing eggs, and six were spawned-out.

We observed only occasional courtship behavior by suckers in our last two surveys on 28 April and 10 May. Surprisingly, the percentage of desert sucker and Sonora sucker spawned-out in the upstream reach in late April and early May was only 40 percent and 80 percent respectively. Apparently not all suckers in the upstream reach spawned in 1989. Unlike the downstream reach, adult suckers remained abundant in the upstream reach throughout the nesting season, and their numbers were probably supplemented by fish moving upstream in late spring.

Interestingly, at both the upstream and downstream reaches, sucker activity on 1 April was considerably different from activity during previous or subsequent surveys. During 30–31 March, flow in the river decreased from 189 cfs to 92 cfs, which apparently disrupted sucker activity. Suckers in the upstream reach did not resume spawning until sometime between 1–12 April, while suckers in the downstream reach never resumed spawning. Perhaps the sudden decrease in flow on 31 March stimulated suckers in the downstream reach to migrate upstream.

Abundance in the Powerline Riffles. During the 1988 and 1989 eagle nesting seasons, we conducted comprehensive visual surveys at the Km 34.5 riffle to record fish abundance and activity. Selection of this riffle was based on its repeated use by the Bartlett pair in both years. We conducted all surveys from an observation point located on a cliff approximately 80 m above the riffle, using binoculars (10 × 50) to examine the riffle and a spotting scope (20–60 ×) for species identification, abundance estimates, and fish behavior classification. In 1988, we made visual surveys on 27–28 January, 3 April, and 3–4 May. Sampling was increased in 1989 to include surveys on 20 February, 4 March, 19 March, 1 April, 12–14 April, 28 April, and 10 May.

We observed suckers in the Km 34.5 riffle during each of the surveys in 1988 and 1989, a fact suggesting that fish were available to eagles in riffle areas throughout the nesting season. However, sucker

abundance in the riffle significantly changed during the nesting season in each year, with higher numbers observed during periods of intense sucker courtship and spawning (Figure B4.1-18).

In 1988, relatively few suckers utilized the riffle during January and May. We did not observe courtship or spawning activity by suckers during these surveys; rather, we saw the fish foraging in the riffle and pre-riffle area. However, in April 1988, significantly more suckers utilized the riffle and pre-riffle area. At that time, we observed vigorous courtship and spawning activity by suckers in the riffle area and pre-riffle habitat at Km 34.5, as well as other locations within the nesting territory. At several locations, we collected eggs from redds immediately following sucker spawning to verify our observational techniques.

Similarly, in 1989 many more suckers occupied the riffle and pre-riffle area during the peak spawning period than before or after (Figure B4.1-18). During surveys in February and early March, no courtship or spawning was observed, and less than 100 adult suckers were observed foraging in the riffle. We observed courtship and spawning activity occurring in the riffle and pre-riffle area in mid-March and mid-April; peak spawning activity occurred in mid-April. During these times, we estimated that over 500 suckers used the riffle and pre-riffle area. Numbers dropped substantially in late April and May after peak spawning concluded.

In 1989, significantly fewer sucker used the powerline riffle following a sudden decrease in flow during 30–31 March; spawning activity also abruptly stopped following the flow change. We believe that the sudden decrease in flow stimulated the suckers to seek deeper habitat until flows stabilized. On 12–14 April, we observed more than 500 suckers vigorously spawning in the riffle and pre-riffle area despite flows of only 99–100 cfs. Thus, the habitat was suitable for spawning even at these low flows.

Sucker availability in the Bartlett territory was not restricted to the riffle at Km 34.5. A survey of riverine habitat on 2 April 1988 from Km 38.8–30.0 revealed numerous other sucker spawning areas (Figure B4.1-19).

Carrion Availability. From 13 April to 31 May 1989, we conducted four carrion surveys on the river and nine on the reservoir and found at least two and as many as nine carrion items in each survey. In the river surveys, each a kilometer or less in length, we recorded 10 medium-sized suckers and a large carp. However, almost all these fish were noted to be old, decomposed, or only bones.

We conducted the nine reservoir surveys by motorboat, cruising slowly along the eastern shore for about 7 km. In the eight surveys, we recorded 42 carrion items, including the remains of 10 carp (32–70 cm), 9 largemouth bass (32–38 cm), 8 crappie (22–40 cm), 5 channel catfish (24–46 cm), 4 small-mouth bass (31–38 cm), 2 brown bullhead (15 and 27 cm), 2 green sunfish (13 and 22 cm), 2 unidentified fish (bones only), 2 bluegill, 2 flathead catfish (38 and 52 cm), 1 goldfish (12 cm), 1 Gila woodpecker, and 1 striped skunk. Some of the fish remains were heads only, or heads and spines (filleted), and had obviously been discarded by anglers. Some of the crappie were fairly fresh and had probably died of spawning stress.

Waterbird Surveys. Table B4.1-12 summarizes the results of seven waterbird surveys in the Bartlett breeding area in 1988 and 1989. In all, we saw 272 waterbirds, 69 percent of which were seen in March on the river (no surveys were conducted on the reservoir in March). We saw 158 common mergansers on the river in March, 15 in April, and only 4 in May. In April, we saw no waterbirds on the reservoir, but there were western grebes and eared grebes present there in May.

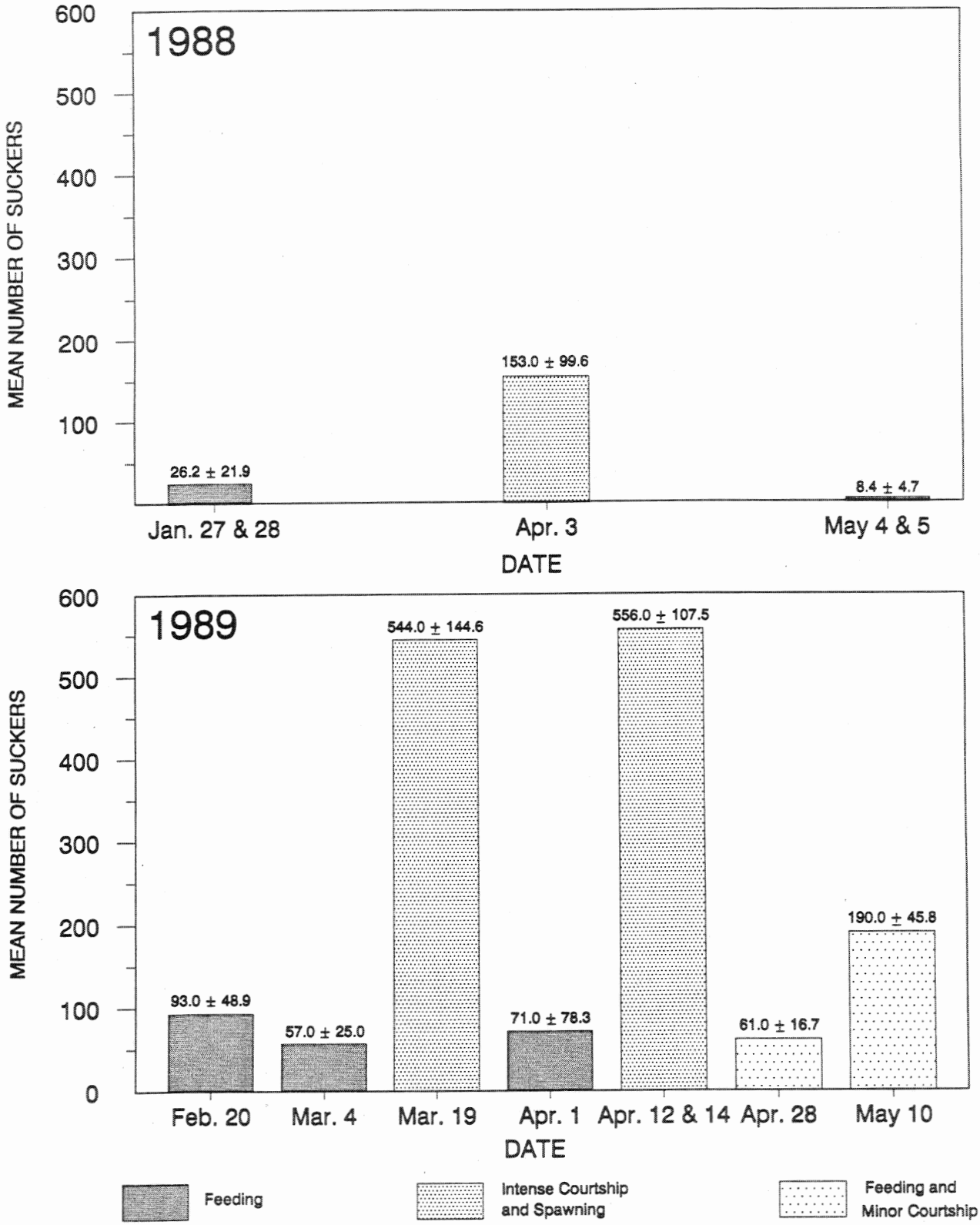


Figure B4.1-18. Mean number (and associated 95% confidence intervals) of suckers observed in the powerline riffle (Km 34.5) in 1988 and 1989. Mean daily flows and mean water temperatures taken between 1000–1400 hr (Km 34.0–35.9) are also listed.

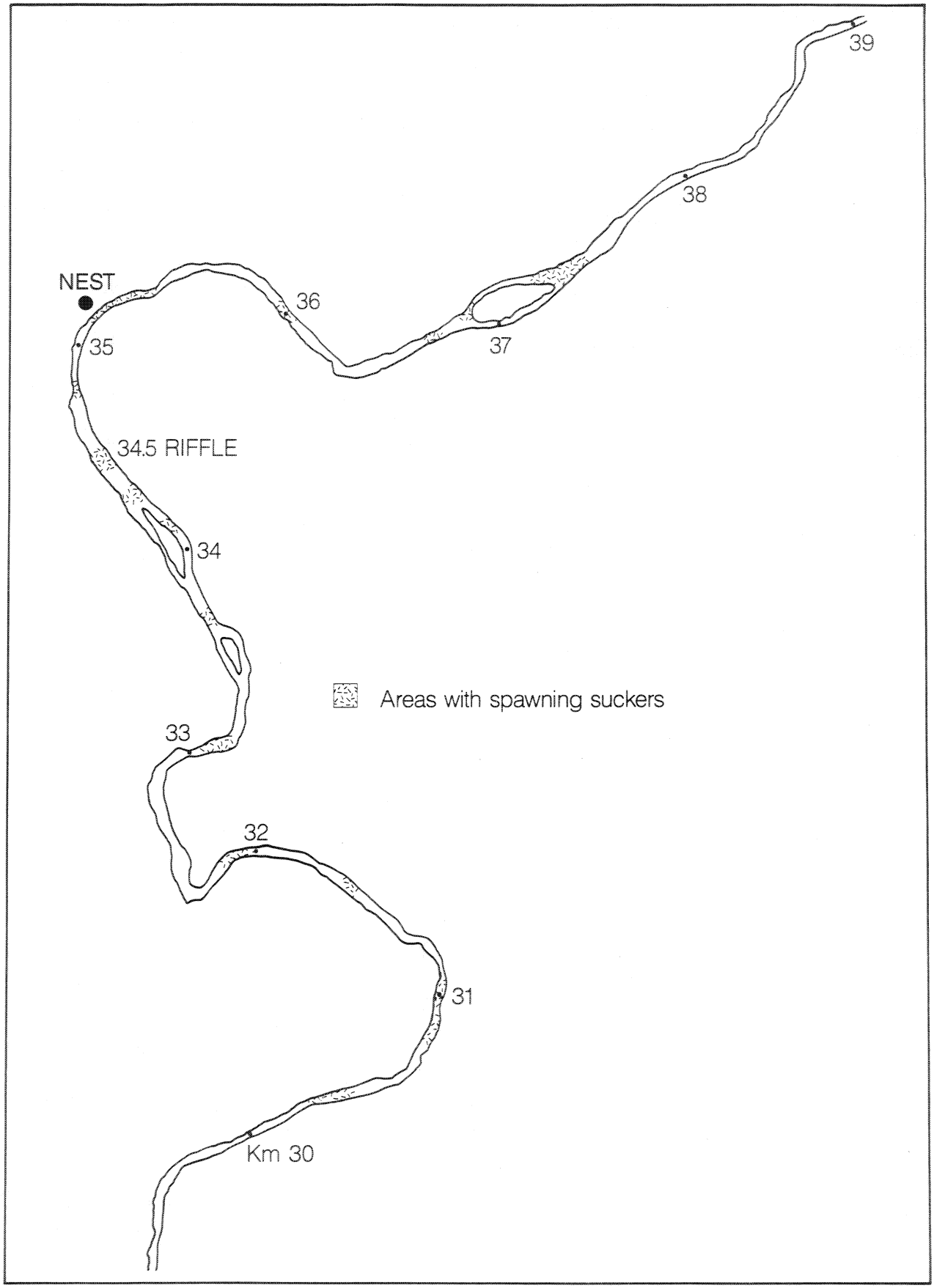


Figure B4.1-19. Locations of shallow habitat with spawning suckers noted on 2 April 1988 (flow = 489 cfs).

Table B4.1-12. Water birds observed in surveys at Bartlett breeding area in 1988 and 1989.

Species	Avg. No. Individuals per Survey	% Species/Month March	April	May Res.	May River
Western Grebe	4.6 (n = 32)	0	0	59.3	0
Eared Grebe	0.9 (n = 6)	0	0	11.1	0
Pied-billed Grebe	0.1 (n = 1)	0	3.5	0	0
Double-crested Cormorant	0.1 (n = 1)	0	3.5	0	0
Mallard	4.3 (n = 30)	15.9	0	0	0
Common Merganser	24.7 (n = 173)	83.6	51.6	22.2	7.4
Great Blue Heron	3.0 (n = 21)	0.5	10.3	0	0
Green-backed Heron	0.1 (n = 1)	0	3.5	0	0
Other Waterbirds	1.1 (n = 8)	0	27.6	0	0
		n = 189 (2 surveys)	n = 29 (1 & 2 surveys)	n = 54 (1 & 1 surveys)	

B4.1.4 Human Impacts

The Bartlett pair experiences some of the highest public use among the nesting eagles of Arizona because: (1) the territory is near one of the closest reservoirs to metropolitan Phoenix, an area whose population is over one million (1990 census); (2) the reservoir is popular for many recreational activities; (3) the nest is located very near road vehicle access; and, (4) the Forest Service closure at Bartlett is often violated. Arizona Nestwatch reports from 1985, 1988, and 1989 cited rafting, gunshots, and close-flying aircraft as types of public use with the most disturbing effects on the eagles. Loud rafting parties caused eagles to flush and be away from the nest for long periods; gunshots elicited a jerking of the head, interruption of activity, or flushing; on one occasion, a helicopter passed the nest twice within 15 m, causing the adults to flush and the chicks to crouch in the nest.

The unusually high turnover (mortality) of adults at Bartlett breeding area (see Sections C3.7 and D4.3), where at least three different males have nested during the past four years, may be another example of

the detrimental effects of extensive public use in that area. Moreover, the nesting substrate is unshaded, and so eggs and small nestlings are susceptible to mortality from exposure. Public users may flush the adults who would otherwise provide insulation or shade.

Because of the high incidence of public use, the Forest Service enacted a closure (Tonto National Forest Order 12–29) in July 1979 restricting all access from 1 November to 30 June and vehicle access year round. The closure was revised in 1987 restricting access from 1 December to 30 June. The closure extends from Km 30.8 to Km 35.7 and includes areas within 0.5 mi. on either side of the river. Floating down the river is permitted provided the rafts do not stop within the closure.

BioSystems recorded the events in Table B4.1-13 on an incidental basis during the 1989 breeding season; they were recorded throughout the breeding area wherever they occurred within 100 m of an eagle. The data are not representative of the actual distribution of public users but rather depended on the location of the observer and the telemetered eagle. The sample size is small and does not lend itself to statistical analysis, but there are some interesting points worth noting: (1) despite the Forest Service closure, 28 (46%) public use incidents were recorded within the closure area, 27 (44%) of these in the nest area itself; and, (2) it appears that all public user types are not equally inclined to flush eagles. For example, only 5 percent of motorized boaters (n = 20) and 8 percent of fishing events (n = 13) flushed eagles while two horseback riding events and three shooting incidents, one over 100m away (and therefore not in the table), flushed eagles (100%), and off-road four-wheel-drive and all-terrain cycles, collectively flushed eagles in 50 percent of the cases (n = 10); 3) we recorded six flushes (46% of the total) in March when chicks were under four weeks of age and susceptible to dying of exposure.

B4.1.5 Discussion

The agencies chose the Bartlett Bald Eagle Breeding Area for study because: (1) it could have been affected by Cliff Dam; (2) dam modifications will be required for "Safety of Dams" considerations; (3) the Bartlett territory receives a considerable amount of public use; and (4) it contains a range of potential foraging habitat to evaluate (i.e., river section, tailrace, and reservoir). Over the years, the high quality of eagle habitat in Bartlett breeding area has been demonstrated by a very significant reproductive contribution to the Arizona population from this territory (20 fledged young in 22 years). The agencies felt that further knowledge on the ecology of this pair would help them prevent some of the causes of nesting failure and adult mortality documented at the site.

Telemetry data from 1988 and 1989 on the movements of the Bartlett adult male revealed both spatial and temporal patterns in habitat selection. In all, the male perched and foraged along 14 Kms of the regulated Verde River downstream of Bartlett Dam and along 13 Kms of Bartlett Reservoir. In the river, he captured mainly desert and Sonora sucker, and his principal foraging area was a riffle at Km 34.5, just downstream of the nest. River foraging locations in early spring included an area near Needle Rock about five river Kms downstream of the nest, but by early April, foraging concentrated almost entirely in the riffles near the nest. By late April and early May, the male's use of Bartlett Reservoir increased to 42 percent of visitations. Interestingly, we have no records of him foraging in the river section between the nest and the dam, probably because of human disturbance and poor habitat in this section.

Suckers tend to spawn in the riffles of the Bartlett territory for unusually long periods in spring because cold water released from the bottom of the dam holds river temperatures low enough for sucker spawning. We surmise that in early spring, cold water from the reservoir's hypolimnetic layer flows some distance from the dam before it warms to temperatures optimum for sucker spawning. For the

Table B4.1-13. Summary of public-use incidents (within 100 m of an eagle) and eagle responses at Bartlett territory in 1989.

Type Public Use	No. Public Use Incidents	Percent of Total Incidents	Duration (min)	Percent Duration	Response to Public User			
					N*	W*	C*	F*
Fishing	13	21.3	387	18.5	0	8	4	1
Picnicking	1	1.6	70	3.4	0	1	0	0
Swimming	2	3.3	79	3.8	0	2	0	0
Boating, non-motorized	7	11.5	429	20.5	1	4	0	2
Boating, motorized	20	32.8	608	29.1	7	12	0	1
Shooting	2	3.3	17	0.8	0	0	0	2
Helicopter	2	3.3	2	0.1	2	0	0	0
Motorcycle, off road	1	1.6	90	4.3	0	1	0	0
Four-wheel drive, off road	5	8.2	124	5.9	2	0	0	3
All-terrain cycle	5	8.2	267	12.8	0	3	0	2
Jet ski	1	1.6	15	0.7	0	1	0	0
Horseback riding	2	3.3	2	0.1	0	0	0	2
Total	61		2090		12	32	4	13

* N = No response; W = Watching; C = Certain avoidance of area; F = Flush.

Bartlett eagles, the first area of significant sucker spawning in spring is the vicinity of Needle Rock, somewhat downstream of the Bartlett nest. As the temperatures of the hypolimnion and ambient air increase during March and April, the zone of optimum temperatures moves upstream until it centers around the riffles near the nest, where water temperatures remain optimum for extended periods.

Several of the riffles between the nest and Needle Rock are especially favorable to both eagles and suckers because they maintain their character as riffles under a variety of flows. We refer to such riffles as "super-riffles" (see Glossary, Section A8). These riffles attract fish both for spawning and for foraging. The photosynthetic productivity of the shallow riffles, their oxygenation, and their complex substrate support algae and insect communities that draw foraging fish from deeper, less productive water.

Summary of Fisheries Studies. Our surveys revealed that suckers were by far the most abundant prey fish in shallow riverine habitat and therefore would be expected to comprise the bulk of fish taken by the Bartlett eagles. Although suckers were observed throughout the nesting season foraging in shallow water, numbers significantly increased in shallow riffle and pre-riffle habitats during spawning. The fish were also easier to approach during courtship and spawning, as their attention may have been directed more toward habitat and mate selection than predator avoidance. Our interpretation is that suckers in riffles and other shallow water habitats were more vulnerable to bald eagle attack when the fish were spawning than when they were feeding.

In 1989, intense sucker spawning first occurred in March in the lower reach near Needle Rock but was delayed until mid-April in the upstream reach near the eagle nest. If the Bartlett bald eagles are specializing on spawning suckers in the river, then they would be expected to switch foraging locations from the Needle Rock area early in the nesting season to the nest area later in the season. Further, since adult suckers may migrate upriver into the nest area in mid-April, the eagles would also key in on the greater relative abundance of fish in the nest area compared to downstream sites late in the nesting season.

The Bartlett eagles do not have to rely solely on the Verde River for prey. Bartlett Reservoir provides an alternative source of fish. The majority of fish taken from the reservoir were largemouth bass and black crappie. These fish are most often preyed upon in April and May. Interestingly, April and May also corresponds to the spawning period of these reservoir species and also a period of increased fishing. Largemouth bass may become vulnerable to the eagles during spawning when they move into shallow water to construct and defend nests (see Section E3), but angling mortality also contributes to the availability of largemouth bass. Black crappie in Arizona reservoirs rarely exceed four years of age and often suffer post-spawning mortality, a common occurrence in crappie populations in other areas (see Section E3 and B4.5). Post-spawning death in the reservoir and angling mortality probably provide the majority of foraging opportunities for eagles on this species. Carrion surveys on the reservoir recorded the abundance of both largemouth bass and black crappie in April and May.

Summary of Observed Forages. We primarily observed eagles foraging on the river near the nest, and suckers were the primary species taken. Almost all suckers captured by eagles were alive when taken, and 46 of 71 observed sucker forages occurred in riffles. The most important of these was the "powerline riffle" at Km 34.5.

Along with shallow depth, the most notable characteristic of these riffle strike points was the constancy of water temperature, even over the course of a season. In 1989, the temperature range was only 13–17°C over the period from 16 March to 31 May, and most measurements were in the 15–17° range.

Other river characteristics at sucker strike points were also consistent. Water was usually shallow, with the bulk of forages occurring in water less than 30 cm in depth and many in water less than 10 cm deep. Water velocities were generally low, turbidity clear to the bottom, and substrate and vegetation tended to be large pebbles or rocks with a mossy algae coating or other vegetation, although a number of strike points showed no vegetation.

The few river forages we observed for other species, channel catfish and bass, were primarily in river pools or runs. However, due to the small number of observed forages for these species, we cannot confidently describe the general habitat where eagles foraged for them.

We observed reservoir forages for channel catfish, bluegill, and largemouth bass, but unfortunately could not identify over half the fish taken. Almost all forages in the reservoir were in water deeper than 200 cm. Distance from shore to strike point ranged from 10-100 m, with 20-50 m being the most common. Water temperatures ranged from 20–23°C, and turbidity was consistently low. These data and those on the geography of forages suggest that eagles foraged where carrion occurred.

Impacts of Dam Repair. Eagles might be either temporarily impacted from the effects of dam repair activities, or permanently impacted by habitat modification resulting from the repairs. Impacts might result from direct disturbance to the eagles, or from fewer foraging opportunities by impacting fish populations or the conditions of their vulnerability to eagles.

Disturbance From Construction Activity. Possible disturbances during construction include direct disturbance from construction activities and habitat disruption due to changing reservoir levels and water flows below the dam.

Construction activities will apparently be no closer than three km to the nest area, which is approximately 3.7 airline km downstream of the dam (U.S. Bureau of Reclamation 1989c)(all current eagle nests in this territory are in Kms 34 and 35). Consequently, it is unlikely that these activities will have any significant direct effect on bald eagle nesting activities unless construction workers violate the closure. However, construction activities may or may not discourage eagle use of the immediate dam area. We have noted eagles foraging on the reservoir just north of the dam at Skm 40, particularly in late April and May. The eagles did not tend to frequent the tailrace area below the dam.

Habitat Alteration—River. Bald eagles at the Bartlett breeding area foraged extensively on the river, and consequently the maintenance of suitable foraging conditions and fish habitat in the river is important. Since anticipated releases under both alternatives will be unaltered (U.S. Bureau of Reclamation 1990), there would be no effect on the maintenance of the riffle areas where eagles take suckers, including the important foraging riffle at Km 34.5.

However, bald eagle foraging areas are notable for their low turbidity, and construction activities, especially the "borrow" of material, can be expected to increase turbidity in the river. The final environmental assessment notes that turbidity impacts can be minimized "by restricting or minimizing instream work and obtaining borrow materials from areas outside the main channel" (U.S. Bureau of

Reclamation 1990). Most bald eagle forages for suckers occur in water less than 50 cm deep. Increased turbidity should not significantly affect eagle foraging opportunities if it does not exceed a level that significantly affects the presence or visibility of suckers in water less than 50 m deep.

Water temperatures below the dam also appear important to eagle foraging on the river. Eagles in this territory forage on suckers all through the breeding season. The protracted spawning of suckers apparently depends on the buffering of water temperature by hypolimnetic releases and, in turn, by temperature stratification in the reservoir. The relative constancy of water temperatures was demonstrated in our measurements at forage points in the heavily-used riffle at Km 34.5. Short-term changes in water temperature due to changes in flows or reservoir stratification during construction, or any permanent changes due to spillway alterations, might reduce foraging opportunities for suckers. Whether such changes would effect nesting success is unknown.

Impacts of Reservoir Drawdown. Reservoir drawdown (not proposed in construction alternatives) may adversely affect bald eagle foraging opportunities. Drawdown may dewater the nests of centrarchid and Ictalurid fish, and can asphyxiate fish if water withdrawals significantly decrease the oxygenated layer of the reservoir. Although this could positively affect eagle foraging activities during the time of drawdown by providing a source of fish carrion, a drawdown which results in a long-term lowering of fish numbers would obviously be detrimental to the eagles (see Horseshoe, Section B4.5). Beneficial effects for eagles of reservoir drawdown are discussed in B4.5.5.

Drawdown of the reservoir could increase the distance from currently used foraging perches to the water. However, in our small sample of foraging perch to strike point distances, a large percentage of forages on the reservoir covered long distances, sometimes over 1000 m. Since the Bartlett eagles often foraged successfully from perches distant from the strike point, a change in perch distances should not be significant.

B4.1.6 Management Recommendations

The Bartlett Bald Eagle breeding area should be considered a territory of significance to the welfare of the endangered Arizona nesting population. The habitat is rich and somewhat stable and will probably remain so if: (1) flows and reservoir levels continue to suit bald eagle foraging ecology; and, (2) the eagles are not excessively impacted by humans in the breeding area. Under such favorable conditions, a pair of bald eagles utilizing the Bartlett environs can be expected to add significantly to the overall recruitment to the population. We make these points on the basis of the history of this pair and our current study of it. Further recommendations on the management of the Bartlett breeding are given in Section D4.3.

Direct observation of forages in the Bartlett breeding area showed a reliance on sucker species taken in riffles, especially the "powerline riffle" at Km 34.5. This riffle remained in place through the breeding season and was notable for the consistency of water temperatures at strike points, even though we observed forages there for approximately two and one-half months in both 1988 and 1989. Constant temperatures in this and presumably in nearby riffles should probably be regarded as favorable to nesting eagles in this breeding area. If river conditions were altered so that suckers no longer used these riffles, other sources of prey would probably be required to maintain the nest.

The small number of observed forages for species other than suckers makes it difficult to determine what habitat these other species are using in this river section when they are vulnerable to eagles, but river

macro- and microhabitat, substrate, and vegetation for the few catfish and bass taken appear to differ somewhat from the habitat measurements for suckers. Generally, it would seem that maintenance of river conditions suitable for large numbers of suckers is the surest method of maintaining eagle foraging habitat in the Bartlett breeding area.

The extended availability of suckers in riffle habitat apparently results from (1) sufficient water in Bartlett Reservoir to maintain a cool hypolimnion; and, (2) release of enough hypolimnetic water from the dam to maintain stream temperatures of about 12–17° or so in March and April. Riffle habitat suitable for bald eagle foraging on suckers from the Bartlett nest cliff extends downstream to about Km 29 near Needle Rock. There is sufficient diversity among these riffles to provide foraging opportunities for eagles over a variety of flows, so the main considerations of deciding which flows would benefit the eagles are (1) those related to maintaining spring temperatures in foraging riffles; and, (2) those which would sustain a population of suckers over the long term.

If flow releases become chronically low and/or low reservoir levels no longer sustain a cool hypolimnion, Verde River water temperatures would generally increase, and carp might come to dominate the Bartlett breeding area (and territories downstream). Whether this would negatively impact occupancy and productivity of the Bartlett bald eagles over the long term is unknown, but our data show that carp and catfish are major prey of bald eagles in many other riverine settings in Arizona.

In April and May eagles took primarily carrion from the reservoir that died either from spawning stress or from angler-induced mortality. Spawning stress primarily involved crappie, an open-water species that experiences considerable post-spawning mortality and thus becomes available to bald eagles at Bartlett and at other reservoirs. Crappie were the most utilized reservoir fish by the Bartlett pair, so management favoring their abundance in the reservoir, especially in the three- and four-year age class, would benefit the eagles. Excessive reservoir drawdown, particularly during spring, might be deleterious to crappie populations in the short- and long-term (see Horseshoe, Section B4.5).

Mortality of reservoir fish due to anglers is generally beneficial to foraging eagles when it results in floating carrion or carrion along the shoreline. Fish heads and other remains discarded by anglers were utilized by the Bartlett eagles as were fish possibly killed by propeller strikes (carp are often killed in this manner) and those hooked and lost. In the latter case, however, there is a danger to eagles from monofilament and fishhooks (see Section C3.3) either of which can seriously injure or kill nestlings and possibly adults. For this reason, we recommend a sustained program of education to make anglers aware of the danger to eagles from monofilament line and fishing lures.

We believe that disturbance to bald eagles by boats on Bartlett Reservoir is for the most part inconsequential. Our experience there and at some of the other large reservoirs has been that eagles generally ignore the boats. At Bartlett Reservoir there are few geographical foci of foraging. This is probably because (1) eagles forage on carrion spread throughout the reservoir; and, (2) there are relatively few shallow areas where live fish are vulnerable to them. Since eagles are apparently not dependent on specific reservoir foraging locations, the impact of disturbance is probably not significant, particularly as compared to certain riverine areas of high prey concentration and availability, such as Km 34.5.

However, there can be little doubt that public use on the river sections is of considerable consequence to the Bartlett pair. Problems include: (1) flushing from the nest during incubation or brooding;

(2) disturbance at important foraging areas that results in eagles avoiding these areas; and, (3) shooting. In the first case, it is obvious that eggs and small young may die in a few minutes from exposure or predation if not attended (*e.g.*, shaded) by the parent eagle. It is therefore important that the annual closure ordered by the Forest Service be strictly enforced. Because bald eagles are particularly prone to failure during the egg stage, the closure should begin prior to the laying of the first egg, and the nest watchers should be present on or prior to that time. The nest watchers should position themselves to have the best opportunity to prevent public users from flushing incubating or brooding eagles during hot days. We believe it would be best to have nest watchers present every day at Bartlett, from just before incubation to the point of thermoregulation (about 4 weeks of age), before going to a "days off" attendance schedule. The watchers themselves should avoid going within 200 m of the nest until the young are at least one month old. Deaths of older nestlings from heat stress are known or suspected at other bald eagle nests in Arizona, so this problem should be kept in mind throughout the breeding season.

We recommend that all public users, including rafters, maintain a distance of at least 500 meters in all directions of the Bartlett nest cliff from the week prior to egg-laying until the young are at least one-month-old. Based on the reproductive history of the site, this period of special concern is from about 10 January to about the end of March. From late February through March, the closure should also protect eagle foraging areas downstream of the nest, including the super-riffle just upstream of Needle Rock. During this approximately 5-week period, no discharge of firearms should be allowed in the vicinity of Needle Rock. We highly recommend this because one and probably two of the adult males at Bartlett were shot within the past five years, and another was shot in 1964. In the event that long- or short-term flow changes alter the distribution of foraging sites, a change in specific closure areas may be in order.

We previously discussed the activities during dam repairs that might impact the eagles. Other than direct disturbance around foraging sites on the reservoir near the dam, and the possibility that the increased human density associated with the work might impinge upon the Forest Service closure, the remaining point is that of increased turbidity, a matter already addressed by the Bureau of Reclamation (1990) who proposes to obtain "borrow material" from outside the stream channel as a way to minimize the problem. In general, foraging opportunities for the eagles would probably not be impacted if Secchi disks can be clearly seen at about 60 cm in the nest vicinity from February through May. According to our measurements at eagle strike points at Bartlett and elsewhere (see BioSystems 1985), low turbidity is essential to eagle foraging success on live prey.

B4.2 BLUE POINT BREEDING AREA

The Blue Point breeding area is located 51 km east of Phoenix, along the regulated Salt River below Stewart Mountain Dam and along Saguaro Reservoir above the dam (Figure B4.2-1). The agencies selected Blue Point for study because: (1) scheduled modifications of Stewart Mountain dam (to improve dam safety) might affect the bald eagles; (2) public use levels at Blue Point are higher than at any other Arizona bald eagle breeding area; and, (3) understanding the ecology of bald eagles in this entirely regulated river and reservoir habitat setting is consistent with the goal of understanding the ecology of the entire population. The similar habitats exploited by the Blue Point and Bartlett pairs provide an opportunity to explore and compare the patterns of eagle prey selection and foraging within habitats dominated by water project influences.

The area surrounding the Blue Point breeding area is characterized by steep slopes and promontory cliffs, although the land opens up downstream. The biotic community is of the Lower Sonoran Life Zone (Brown and Lowe 1980, Brown 1982). Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Paloverde-Cacti–Mixed Scrub Series. The riparian habitat is a mixture of the Sonoran Riparian Deciduous Forest and Woodlands Biome, the Sonoran Riparian Scrubland Biome, and the Sonoran Interior Strands Biome (see Section D2 for a more comprehensive view of bald eagle habitats in Arizona).

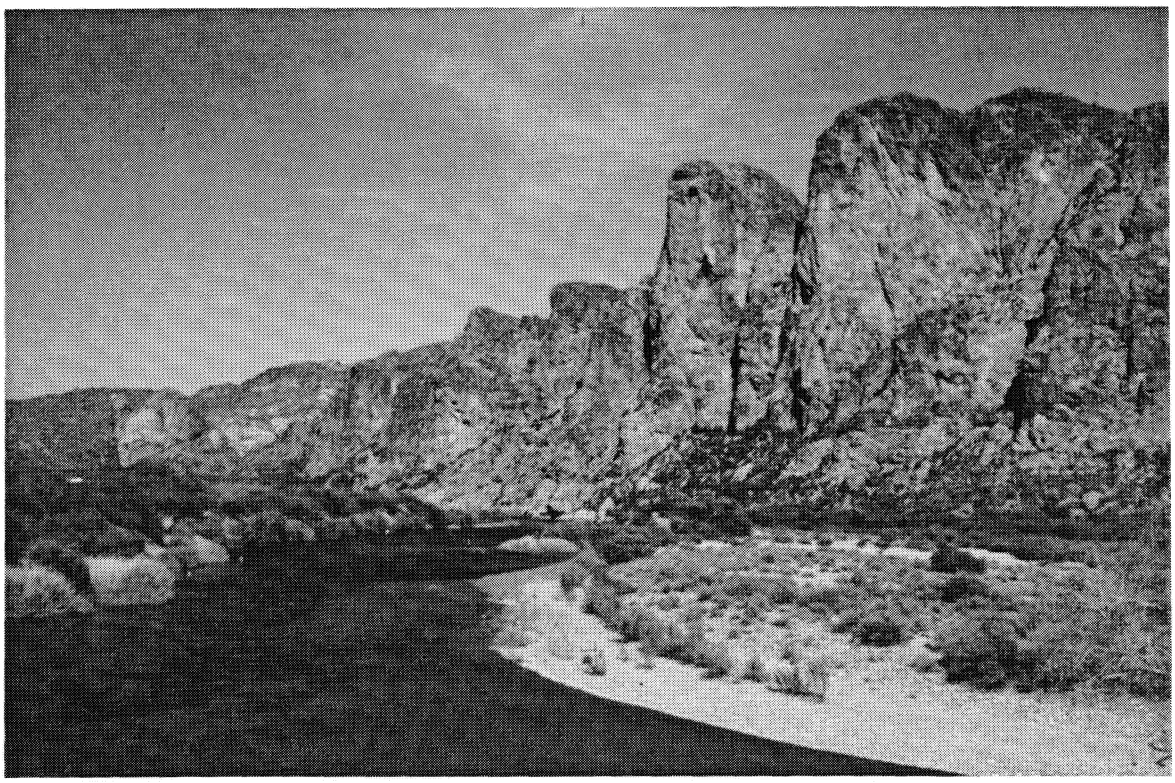


Plate B7. Bulldog Cliffs (Blue Point) along the regulated Salt River (photo by P. Becker).

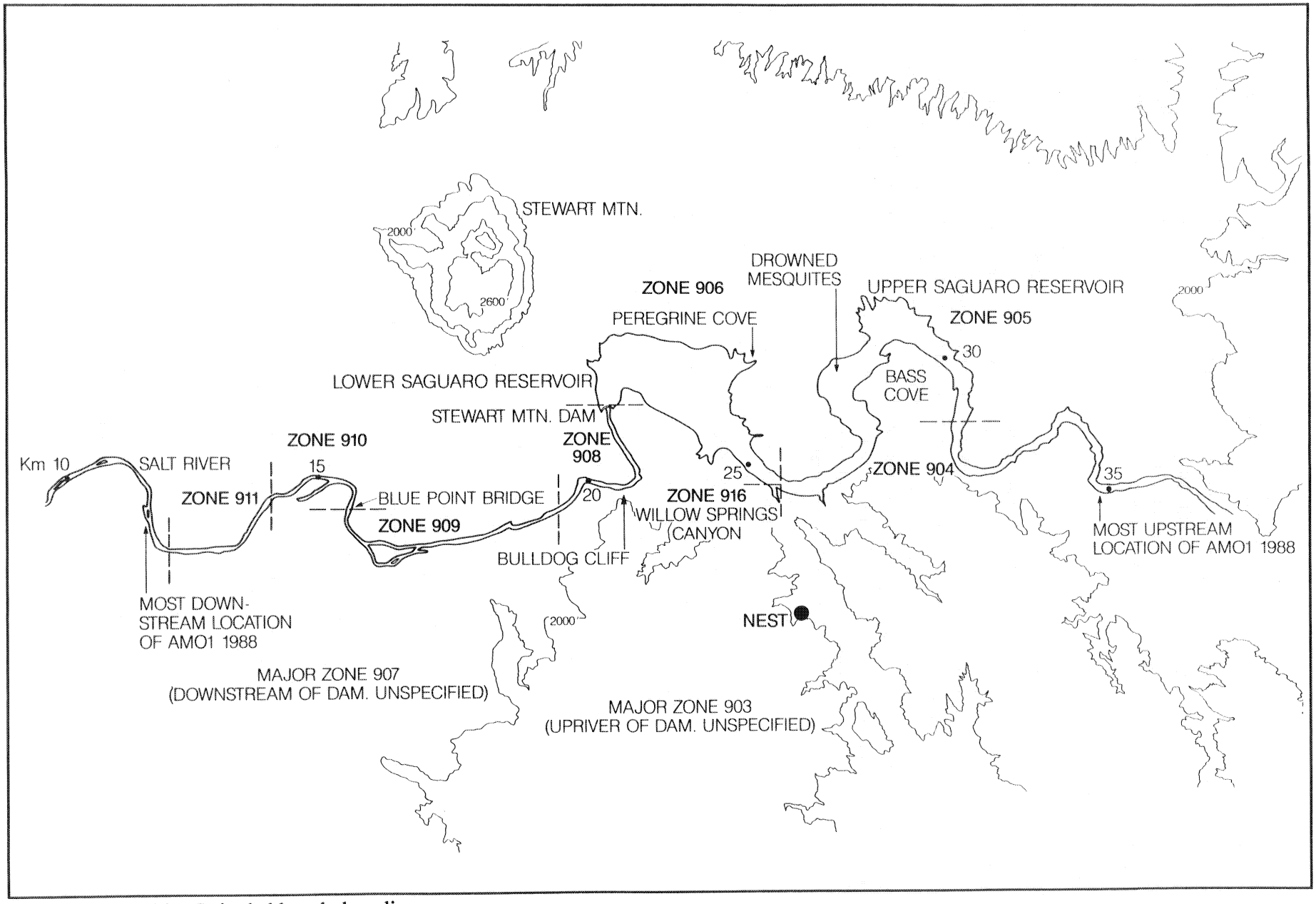


Figure B4.2-1. Blue Point bald eagle breeding area.

Saguaro Reservoir is bounded by a number of promontory cliffs, although shallow water areas occur in coves, sometimes with cottonwood or mesquite snags standing in the water. The shoreline, in areas not bounded by cliffs, contains mesquite and some emergent vegetation. Emerging from the Goldfield Mountains to the south, Willow Springs Canyon intersects the reservoir about 4 km above the dam.

History of Reproduction

The Blue Point breeding area, discovered in 1930, currently contains a pinnacle nest and a cliff nest on the regulated river reach below Stewart Mountain dam, and a pinnacle nest in a side canyon off Willow Springs Cove on Saguaro Reservoir. Early productivity data remain incomplete, although first occupancy records include the period from 1930–1936 (Phillips *et al.* 1964), during which one or two young fledged in 1932 and 1933 (Rubink and Podborny 1976). A cottonwood tree nest near Blue Point Ranger Station fledged two young in 1971 (Forbis 1986); it may also have fledged young in 1972 (Haywood and Ohmart 1983), although other reports list it as unsuccessful (Forbis 1986). The breeding area remained unoccupied at known nest sites from 1973–1978; however, one adult was seen in the area in 1978. The nesting territory was occupied in 1979 and 1980, but no known eggs were laid. The Blue Point pair fledged 12 young from 1981–1985, but did not nest in any of the known nest locations in 1986. After rebuilding the 1985 Bulldog Cliff nest, both adults sat together in the nest as late as 15 January 1987, then disappeared; they were found later with three young in a pinnacle nest off Willow Springs Canyon, approximately 1.6 km from Saguaro Reservoir. The pair again raised three eaglets in the Willow Springs Cove nest in 1988. The possibility exists that the Blue Point pair may also have nested in this location in 1986 and in previous years when the territory was believed to be unoccupied. The eagles hatched two young in 1989 which died in the nest. The site was occupied in 1990, although apparently no eggs were laid. The Blue Point eagles have laid at least 27 eggs and fledged 22–24 known young. See Section D4.4 for details on annual productivity and mortality at Blue Point.

Saguaro Reservoir (Blue Point territory)

Just northeast of Phoenix, Stewart Mountain Dam creates Saguaro Reservoir, with a holding capacity of 69,765 acre-feet, surface acreage of 1260 acres, and a hydraulic height of 114 feet. The dam was first built between 1928 and 1930 (the year the Blue Point nesting pair was discovered) by the Salt River Valley Water User's Association with an open super-elevated channel spillway equipped with radial gates. In 1936, the Bureau of Reclamation modified the spillway by constructing a concrete-lined spillway discharge channel below the existing spillway. The final spillway has a flow capacity of 105,000 cfs.

Except for fall and winter 1989 Saguaro Reservoir elevations were similar from 1987 to 1989. From January to December of 1987, the mean water elevation was 1524 ft; and 1520 ft for 1988. The first half of 1989 had an average water level of 1521 feet. In 1987, the range of elevation levels was 1522 ft (February) to 1528 ft (December) while in 1988, minimum level was 1506 ft (February) and the highest was 1526 ft (December)(Figure B4.2-2). Levels varied in 1989 from 1510 ft (January) to 1524 ft (March–June).

Salt River (Blue Point territory)

Flow is released via the outlet works consisting of one steel pipe with an 84-inch butterfly valve, and its flow capacity is 1800 cfs. Average annual discharge from Stewart Mountain Dam into the Salt River is generally 608,562 acre-feet. Mean discharge rates from the Stewart Mountain Dam into the Salt River

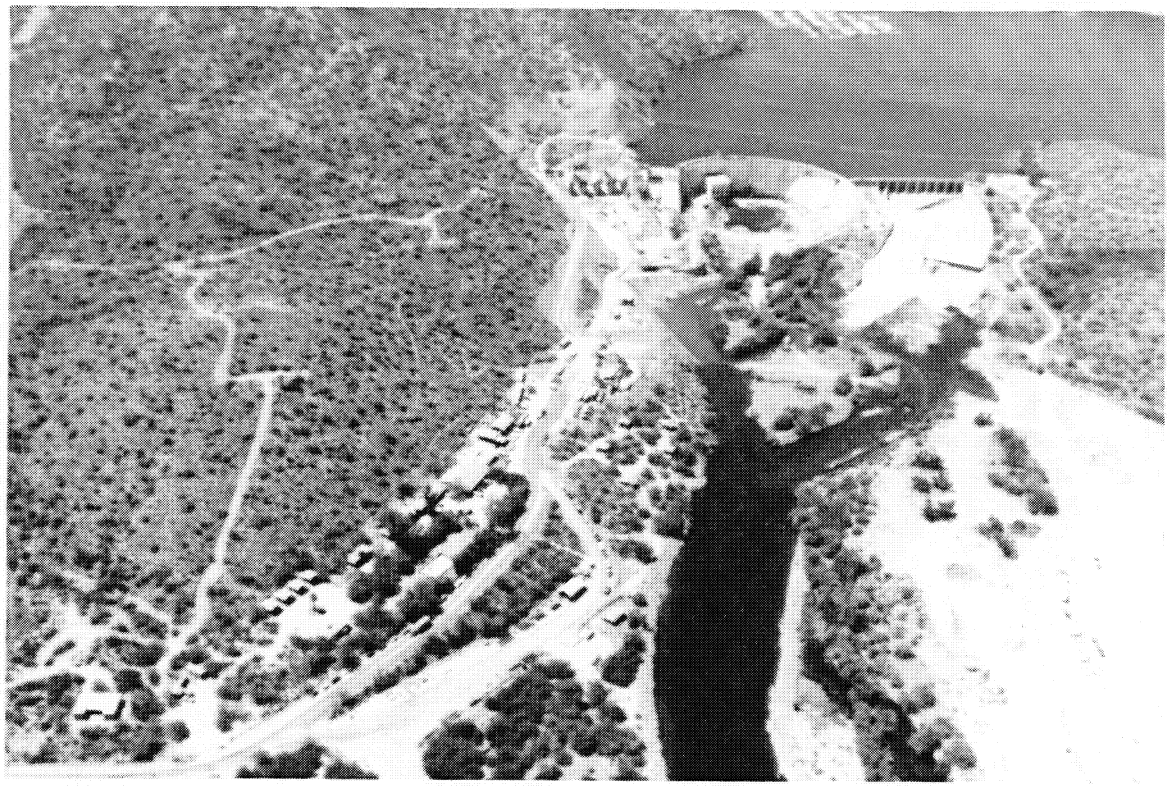


Plate B8. Stewart Mountain Dam and Saguaro Reservoir, February 1989. Water from the reservoir passes through hydroelectric turbines, producing power before it flows into the lower Salt River (photo by D. Driscoll).

below were considerably higher in 1987 than 1988; but returned to an elevated flow by mid-spring 1989. Average discharge for 1987 was 1018 cfs, and 896 cfs in 1988. In 1987, minimum mean monthly flow was 7 cfs (January) and the highest discharge was 2240 cfs in March (Figure B4.2-3). The range of flow rates in 1988 was 3 cfs in December to a maximum of 2340 cfs in February. Similarly in 1989, flows varied from 0 cfs (January/February) to 2350 cfs (June) in 1989.

Patterns in mean monthly discharge show similarities for 1987 to 1989 with flows generally increasing from the beginning of the year and reaching peaks in spring and summer. In 1987, mean monthly flow rose to maximum flows by April (1791 cfs) and in June (1739 cfs). Likewise, in 1988, mean monthly flow climbed to 1487 by March and rose to a peak again in June (1743 cfs). The flow pattern for the first half of 1989 showed a more delayed rise from no flow in January and February to a high discharge rate of 2124 cfs by June.

Daily mean flows present a magnified view of discharge for December to June and show a pattern of very low flows until late winter to spring. In 1986–1987, flow varied from a minimum of 7 cfs to 2240 cfs (Figure B4.2-4). Significant changes in discharge occurred: in early January when flow increased from 7–9 cfs to 678 cfs, and a dip in February/March from 1050 cfs to 8–11 cfs and then back to 2240 cfs. In 1987–1988, daily mean releases ranged from a very low flow of 8 cfs at the first of the year to a subsequent acute rise to 2340 cfs in late February (Figure B4.2-4). Another notable change in flow occurred in late April when discharge dropped to 17 cfs. Flows in 1988–1989 were likewise lowest

(3–5 cfs) at the beginning of the year until the beginning of March when discharge rose to 1500 cfs and then continued climbing to a maximum of 2350 cfs (Figure B4.2-5).

Water Projects

When we began this field study in late 1986, we were instructed to address the possible impacts of the Plan 6 water project within the Blue Point breeding area, specifically those involving the modification of Stewart Mountain Dam for safety purposes. According to the Plan, water supply, hydropower capacity, and recreational facilities would be maintained and no new flood storage space or Central Arizona Project (CAP) regulatory space would be provided. During our study, safety problems at Stewart Mountain Dam required the construction of an auxiliary spillway and modification of the existing dam, since it might not withstand the maximum credible earthquake. The modified dam would have a height of 116 ft, with a total spillway capacity of 210,000 cfs. The water level in Saguaro Reservoir would remain at existing levels after construction. The reservoir level would periodically fluctuate during construction to accommodate safety modifications to the existing dam. These and other details regarding dam modification are given in the Stewart Mountain Dam Draft Environmental Assessment of

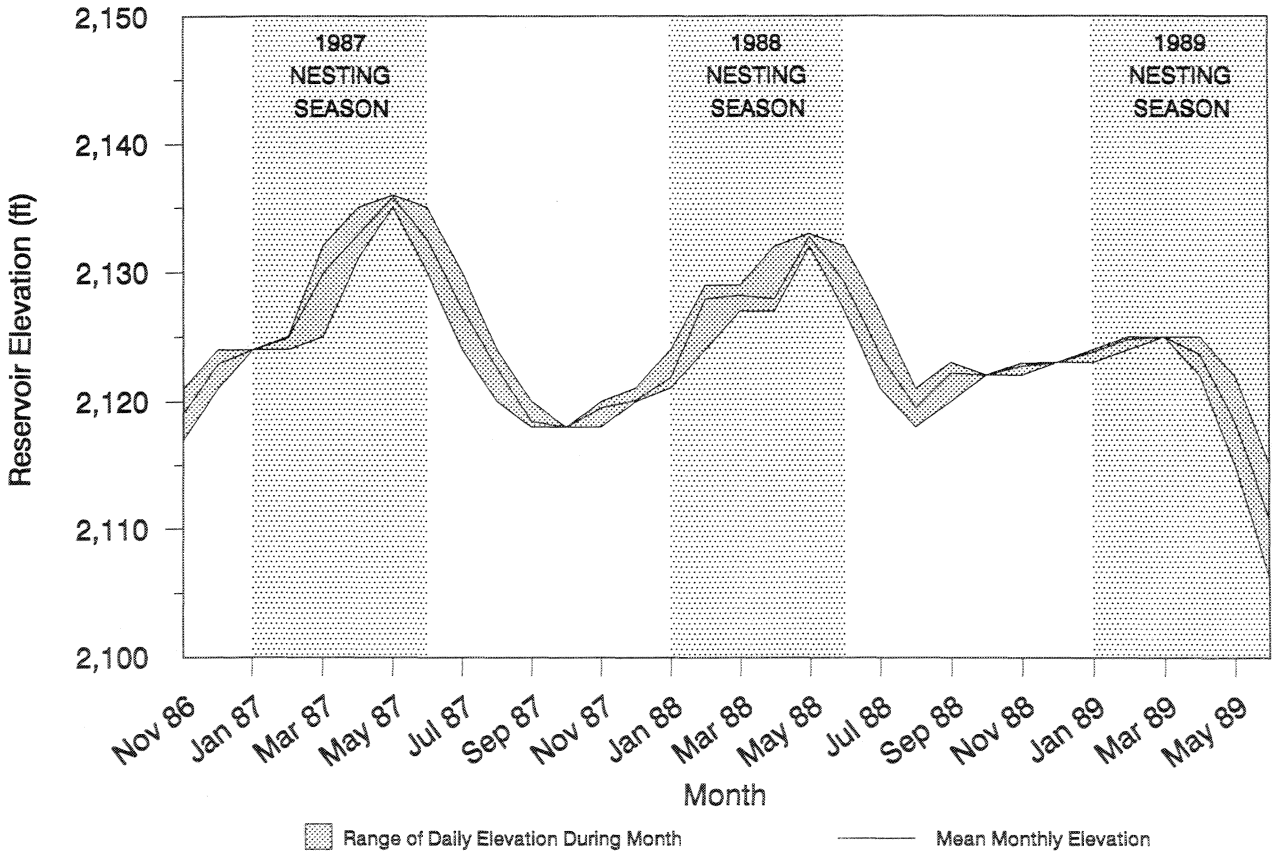


Figure B4.2-2. Mean monthly elevation and range of daily elevations in Saguaro Reservoir from November 1986–May 1989.

September 1987 (Arizona Projects Office, Bureau of Reclamation, Phoenix, AZ). These modifications to Stewart Mountain Dam were underway during our field work and have since been completed.

Schedule of Study

We captured the adult male at the Blue Point breeding area and fitted him with a radio transmitter on 20 March 1987. During 22 March–30 June 1987, we monitored his home range and foraging activities, radio-tracking for 55 days. In 1988, we studied the Blue Point pair from 6 January–1 June in regular monitoring sessions of 7–10 days duration. Research included continuous observation of the nest during those same sessions from 12 March–19 May. The observer sat about 175 m from the nest, identifying and sizing prey items as they were delivered, while communicating via radio with the trackers. Only AM01 had a radio transmitter. During the 1988 nesting season (February–May), we used a boat on Saguaro Reservoir to observe behavior and track eagle movements; in 1987 we used a boat only during late May and early June.

B4.2.1 Home Range

We monitored the movements of the Blue Point male, AM01, from 22 March through 30 June 1987 and from 6 January through 1 June 1988. In both years, the nest was located on a pinnacle up Willow Springs Canyon, 1.6 km from Saguaro Reservoir. We did not weight the visitation data because the nest was not located directly along the reservoir or river.

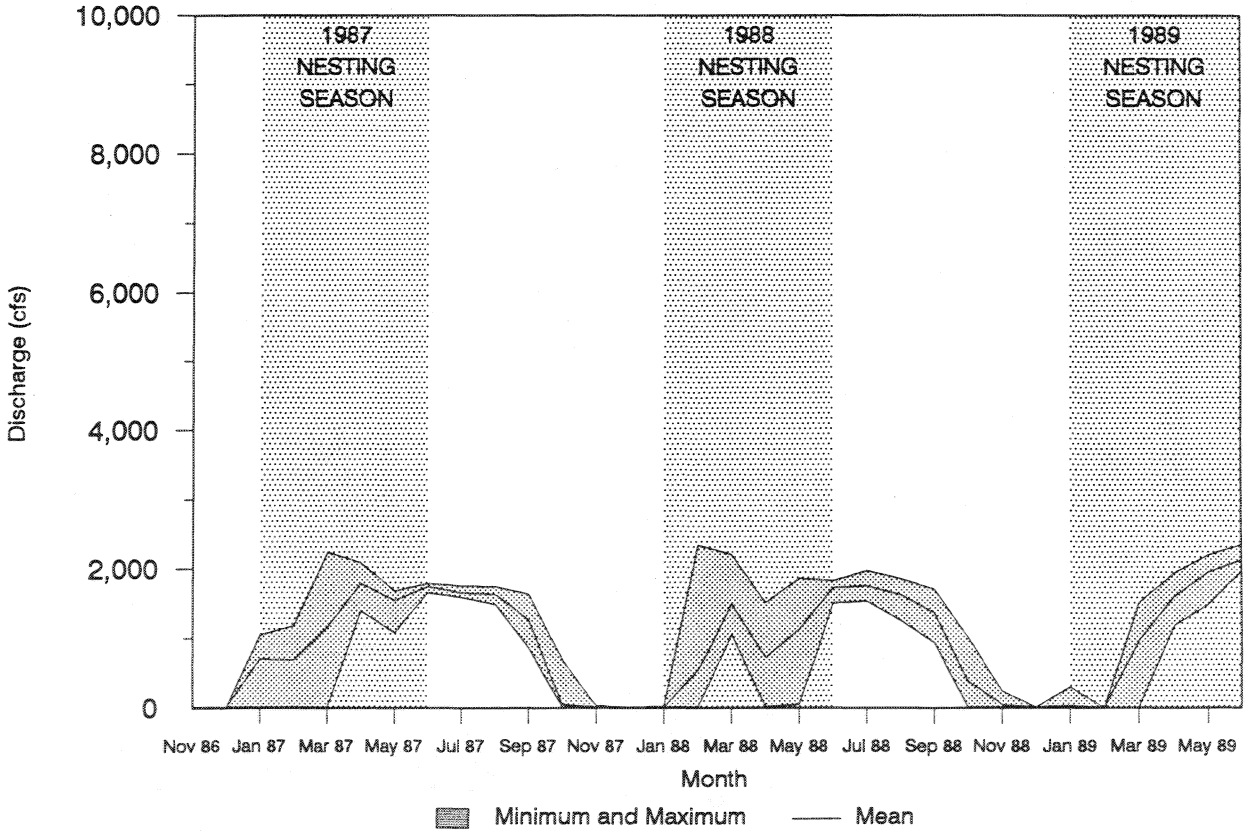


Figure B4.2-3. Mean monthly flows in the Salt River below Stewart Mountain Dam from November 1986–May 1989.

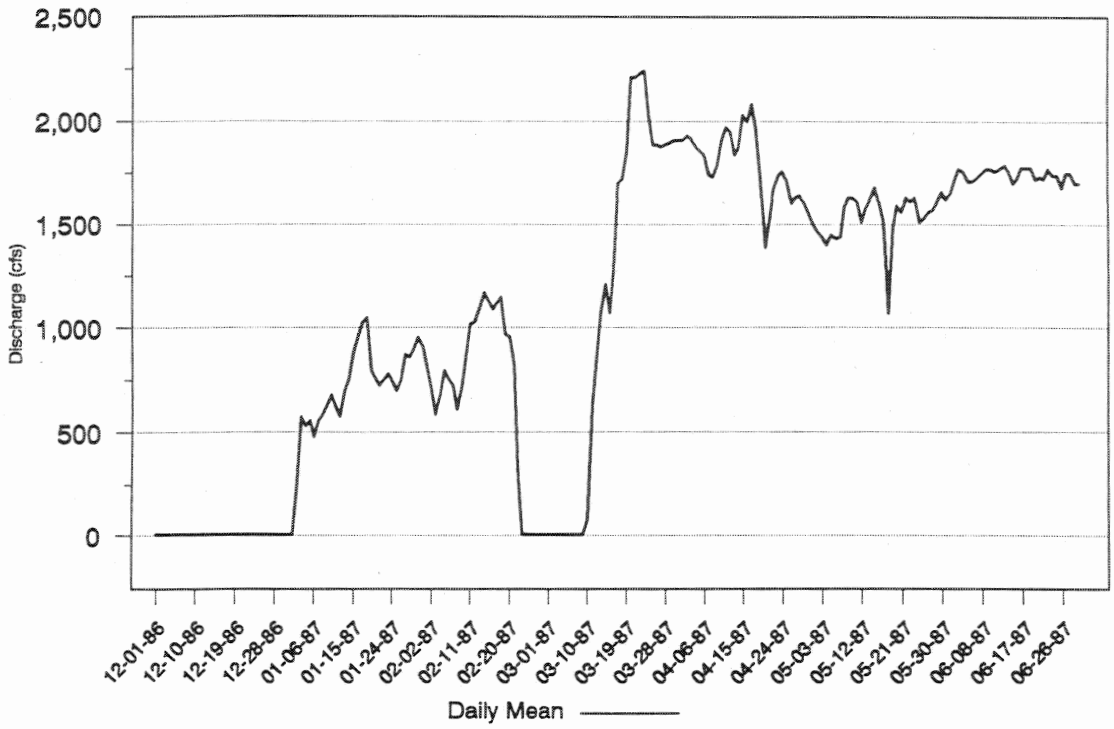


Figure B4.2-4. Mean daily flow in the Salt River below Stewart Mountain Dam from December 1986 –June 1987.

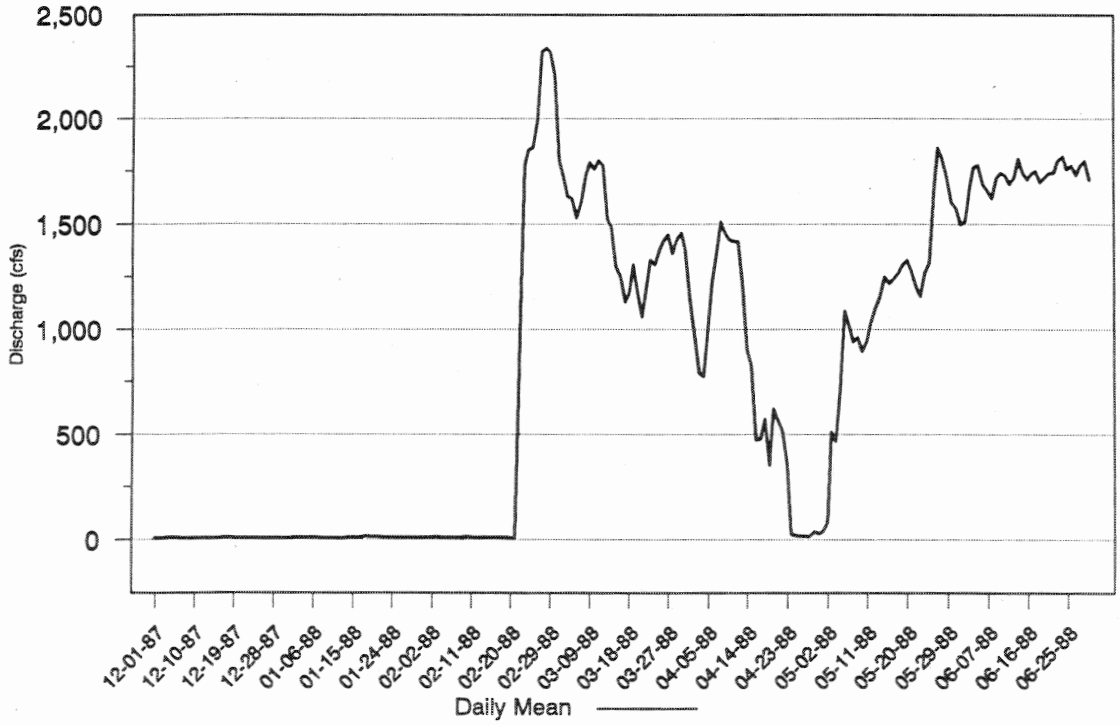


Figure B4.2-5. Mean daily flow in the Salt River below Stewart Mountain Dam from December 1987 –June 1988.

Saguaro Reservoir consists of two large open water areas connected by a relatively narrow channel. We refer to the upper and lower reservoir based on their upstream and downstream positions, dividing them at the point where Willow Springs Canyon enters the narrow channel from the south at Km 25.5.

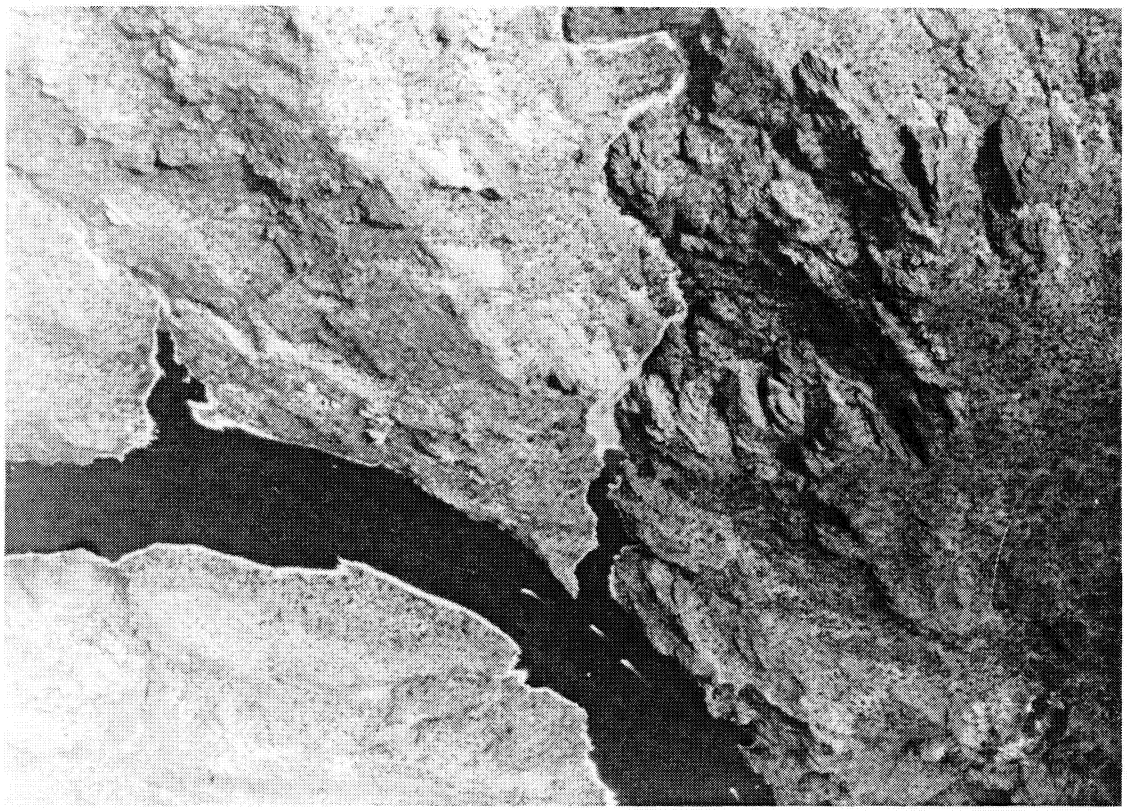


Plate B9. Willow Springs Cove on Saguaro Reservoir was an important foraging area of the Blue Point pair. The cove was also used by the juveniles after fledging from nest 6, which is located up Willows Springs Canyon, (February 1989, photo by D. Driscoll).

The Blue Point male's total home range for both years combined was 25 river Km in length and extended from Km 11 to Km 36 on the Salt River and included all of Saguaro Reservoir (Figure B4.2-6). AM01 spent most of his time at several distinct areas on the Salt River and Saguaro Reservoir. AM01's favorite perch was on Bull Dog Cliff at Km 20 of the Salt River where we recorded 22 percent of his visitations.

These cliffs were over 100 m in height and provided an view of several riffles. Another 9 percent of AM01's visitations were to an area of the river near Blue Point Bridge from Km 13 through Km 15. AM01 also frequented upper Saguaro Reservoir at Km 27 and Km 28 where the reservoir was shallow with many drowned mesquite snags on which AM01 perched ("Drowned Mesquites"). About one-fourth of AM01's visitations were to these 2 Kms. Another area frequented by AM01 was Willow Springs Cove at Km 25 where we recorded 11 percent of his visitations. This narrow cove is walled in by cliffs on either side, and its southern tip is quite shallow. AM01 used Km 24, just downstream from the mouth of Willow Springs Cove, for 7 percent of his visitations. Other Kms within AM01's home range received less than 4 percent of his visitations and only a few Kms were never visited.

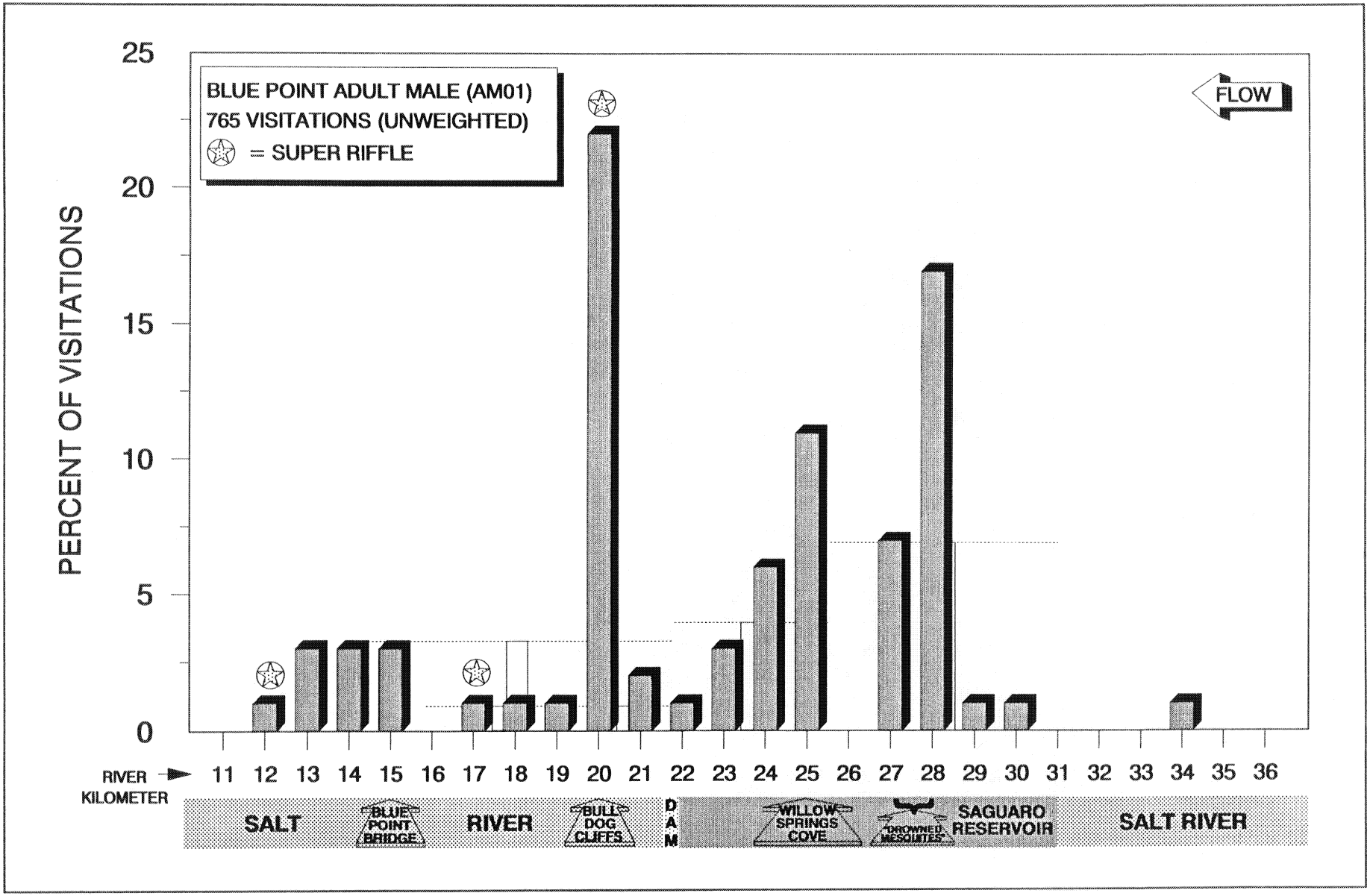


Figure B4.2-6. The home range of the telemetered Blue Point adult male (AM01) during the 1987 and 1988 breeding seasons. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from those bars indicate zones of eagle occupancy for the imprecise locations. These visitation scores are not weighted because the nest was located off-river.

The Blue Point male frequently soared overland from his nest in Willow Springs Canyon to Bulldog Cliffs. AM01 occasionally soared up to 5 kms from the Salt River or Saguaro Reservoir over the Goldfield Mountains and Stewart Mountain although we never recorded him perched during these inland forays.

B4.2.1.1 Seasonal Shifts. During 1987 and 1988, AM01's use of his home range within 28-day study periods varied in size from 15 to 21 river Kms. Generally, the area used was larger early in the breeding season and shrank as the season progressed. AM01's pattern of use of his home range was similar in both years (Figs. B4.2-7 and B4.2-8).

We studied the early breeding season in 1988 only. In January, almost all (94%) of AM01's visitations were to Saguaro Reservoir. He most frequently perched at Km 27 and Km 28 on the upper reservoir or Km 24 on the lower reservoir. Both of these areas had shallow water along the shore with nearby bluffs or snags for perches. There are several small coves located at Km 24 in which carrion would often collect. We recorded AM01 perched at the extreme upstream end of his home range (Km 36) on the Salt River during this time. In February, AM01 continued to use Saguaro Reservoir most of the time but about one-third of AM01's visitations were to the Salt River where he began frequenting Bull Dog Cliff at Km 20 and another section of the river at Km 18.

In March and April of 1987 and 1988, AM01 used the river portion of his home range much more than he used the reservoir section. For example, in April of 1987 he used the Salt River for 72 percent of his visitations. AM01 used the furthest downstream portion of his home range in March and April; we recorded him perched at Km 11 in both years. Throughout the rest of the breeding season, AM01's use of the river dwindled as his visits to the reservoir increased. AM01's use was concentrated in a few key areas. His favorite perching areas in May and June were in Willow Springs Cove and Km 28 of upper Saguaro Reservoir. The shallow water of Willow Springs Cove was filled with vegetation in June and provided good habitat for carp. Km 28 had many mesquite snags located in the shallow water along the northwest shore of the upper reservoir. In both years, AM01 used much less of his total home range at the end of the breeding cycle.

B4.2.1.2 Soaring Range. The soaring range of the Blue Point male (AM01) extended from about Km 10 to Km 35 on the Salt River. We observed him once at Km 10 escorting an adult bald eagle (likely one of the Orme eagles) from his territory. Both AM01 and his mate appeared to soar up to 6 or so kms north and south of the drainage in what seemed to be territorial patrolling. We estimate the Blue Point's soaring range to be about 192 square kms.

B4.2.2 Foraging Studies

We studied foraging by the Blue Point male bald eagle from the 1 March–20 June 1987 and 31 January–21 May 1988. We also have incidental forage information of the male from 21 June 1987 to 2 January 1988. During our study, we wanted to identify prey taken by the eagle seasonally, to locate foraging sites, and to evaluate macro- and microhabitat selection by the foraging eagles.

B4.2.2.1 Prey Selection. Prey species selection by the Blue Point male (AM01) as determined by radio-tracker's observations and prey remains collections following forages in 1987 appear in Table B4.2.1. Sample size is low compared to the 1988 data when we recorded prey deliveries, and the comparison illustrates the effectiveness of the nest observer methodology. The 1987 diet consisted primarily of fish (78% of estimated biomass). The high percentage of unknown fish (50% numerically) again reflected

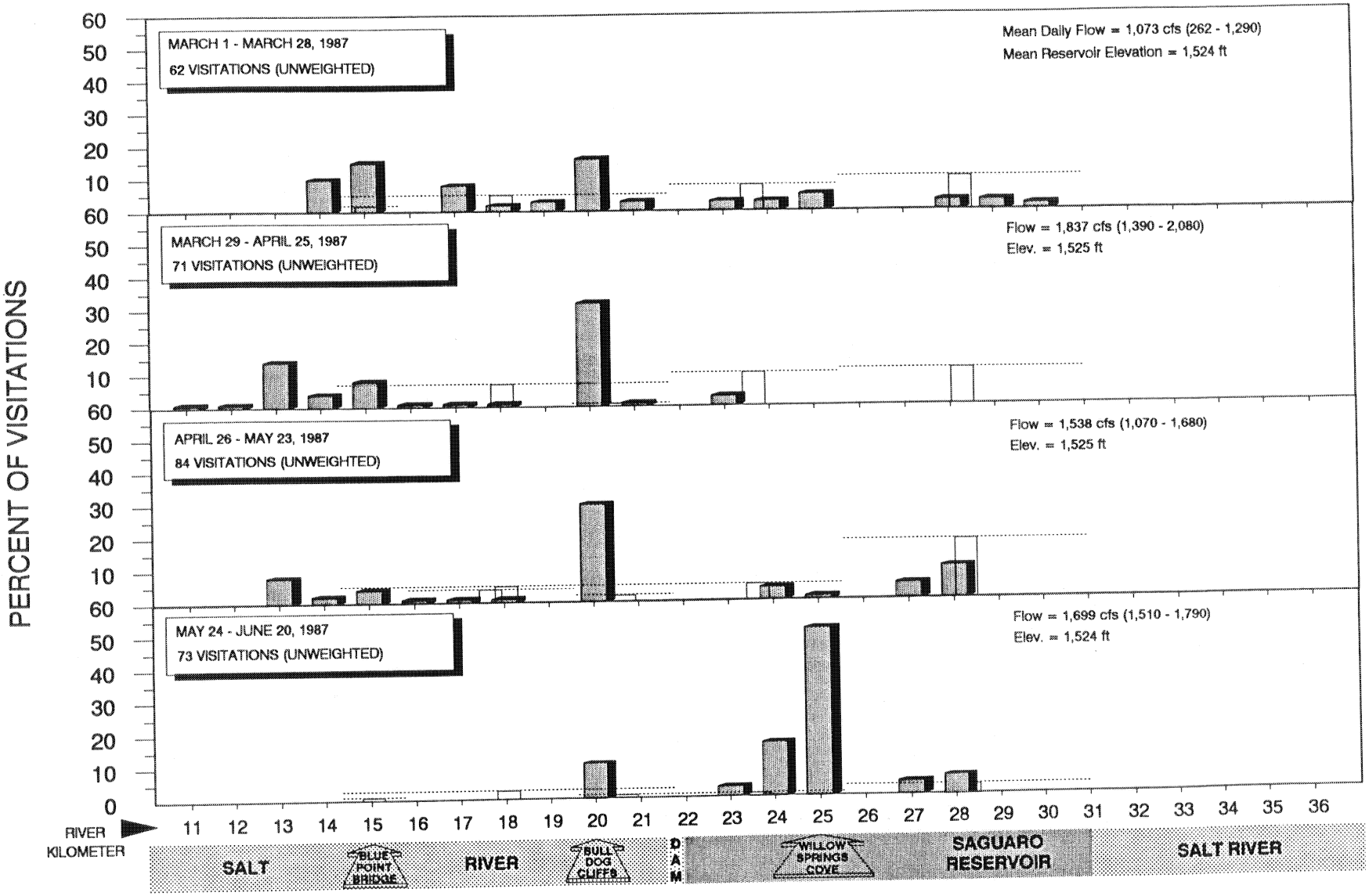


Figure B4.2-7. Seasonal changes in the distribution of visitations (%) by the telemetered Blue Point male (AM01) during 1 March–20 June 1987. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from those bars indicate zones of eagle occupancy for the imprecise locations (data are not weighted).

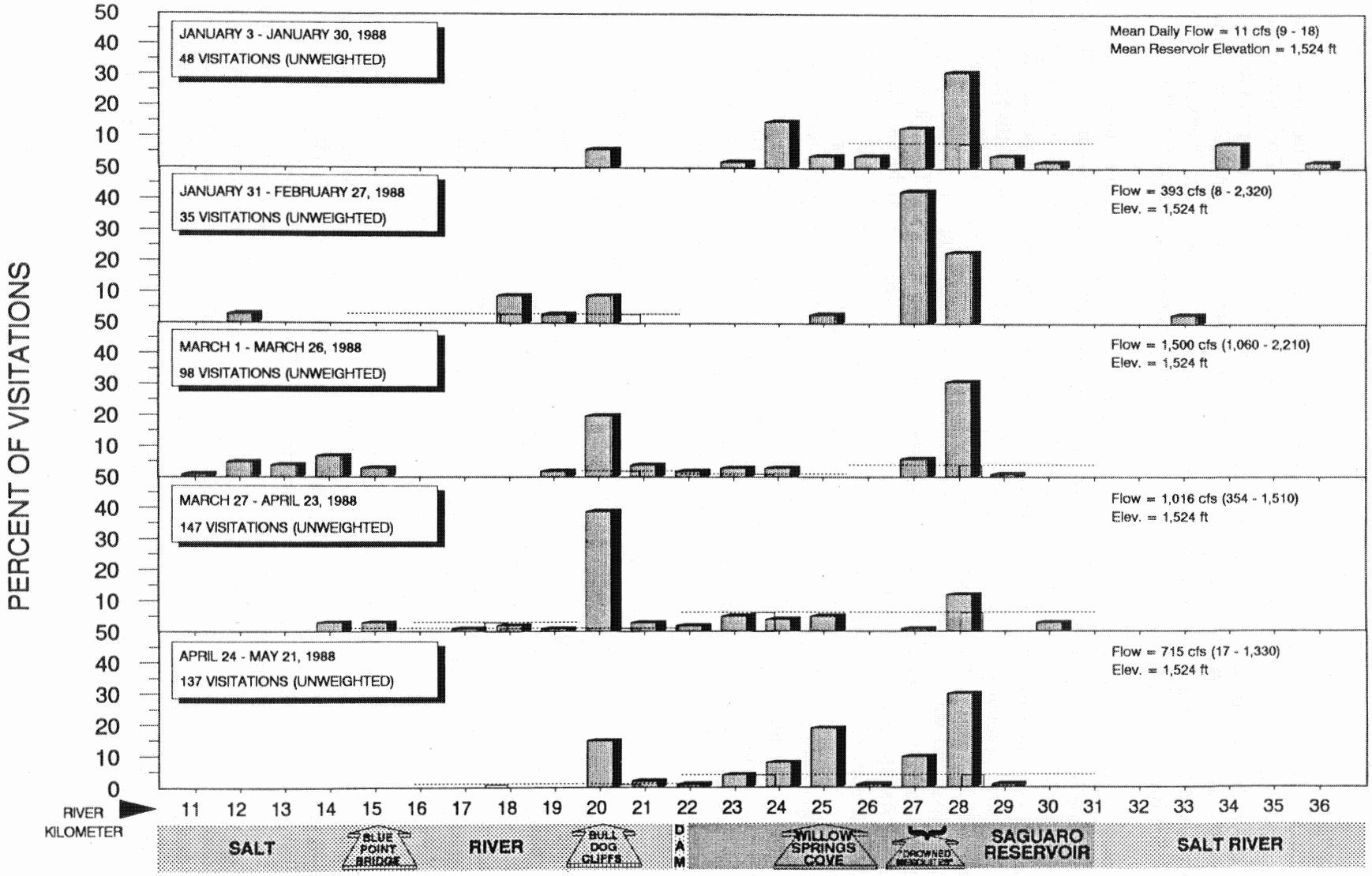


Figure B4.2-8. Seasonal changes in the distribution of visitations by the telemetered Blue Point male (AM01) during 3 January–21 May 1988. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from those bars indicate zones of eagle occupancy for the imprecise visitations (data are not weighted).

the limitations of using only tracking data. Channel catfish and suckers represented most of the fish biomass utilized in 1987. Unidentified carrion (from the reservoir, possibly fish) also contributed substantially to the 1987 biomass (17%). The channel catfish and yellow bass listed in the 21 June to 2 January column of Table B4.2-1 were captured in late June 1987. Two eared grebes were taken by the male eagle in October and November on Saguaro Reservoir. We incidentally observed five forages on fish by the Blue Point female in 1987 including one channel catfish and four unidentified fish.

We again recorded waterfowl use by AM01 in January 1988 when he captured three coots on the reservoir (Table B4.2-2). Coots and grebes were taken throughout the nesting season in small numbers by the male and female (Table B4.2-3) although only one was delivered to the nest in May 1988. Fish dominated the prey deliveries of AM01 in 1988 and represented 80 percent of the biomass delivered to the nest. Suckers accounted for 32 percent of his biomass contribution to the nestlings, followed by yellow bass (19%) and largemouth bass (18%). Other fish included channel and flathead catfish, carp, smallmouth bass, and walleye pike. AM01 brought in 10 individual non-fish prey items including a jackrabbit and four rock squirrels in addition to the waterfowl discussed above. These items represented 20 percent of AM01's delivered biomass. The Blue Point female's deliveries to the nest totaled just over one-half of the male's: 17.7 kg estimate biomass (n = 53) compared to 34.2 kg (n = 99) for AM01. Mean weight of fish prey deliveries for DF02 (319 g) were only slightly larger than for the male eagle (308 g). Yellow bass (25%) represented the greatest biomass contribution by the female, followed by suckers (22%), largemouth bass (18%), and channel catfish (12%). DF02 apparently captured more yellow bass and channel catfish and less suckers than her mate. This had partly to do with her tendency to stay near the nest during the first half of the chick cycle and possibly a greater idiosyncratic reliance on the reservoir. The results our analysis of prey remains from the Blue Point nest are presented in Section B5.1.3.

Seasonal differences existed in prey species taken by the Blue Point eagles in 1987 and 1988 (Tables B4.2-1 and B4.2-4). The eagles focused on waterfowl during the winter months into early spring. Mammals were also utilized in the early spring. Suckers were taken throughout the nesting season, with peak use in mid-March. In general, black bass (sp.) and yellow bass utilization increased as the number of suckers decreased. We observed peak use in perciform (bass) species during late April and early May. We observed a similar trend at Bartlett where perciform fish also became important when sucker utilization declined. Catfish (sp.) were consumed throughout the 1988 nesting observation periods, but most heavily in March.

B4.2.2.2 Geography of Foraging. Bald eagles at the Blue Point breeding area have been known to forage on Saguaro Reservoir and in the regulated Salt River below Stewart Mountain Dam, especially below Bulldog Cliffs and near the dam spillway (Haywood and Ohmart 1982, Haywood and Ohmart 1983, Sherman 1983, Grubb *et al.* 1983, Canestorp *et al.* 1984, Grubb 1984, Collie *et al.* 1985, Grubb 1986a). The eagles were reported as far west as Granite Reef Dam, and up the Verde River; however, these birds were not radio-tagged, and the adults seen were probably from the Orme breeding area, located at the confluence of the Salt and Verde rivers. Foraging observations were concentrated near the Stewart Mountain Dam spillway after AGF stocked trout in the area. The eagles were noted to frequent the reservoir more as river recreation (tubing) increased (Canestorp *et al.* 1984, Collie *et al.* 1985). The above sources also observed the eagles using the Blue Point Cliffs and the mud cliffs near the Blue Point Ranger Station for perching. Although ABENWP personnel saw the eagles fly to the reservoir, they usually lost sight of the birds.

In the present study, we found that both the river and the reservoir contributed significantly to the diet of the Blue Point eagles in 1987 and 1988. Suckers were taken exclusively from the river, while all

Table B4.2-1. Prey taken by the male bald eagle (AM01) in the Blue Point breeding area in 1987. Column A indicates number of prey from observed forages. Column B gives estimated whole biomass (grams) of all prey items shown in A. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals						B. Whole Biomass (grams)					
	28-Day Period:						28-Day Period:					
Species	3/01/87–3/28/87	3/29/87–4/25/87	4/26/87–5/23/87	5/24/87–6/20/87	6/21/87–1/02/88	Total	3/01/87–3/28/87	3/29/87–4/25/87	4/26/87–5/23/87	5/24/87–6/20/87	6/21/87–1/02/88	Total
Fish Species												
Sucker	1 20%	1 33%				2 5%	343 21%	993 77%				1,336 11%
Probable Sucker	1 20%					1 3%	163 10%					163 1%
Carp		1 33%		1 6%		2 5%		288 22%		462 9%		750 6%
Channel Catfish				3 18%	2 20%	5 13%				944 19%	658 26%	1,602 14%
Yellow Bass				2 12%	1 10%	3 8%				450 9%	146 6%	596 5%
Unknown Fish	2 40%	1 33%	3 75%	10 59%	3 30%	19 49%	381 23%	12 1%	654 63%	2,817 56%	743 29%	4,607 40%
Subtotal	4 80%	3 100%	3 75%	16 94%	6 60%	32 82%	887 54%	1,293 100%	654 63%	4,673 92%	1,547 60%	9,054 78%
Other Species												
Eared Grebe					2 20%	2 5%					594 23%	594 5%
Cactus Wren					1 10%	1 3%					39 2%	39 0%
Subtotal					3 30%	3 8%					633 25%	633 5%
Unidentified Carrion	1 20%		1 25%	1 6%	1 10%	4 10%	767 46%		389 37%	389 8%	389 15%	1,934 17%
TOTAL	**5 100%**	**3 100%**	**4 100%**	**17 100%**	**10 100%**	**39 100%**	**1,654 100%**	**1,293 100%**	**1,043 100%**	**5,062 100%**	**2,569 100%**	**11,621 100%**

Table B4.2-2. Prey taken and prey delivered to nest by the male bald eagle (AM01) from Blue Point breeding area in 1988. Column A indicates number of prey from observed forages plus prey deliveries to the nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals						B. Whole Biomass (grams)					
	28-Day Period:						28-Day Period:					
Species	1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	3/27/88–4/23/88	4/24/88–5/21/88	Total	1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	3/27/88–4/23/88	4/24/88–5/21/88	Total
Fish Species												
Sucker		2 67%	7 47%	20 34%	6 15%	35 29%		686 84%	1,981 32%	6,386 28%	2,566 19%	11,619 26%
Probable Sucker				2 3%		2 2%				1,300 6%		1,300 3%
Carp			1 7%		1 3%	2 2%			1,651 27%		368 3%	2,019 4%
Flathead Catfish					1 3%	1 1%					421 3%	421 1%
Channel Catfish			1 7%	3 5%	1 3%	5 4%			128 2%	1,069 5%	608 5%	1,805 4%
Unknown Catfish					1 3%	1 1%					96 1%	96 0%
Largemouth Bass			1 7%	8 14%	8 21%	17 14%			409 7%	2,732 12%	3,629 27%	6,770 15%
Smallmouth Bass					1 3%	1 1%					165 1%	165 0%
Unknown Bass				1 2%	2 5%	3 3%				195 1%	416 3%	611 1%
Unknown Centrarchid				2 3%		2 2%				455 2%		455 1%
Yellow Bass			1 7%	11 19%	16 41%	28 24%			146 2%	2,530 11%	4,569 34%	7,245 16%
Walleye Pike					1 3%	1 1%					230 2%	230 1%
Unknown Fish		1 33%	1 7%	3 5%	1 3%	6 5%		128 16%	403 7%	703 3%	343 3%	1,577 3%
Subtotal		3 100%	12 80%	50 85%	39 100%	104 87%		814 100%	4,718 77%	15,370 67%	13,411 100%	34,313 76%
Other Species												
Coot	3 100%		1 7%	3 5%		7 6%	1,926 100%		642 11%	1,926 8%		4,494 10%
Eared Grebe			1 7%			1 1%			297 5%			297 1%
Pied-billed Grebe			1 7%			1 1%			442 7%			442 1%
Jackrabbit				1 2%		1 1%				2,114 9%		2,114 5%
Rock Squirrel				4 7%		4 3%				3,268 14%		3,268 7%
Subtotal	3 100%		3 20%	8 14%		14 12%	1,926 100%		1,381 23%	7,308 32%		10,615 23%
Unidentified Carrion				1 2%		1 1%				389 2%		389 1%
TOTAL	**3 100%**	**3 100%**	**15 100%**	**59 100%**	**39 100%**	**119 100%**	**1,926 100%**	**814 100%**	**6,099 100%**	**23,067 100%**	**13,411 100%**	**45,317 100%**

Table B4.2-2. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	3/27/88–4/23/88	4/24/88–5/21/88	Total
Fish Species						
Sucker			1,644 *(7) 53%	6,017 (20) 31%	1,829 (4) 16%	9,490 (31) 28%
Probable Sucker				1,300 (2) 7%		1,300 (2) 4%
Carp					368 (1) 3%	368 (1) 1%
Flathead Catfish					421 (1) 4%	421 (1) 1%
Channel Catfish			128 (1) 4%	967 (3) 5%	547 (1) 5%	1,642 (5) 5%
Unknown Catfish						
Largemouth Bass			409 (1) 13%	2,102 (7) 11%	3,629 (8) 31%	6,140 (16) 18%
Smallmouth Bass					165 (1) 1%	165 (1) 0%
Unknown Bass				195 (1) 1%	416 (2) 4%	611 (3) 2%
Unknown Centrachid				46 (1) 0%		46 (1) 0%
Yellow Bass				2,470 (11) 13%	4,170 (14) 35%	6,640 (25) 19%
Walleye Pike					230 (1) 2%	230 (1) 1%
Unknown Fish				360 (2) 2%		360 (2) 1%
Subtotal			2,181 (9) 70%	13,457 (47) 70%	11,775 (33)100%	27,413 (89) 80%
Other Species						
Coot			642 (1) 21%	1,894 (3) 9%		2,536 (4) 7%
Eared Grebe			297 (1) 10%			297 (1) 1%
Pied-billed Grebe						
Jackrabbit				846 (1) 4%		846 (1) 2%
Rock Squirrel				3,169 (4) 16%		3,169 (4) 9%
Subtotal			939 (2) 30%	5,839 (8) 30%		6,848 (10) 20%
Unidentified Carrion						
TOTAL			**3,120 (11)100%**	**19,366 (55) 100%**	**11,775 (33)100%**	**34,261 (99) 100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

Table B4.2-3. Prey taken and prey delivered to nest by the female bald eagle (DF02) from Blue Point breeding area in 1988. Column A indicates number of prey from observed forages plus prey deliveries to nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass of prey (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

Species	A. Number of Individuals 28-Day Period: 3/01/88 3/26/88	3/27/88–4/23/88	4/24/88–5/21/88	Total	B. Whole Biomass (grams) 28-Day Period: 3/01/88–3/26/88	3/27/88–4/23/88	4/24/88–5/21/88	Total
Fish Species								
Sucker	3 43%	5 22%	1 4%	9 17%	1,037 30%	2,311 31%	512 5%	3,860 19%
Carp			1 4%	1 2%			999 11%	999 5%
Channel Catfish	3 43%	3 13%	3 13%	9 17%	282 8%	497 7%	1,396 15%	2,175 11%
Unknown Catfish		1 4%		1 2%		343 5%		343 2%
Largemouth Bass			6 26%	6 11%			3,164 34%	3,164 16%
Smallmouth Bass			1 4%	1 2%			165 2%	165 1%
Unidentified Bass		2 9%		2 4%		341 5%		341 2%
Yellow Bass		9 39%	7 30%	16 30%		2,692 36%	1,959 21%	4,651 23%
Unknown Fish		1 4%	3 13%	4 8%		195 3%	541 6%	736 4%
Subtotal	6 86%	21 91%	22 96%	49 92%	1,319 38%	6,379 86%	8,736 93%	16,434 81%
Other Species								
Coot		1 4%	1 4%	2 4%		642 9%	642 7%	1,284 6%
Jackrabbit	1 14%			1 2%	2,114 62%			2,114 10%
Subtotal	1 14%	1 4%	1 4%	3 6%	2,114 62%	642 9%	642 7%	3,398 17%
Unidentified Carrion		1 4%		1 2%		389 5%		389 2%
TOTAL	**7 100%**	**23 100%**	**23 100%**	**53 100%**	**3,433 100%**	**7,410 100%**	**9,378 100%**	**20,221 100%**

Table B4.2-3. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 3/01/88 3/26/88	3/27/88–4/23/88	4/24/88 5/21/88	Total
Fish Species				
Sucker	1,003 *(3) 60%	2,311 (5) 31%	512 (1) 6%	3,826 (9) 22%
Carp			500 (1) 6%	500 (1) 3%
Channel Catfish	263 (3) 15%	497 (3) 7%	1,391 (3) 16%	2,151 (9) 12%
Unknown Catfish		343 (1) 5%		343 (1) 2%
Largemouth Bass			3,164 (6) 36%	3,164 (6) 18%
Smallmouth Bass			165 (1) 2%	165 (1) 1%
Unidentified Bass		341 (2) 5%		341 (2) 2%
Yellow Bass		2,639 (9) 36%	1,774 (7) 20%	4,413 (16) 25%
Unknown Fish		195 (1) 3%	541 (3) 6%	736 (4) 4%
Subtotal	1,266 (6) 75%	6,326 (21) 86%	8,047 (22) 93%	15,639 (49) 88%
Other Species				
Coot		642 (1) 9%	642 (1) 7%	1,284 (2) 7%
Jackrabbit	422 (1) 25%			422 (1) 2%
Subtotal	422 (1) 25%	642 (1) 9%	642 (1) 7%	1,706 (3) 10%
Unidentified Carrion		389 (1) 5%		389 (1) 2%
TOTAL	**1,688 (7) 100%**	**7,357 (23) 100%**	**8,689 (23) 100%**	**17,734 (53) 100%**

* Number in parentheses represents number of prey items in Column A actually delivered to the nest. Those not delivered were consumed elsewhere by adults.

Table B4.2-4. Summary of estimated biomass (grams) of prey delivered to the Blue Point bald eagle nest in 1988 by both male and female adults. Numbers in parentheses refer to number of individuals delivered to nest. Some species are grouped for analysis. Percentages expressed as percent of column total rounded to nearest whole number.

	OBSERVATION PERIOD/DAYS OBSERVED					
Species	3/13-3/26/88 8 days	3/27-4/9/88 9 days	4/10-4/23/88 9 days	4/24-5/7/88 8 days	5/8-5/21/88 6 days	Total 40 days
Fish Species						
Sucker sp.	2,647 (10) 55%	4,904 (13) 42%	4,724 (14) 31%	1,510 (3) 11%	831 (2) 13%	14,616 (42) 28%
Carp					868 (2) 14%	868 (2) 2%
Catfish sp.	391 (4) 8%	1,401 (6) 12%	406 (1) 3%	1,640 (4) 11%	719 (1) 12%	4,557 (16) 9%
Black Bass sp.	409 (1) 8%		2,638 (10) 18%	6,227 (15) 44%	1,312 (3) 21%	10,586 (29) 20%
Other Centrarchid			46 (1) 0%			46 (1) 0%
Yellow Bass		1,801 (8) 16%	3,299 (12) 22%	4,373 (15) 31%	1,571 (6) 25%	11,053 (41) 21%
Walleye					230 (1) 4%	230 (1) 0%
Unknown Fish		360 (2) 3%	195 (1) 1%	541 (3) 4%		1,096 (6) 2%
Subtotal	3,447 (15) 72%	8,475 (29) 73%	11,308 (39) 75%	14,291 (40) 100%	5,531 (15) 90%	43,052 (138) 83%
Other Species						
Waterfowl sp.	939 (2) 19%	1,252 (2) 11%	1,284 (2) 9%		642 (1) 10%	4,117 (7) 8%
Rabbit sp.	422 (1) 9%		846 (1) 6%			1,268 (2) 2%
Other Mammals		1,552 (2) 13%	1,617 (2) 11%			3,169 (2) 6%
Unknown Carrion		389 (1) 3%				389 (1) 1%
Subtotal	1,361 (3) 28%	3,193 (5) 27%	3,747 (5) 25%	0 (0) 0%	642 (1) 10%	8,943 (14) 17%
TOTAL	**4,808 (18) 100%**	**11,668 (34) 100%**	**15,055 (44) 100%**	**14,291 (40) 100%**	**6,173 (16) 100%**	**51,995 (152) 100%**

waterfowl, yellow bass, and flathead catfish came from the reservoir (Table B4.2-5). Carp, channel catfish and largemouth bass were taken from both the river and reservoir, but most came from the reservoir.

In March 1988, prey were captured in near-equal percentages from the reservoir (53%) and from the river (47%)(Table B4.2-5). Suckers were taken from the lower river (Km 14.2–12.3) and from near Saguaro Reservoir dam during the March observation period. The eagles took a variety of fish and waterfowl from the reservoir in March. By April 1988, AM01 was taking suckers in the Salt River mostly from the Blue Point Bridge (Km 15.8) upstream to the dam. The number of prey items taken from the river in April (n = 26, 44%) were again close to the number captured in the reservoir (n = 24, 41%). Prey taken from the reservoir included mostly black bass (sp.), yellow bass, and coots. In late April and May we recorded only 18 percent of prey items with origins in the river; mostly suckers (n = 5, 13%) from near the dam. The bulk of prey originated from the reservoir (n = 18, 70%): primarily largemouth bass and yellow bass.

Table B4.2-5. Origin of prey taken by the radio-telemetered Blue Point adult male (AM01) bald eagle in 1988. (Not all items were delivered to the nest.) Known forage locations by unradioed female shown in parentheses are not included in totals.

		Reservoir (Saguaro Lake)					Salt River						
Observation Period	Species	Upstream of Dam Unspecified 903	River Upstream of Lake 904	Upper Reservoir 905	Lower Reservoir 906	Lower Willow Springs Canyon 916	Downstream of Dam Unspecified 907	Dam to Km 19.5 Bulldog Cliffs 908	Bulldog Cliffs to Blue Pt. Bridge Km 19.5-15.8 909	Blue Pt. Bridge to Sheep Bridge Km 15.8-14.2 910	Km 14.2-12.3 911	Unknown	Total
3/1/88-3/26/88	Sucker	-	-	-	-	-	(1)	3	-	-	4	-	7 47%
	Carp	-	-	-	1	-	-	-	-	-	-	-	1 7%
	Channel Catfish	1		(1)	-	-	-	-	-	-	-	-	1 7%
	Largemouth Bass	-	-	1	-	-	-	-	-	-	-	-	1 7%
	Yellow Bass	-	-	1	-	-	-	-	-	-	-	-	1 7%
	Unknown Fish	-	-	-	1	-	-	-	-	-	-	-	1 7%
	Eared Grebe	-	-	1	-	-	-	-	-	-	-	-	1 7%
	Pied-billed Grebe	-	-	1	-	-	-	-	-	-	-	-	1 7%
	American Coot	-	-	-	1	-	-	-	-	-	-	-	1 7%
	Jackrabbit	-	-	-	-	-	-	-	-	-	-	-	0 0%
	Subtotal	1 7%	0 0%	4 27%	3 20%	0 0%	0 0%	3 20%	0 0%	0 0%	4 27%	0 0%	15 100%
3/27/88-4/23/88	Sucker	-	-	-	-	-	5 (1)	7	7	1	-	2	22 37%
	Channel Catfish	-	-	2	-	-	1	-	-	-	-	-	3 5%
	Catfish sp.	-	-	-	-	-	-	-	-	-	-	-	0 0%
	Largemouth Bass	-	-	4	-	-	-	-	-	-	-	3	7 12%
	Black Bass sp.	-	-	1	-	-	-	-	-	-	-	1	2 3%
	Centrarchid sp.	-	-	2	-	-	-	-	-	-	-	-	2 3%
	Yellow Bass	-	2	1 (1)	6 (1)	1	-	-	-	-	-	1	11 19%
	Unknown Fish	-	-	-	-	-	1	-	1	1	-	-	3 5%
	American Coot	-	-	-	3	-	-	-	-	-	-	-	3 5%
	Jackrabbit	-	-	1	-	-	-	-	-	-	-	-	1 2%
	Rock Squirrel	-	-	-	-	-	-	1	1	-	-	2	4 7%
	Unknown Carrion	-	-	1	-	-	-	-	-	-	-	-	1 2%
	Subtotal	0 0%	2 3%	12 20%	9 15%	1 2%	7 12%	8 14%	9 15%	2 3%	0 0%	9 15%	59 100%

Table B4.2-5. (Continued)

Observation Period	Species	Reservoir (Saguaro Lake) Upstream of Dam Unspecified 903	River Upstream of Lake 904	Upper Reservoir 905	Lower Reservoir 906	Lower Willow Springs Canyon 916	Salt River Downstream of Dam Unspecified 907	Dam to Km 19.5 Bulldog Cliffs 908	Bulldog Cliffs to Blue Pt. Bridge Km 19.5-15.8 909	Blue Pt. Bridge to Sheep Bridge Km 15.8-14.2 910	Km 14.2-12.3 911	Unknown	Total
4/24/88-5/21/88	Sucker	-	-	-	-	-	2	3	-	-	-	1	6 15%
	Carp	-	-	-	1	-	-	-	-	-	-	-	1 3%
	Channel catfish	-	-	1	-	-	-	-	-	-	-	-	1 3%
	Flathead catfish	-	-	-	1	-	-	-	-	-	-	-	1 3%
	Unknown catfish	-	-	-	-	-	-	-	-	-	-	1	1 3%
	Largemouth bass	-	-	3	3	-	1	1	-	-	-	-	8 20%
	Smallmouth bass	-	-	-	-	-	-	-	-	-	-	1	1 3%
	Black bass species	-	-	1	1	-	-	-	-	-	-	-	2 5%
	Yellow bass	-	-	7 (2)	7 (1)	1	-	-	-	-	-	2	17 43%
	Walleye Pike	-	-	1	-	-	-	-	-	-	-	-	1 3%
	Unknown fish	-	-	1	-	-	-	-	-	-	-	-	1 3%
	American coot	-	-	-	-	-	-	-	-	-	-	-	0 0%
	TOTAL	0 0%	0 0%	14 35%	13 33%	1 3%	3 8%	4 10%	0 0%	0 0%	0 0%	5 13%	40 100%

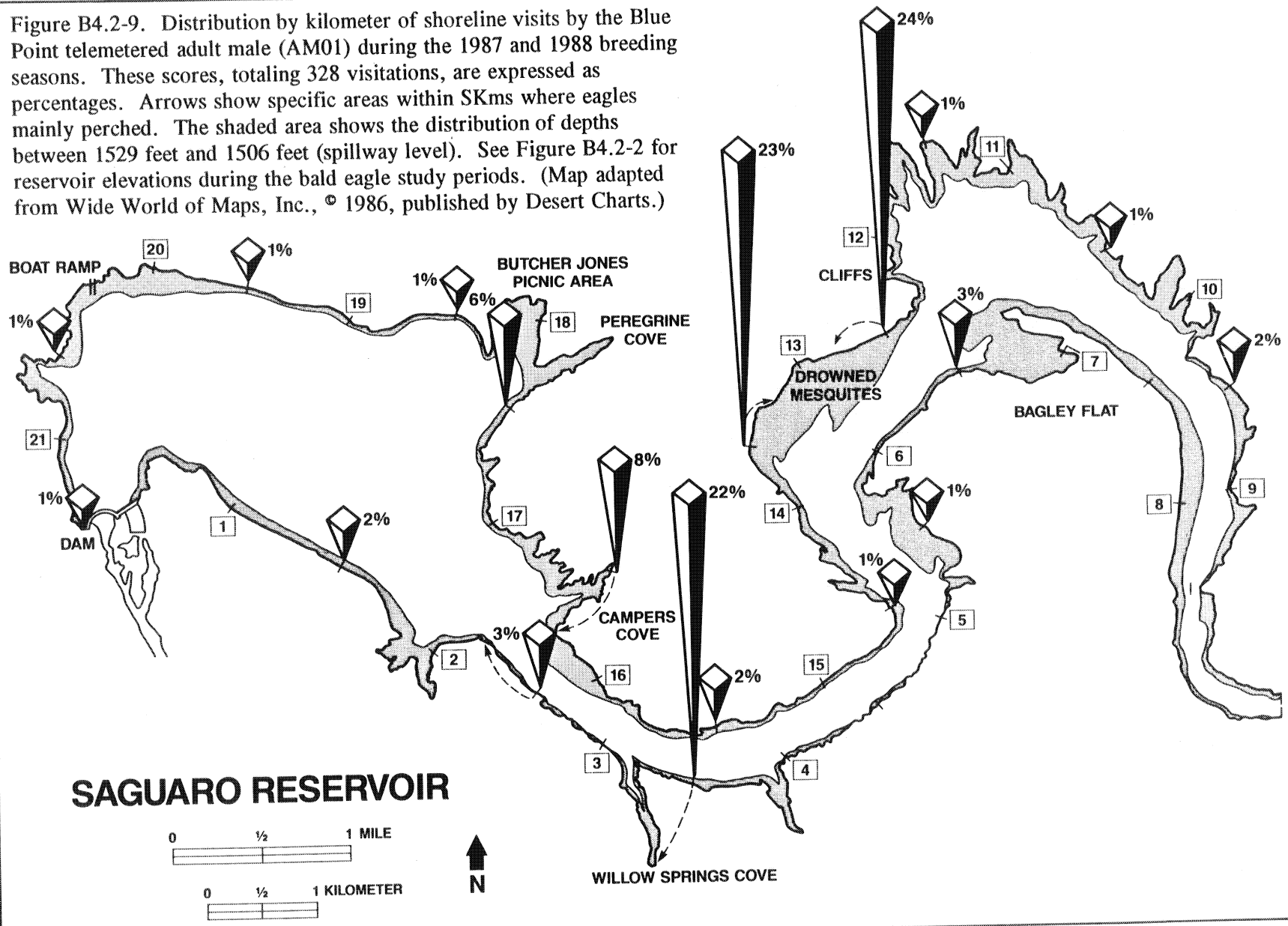
Figures B4.2-7 and B4.2-8 show that the pattern of habitat use by the male eagle was similar in 1987 and 1988 and also reflected foraging patterns described above for the 1988 nesting season. In early 1988 (January and February), the male eagle spent considerable time on the reservoir and made only occasional visits to the river. The eagle foraged extensively on waterfowl on the reservoir at this time. In late February through April he spent more time on the river, foraging on suckers which were spawning, although he continued to frequent the reservoir as well. The eagle visited a larger area of the river in March 1988 (Kms 11–21), compared to April (Kms 14–21), and May (Kms 20–21). River forages were concentrated on spawning suckers. Similar to the pattern observed in the Bartlett breeding area (Section B4.1), we found that suckers first spawned in the lower reaches of the river, but by May, sucker spawning occurred mostly upstream. The male's visitations to the river were restricted to Bulldog Cliffs near the dam in late spring. The gradual movement upstream of visitations evident during the months of April and May 1988 was concurrent with increased use of the reservoir.

The male eagle used the downstream-most river kilometers first in April of 1987, one month behind his activity the following year (Figure B4.2-7). The 1987 visitations data revealed a gradual movement upriver in May and June with increased visitations also to the reservoir. It may be important to note that large spring flows from the dam occurred almost one month later in 1987 (10 March, Figure B4.2-4) than in 1988 (20 February, Figure B4.2-5). Salt River flows below the Stewart Mountain Dam also steadily declined from late February through early May in 1988 (discharge near zero); however flows remained relatively constant during spring 1987 following the initial onset described above. The one month difference between the onset of downstream sucker foraging and the eventual movement upstream may have been related to the delay in 1987 of high flows and the maintenance of higher flows in 1987. Optimal spawning temperatures for suckers possibly occurred later and lasted longer in 1987 which possibly explains the observed difference in sucker use.

Use of the reservoir was minimal in the early spring, but in late May and June 1987 the eagle spent the majority of his time on the reservoir, especially in Willow Springs Cove. In May, the eagle frequented the reservoir and foraged largely on yellow bass which had died (or were moribund) shortly after spawning. Figure B4.2-9 shows visitations of AM01 along shoreline Kms of Saguaro Reservoir. These were concentrated in three areas: (1) the area of the "drowned mesquites" in Skms 12 and 13; (2) Willow Springs Cove (Skm 3); and, (3) the northern shoreline of the lower reservoir in Skms 16 and 17 (Camper's Cove area). These three areas of high visitation scores were where we also observed the most forages (see Observed Forages, below). Reservoir elevation levels remained relatively constant during both 1987 and 1988 breeding seasons (see Figure B4.2-2).

B4.2.2.3 Observed Forages. We directly observed 163 forages in the Blue Point breeding area; their distribution by zone is shown in Figure B4.2-10. We identified 134 of these as to prey type. One hundred (74.6%) were identified as forages for fish, 33 (24.6%) for birds, primarily waterfowl, and one (0.7%) as a forage for a mammal. Of the remaining 29 forages in which prey type could not be identified, most were probably fish because (1) they occurred on the water; (2) few of them took place in the winter when most waterfowl forages occur; and, (3) forages for waterfowl could be readily identified. Because we observed prey deliveries in 1988 (but not in 1987), we were able to identify prey more often in 1988. The reader should be aware that the distribution of *observed forages* shown in the table is not equivalent to the distribution of *actual forages* because of the chance factor of observer location and because it is easier to see eagles foraging on the reservoir than on the river where visibility is often restricted.

Figure B4.2-9. Distribution by kilometer of shoreline visits by the Blue Point telemetered adult male (AM01) during the 1987 and 1988 breeding seasons. These scores, totaling 328 visitations, are expressed as percentages. Arrows show specific areas within SKms where eagles mainly perched. The shaded area shows the distribution of depths between 1529 feet and 1506 feet (spillway level). See Figure B4.2-2 for reservoir elevations during the bald eagle study periods. (Map adapted from Wide World of Maps, Inc., © 1986, published by Desert Charts.)



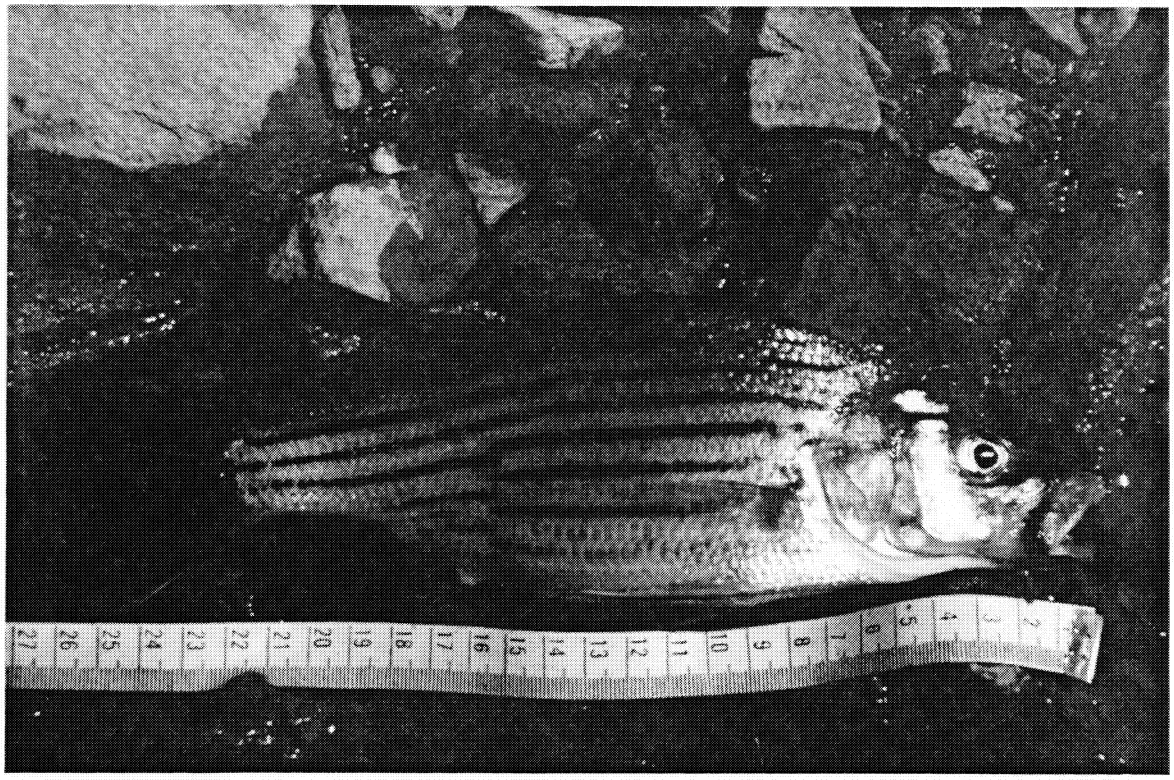


Plate B10. Yellow bass became an important prey fish of the Blue Point eagles in May due to post spawning stress and mortality on Saguaro Reservoir (photo by P. Becker).

Observed River Forages For Fish. In 1987 and 1988 we observed eagles forage 33 times for fish and ten times for unidentified prey (all were probably fish). There were 19 observed forages in 1987 (11 for "fish" and eight "unidentified") and 24 in 1988 (22 for "fish" and 2 "unidentified").

Fish Prey Species. We observed forages for fish along 10 Km of the Salt River, from Km 21, below Stewart Mountain Dam, downstream to Km 12, above Blue Point Ranger Station (Figure B4.2-11). The prey taken in these river forages was primarily sucker species, with 21 suckers or probable suckers identified (Table B4.2-6). Only two other fish species were identified, channel catfish and carp. Ten fish could not be identified. There was a conspicuous absence of carrion prey in river forages, with only one verified carrion forage observed (a channel catfish taken at Km 20.3). Prey status (alive or dead) was determined for 12 of 21 suckers (including probable suckers); all 12 were judged to be alive when taken. There is no reason to believe that many of the remaining forages were for carrion, since verified live suckers were taken in all the microhabitats where we observed forages for suckers of unknown status. The lack of records of carrion taken on the river is curious because we commonly found carrion suckers along the river (see Section B4.2.3).

Microhabitat. We identified river habitat for 28 forages for identified fish in 1987 and 1989. The majority occurred in runs (n = 9), riffles (n = 9), or pools (n = 6), and the others were distributed between pocket water, backwater, and pre-riffle (Table B4.2-7). One, for which precise data could not be obtained, was in either a pool tail or backwater. Table B4.2-7 also gives a breakdown of river substrate and vegetation at these strike points. Substrate for all forages is primarily rocks (22 of 24

observations), while vegetation is generally a mossy coating of algae (n = 14) or nonexistent (n = 13), with one point noted as "grassy".

The distribution of water depth at river foraging points is shown in Figure B4.2-12. Depth was 100 cm or less at 26 strike points and greater than 200 cm at four points for which the data were obtainable. Water temperatures at river strike points are shown in Figure B4.2-13. These temperatures remained fairly constant even though they were taken over the course of two seasons: from the middle of March to the end of May in 1987, and from the beginning of February to the beginning of May in 1988. These temperatures are similar to those observed at foraging strike points in the Bartlett breeding area where bald eagles also took suckers in a regulated river section near a dam.

Turbidity was clear to the bottom at 30 of 38 strike points where data could be obtained. Surface conditions were generally calm: twenty-seven strike points had either a glassy surface (n = 12) or one which was disturbed only by swirls (n = 15), and five more had only 1 cm waves.

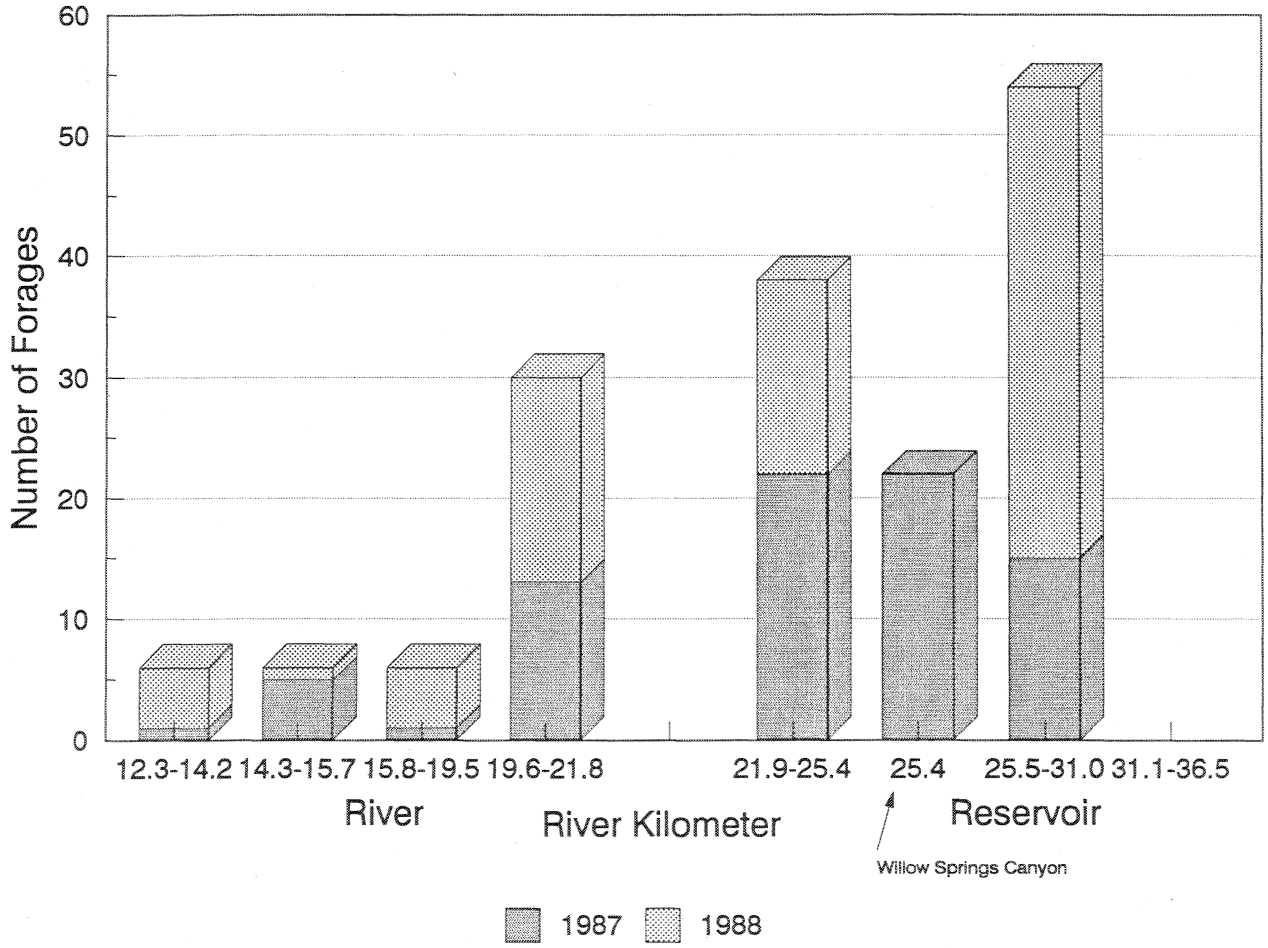


Figure B4.2-10. Distribution of observed forages in the Blue Point territory in 1987 and 1988, by zone. Because river forages were more difficult to observe than reservoir forages, the extent of river foraging is underestimated in this graph. Visitation data give a less biased view of overall foraging distribution in the breeding areas.

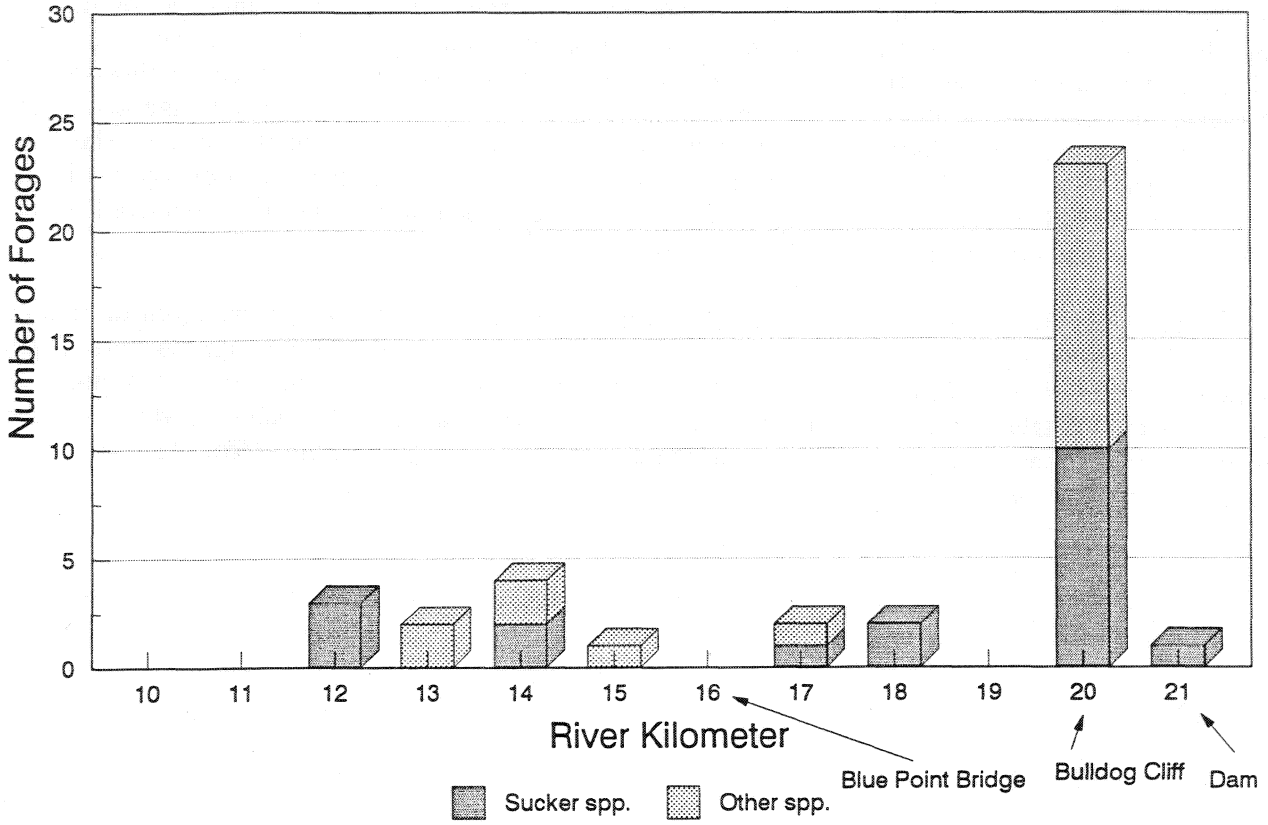


Figure B4.2-11. Location by segment of observed forages for fish on the Salt River, Blue Point territory. Data do not include the single piracy observed. Four river forages were not located to segment, including two for suckers. Segment 21 is the first segment downstream of Stewart Mountain Dam; Segment 20 is in the area of Bulldog Cliffs.

Perch Distances. Distance from perch to attack point was highly variable, with a low value of 3 m and a high value 400 m for attacks classified as originating from a perch. Most of the high distance values were from attacks from Bulldog Cliff (Km 20), where the height of the perches allowed long, descending flights directly to attack points up to 400 m from the perch. If all records for attacks classed as being from perches are counted, the average distance from perch to attack point is 92 m (n = 30). When the same calculation is done only for the river below Km 19, eliminating forages from Bulldog Cliff, the average distance is 27 m (n = 11).

Observed Reservoir Forages For Fish. We observed 67 forages for fish in Saguaro Reservoir; these are summarized in Table B4.2-8. The two most frequently observed fish prey were yellow bass and channel catfish. Carrion fish were the majority of the identified prey, with a total 23, compared to 17 live fish and 21 of unidentified status. Incidental observations suggest that most of the fish judged to have been alive when taken were injured or dying on or near the surface (see below).

Yellow Bass. We observed 14 forages for yellow bass; seven in the lower reservoir (Zone 906) and seven in the upper (Zone 905). Five forages were for live fish, five for carrion, and four for fish of unknown

status. We suspect that some or all of the yellow bass recorded as "live" were actually dying on the surface of the reservoir when taken by the eagle, since we frequently observed this species floating moribund, apparently dying from spawning stress. Observed forages were clustered in two areas. The first was the "drowned mesquites" area of the upper reservoir at Skms 12–13, where we observed six forages, including one in the center channel in Km 27. There was one additional forage across the reservoir from this area in Skm 6. The other area was the lower reservoir, along the northern shoreline in Skms 16–17 (Camper's Cove). We observed four forages in this area, plus two downstream in the center channel in Kms 22 and 23. One other forage occurred in the lower reservoir when a live fish was taken on the southern shore close to the dam in Skm 1.

Water depths at the strike points were generally deep, again suggesting that fish were taken in dead or moribund condition. Two yellow bass were taken in depths of 50 and 100 cm, but ten other depth measurements were over 200 cm. In this deeper water, eagles took two live fish, four carrion, and four fish of unknown status. Observers classed three of the strike points as reservoir shallows, while the other eleven were noted as open reservoir. Water temperatures at the strike points ranged from 13–26°C, with an average of 19° (n = 13).

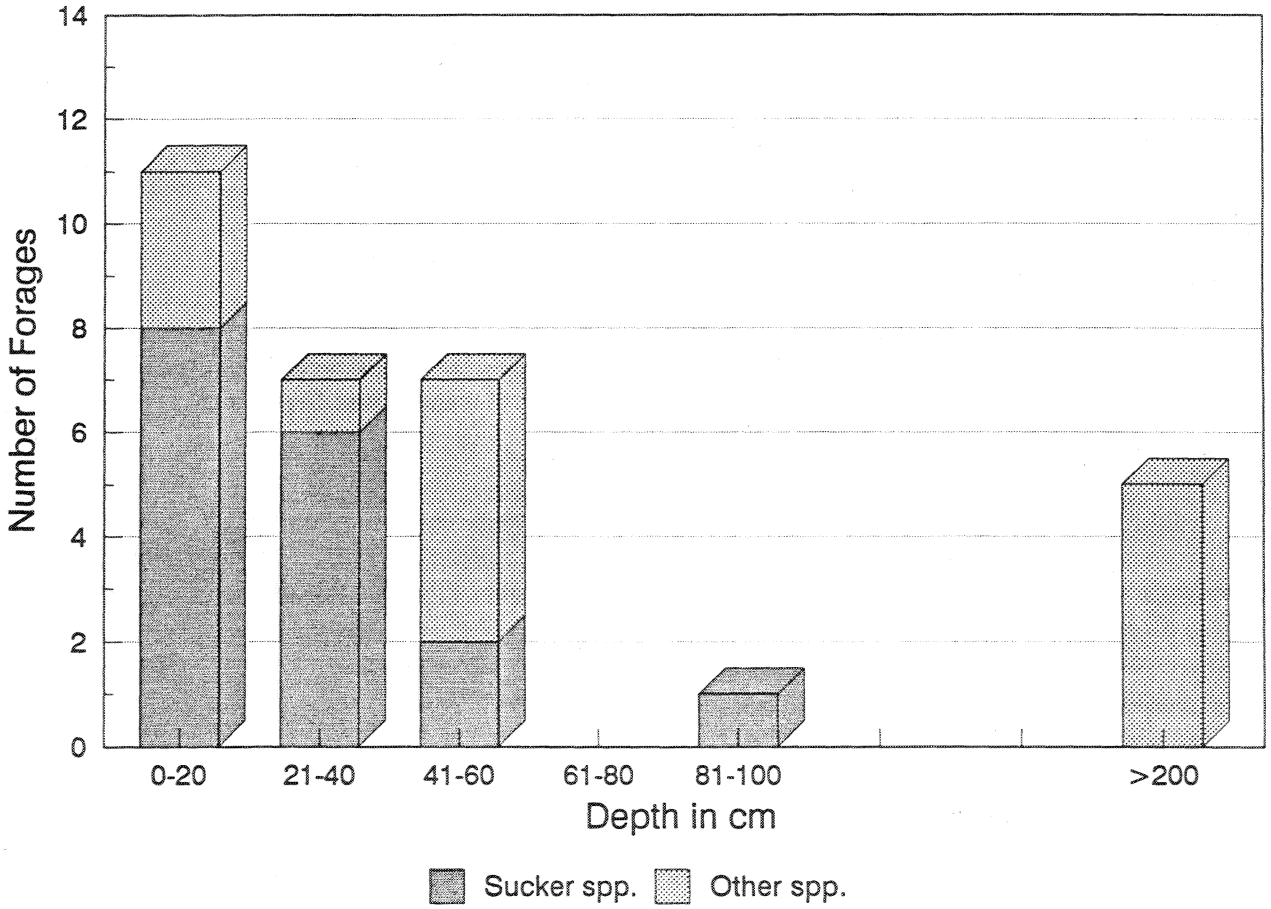


Figure B4.2-12. Profile of observed forage depths on the Salt River, Blue Point territory. Data for suckers include all observed sucker species, including fish identified as probable suckers. "Others" includes unidentified fish.

Table B4.2-6. Fish species taken in observed forages on the Salt River, Blue Point territory.

Species	Total	Live	Carrion	Piracies	Unknown
1987					
Sucker spp.	1	1	—	—	—
Sonora Sucker	1	1	—	—	—
Probable Sucker	1	—	—	1	—
Carp	1	1	—	—	—
Channel Catfish	1	—	1	—	—
Unknown Fish	6	1	—	4	1
1987 Total	11	4	1	5	1
1988					
Sucker spp.	15	8	—	7	—
Desert Sucker	1	1	—	—	—
Probable Sucker	2	1	—	1	—
Unknown Fish	4	1	—	3	—
1988 Total	22	11	0	11	0
TOTAL	**33**	**15**	**1**	**16**	**1**

Channel Catfish. We observed four forages (not including one piracy) in the upper reservoir (Zone 905) and two in the lower (Zone 906). Three of the forages in the upper reservoir were in the "drowned mesquites" area on the northern shore. One forage in the lower reservoir was in the Camper's Cove region of Skm 16, while the other was across the narrows in Skm 3. Microhabitat measurements for channel catfish in this breeding area are too few to determine any patterns. Two carrion fish were taken in shallow water of 3 and 8 cm depth, while one was taken in water over 200 cm. Four water temperatures ranged from 20 to 26°C, averaging 23°.

Observed Reservoir Foraging Locations (fish). There were three main foraging locations for fish on the reservoir: Willow Springs Canyon, the "drowned mesquites" area of the upper reservoir, and the Camper's Cove area (see Figure B4.2-9). The shore locations nearest the observed forages are shown in Figure B4.2-14.

Lower Reservoir (Zone 906). Most observed forages in lower Saguaro Reservoir occurred in the same general area extending from the center of the reservoir around Km 23 (south of the Saguaro del Norte

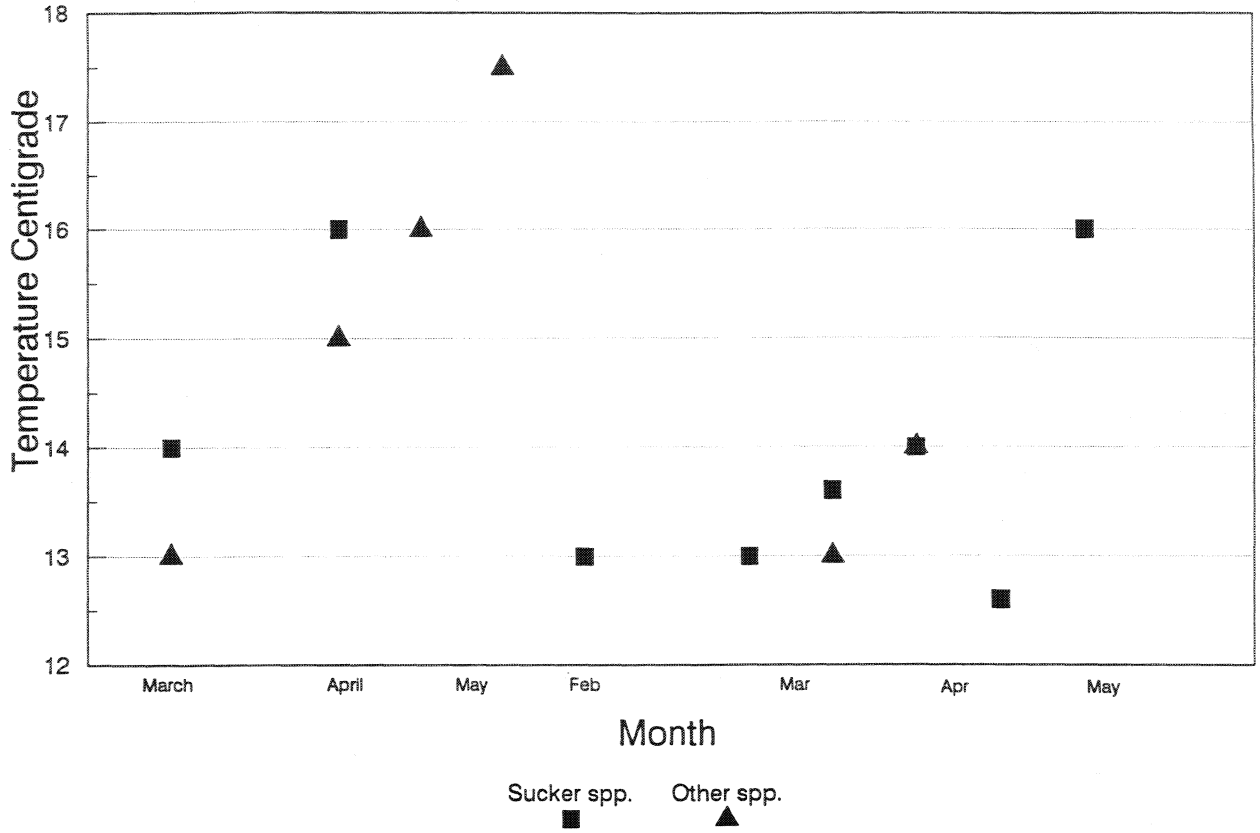


Figure B4.2-13. Water temperatures at observed strike points on the Salt River, Blue Point territory. Temperatures shown are the averages for each period.

Recreation Area parking lot) upstream to the narrow mouth of the Salt River channel at roughly Km 25.3. In contrast to the depths recorded at forage locations in the areas of the "drowned mesquites" and in Willow Springs Canyon, 14 of 15 recorded depths at forage locations in the lower reservoir are greater than 200 cm (Figure B4.2-15). Temperatures at the foraging locations ranged from 12 to 26°C and averaged 19° (n = 26).

Yellow bass were the most numerous identified prey fish in this zone (Table B4.2-9). Four of these fish were taken offshore of SKms 16–17 in the Camper's Cove area of cliffs and shallows on the north shore of the reservoir; three were alive when taken and the status of one was undetermined. Two others, both carrion, were taken from the center channel of the reservoir at Kms 22.9 and 23.0, roughly offshore of SKm 19 and downstream of the area where the others were taken. One live yellow bass was taken on the opposite shore in SKm 1. Other forages were also primarily in the region of SKms 16–17, or downstream of it. Two carp (one live and one a piracy) were taken in Skm 16 (near Camper's Cove), as was one observed carrion channel catfish. The single largemouth bass was taken in SKm 17. Four of the unidentified fish (two carrion and two of unknown status) were taken in SKm 17, and one (a carrion fish) was taken downstream in SKm 18. Another (of unknown status) was taken on the south shore in SKm 2, across the reservoir from SKm 16. Two others (one carrion and one a piracy) were taken in SKm 15, the narrow channel between the upper and lower reservoir, downstream of the "drowned mesquite" area of the upper reservoir.

Table B4.2-7. Microhabitat at observed forage points for fish, Salt River, Blue Point territory, 1987 and 1988.

Species	River Habitat	No.	Substrate	No.	Vegetation	No.
Sucker spp.	Riffle	6	Rocks	13	Mossy algae	9
	Run	4	2-5 cm Pebble	1	Grassy	1
	Pocket water	3			No vegetation	6
	Backwater	1				
	Pool	1				
Sonora Sucker	Pool	1	Rocks	1	Mossy algae	1
Desert Sucker	Pool	1	Sand	1	No vegetation	1
Carp	Riffle	1	Rocks	1	Mossy algae	1
Channel Catfish	—	—	—	—	—	—
Unknown Fish	Run	5	Rocks	5	Mossy algae	2
	Riffle	2			No vegetation	4

Willow Springs Canyon (Zone 916). In 1987, AM01 frequently foraged in the cove at the lower end of Willow Springs Canyon during the latter part of the nesting cycle. We observed forages by AM01 from 23 May to 30 June. We also observed the female and juvenile eagles foraging there. In 1988 the nestlings died in mid-May, and we observed no forages in this area. Willow Springs Cove is narrow and surrounded by cliffs which overlook the water. These cliffs were used by the eagles both for hunting and loafing. The cove is deep near its entrance into the main river channel, but gradually becomes very shallow, rising to a sandy beach. The shallow portion of the cove contains submerged vegetation, providing cover for fish, which may become vulnerable to eagle attack when feeding in the shallows (see Section B4.2.3).

Nine of sixteen recorded depths in Willow Springs Canyon were less than 200 cm (Figure B4.2-15). Recorded water temperatures ranged from 21 to 28°, with an average of 24° (n = 16). The higher temperatures were noted in late spring and early summer, and it is interesting to note that temperatures in the canyon were higher than in the main reservoir.

We observed 16 forages for fish in Willow Springs Canyon (Figure B4.2-14), along with six forages for unidentified prey which were probably for fish. Fourteen of these forages were by the Blue Point male, AM01, with six by the female DF01, and two by juveniles. The only identified fish prey were catfish, one a channel catfish and one unknown catfish. The high proportion of unidentified fish is due to the fact that the eagles only used this area in 1987, when there was no nest observer. Two of the unidentified fish were taken as piracies by AM01, and the unidentified catfish was taken in a piracy by the female.

Table B4.2-8. Fish species taken on Saguaro Reservoir, Blue Point territory, 1987 and 1988.

Species	Total	Live	Carrion	Piracies	Unknown
Yellow Bass	14	5*	5	4	—
Largemouth Bass	4	—	3	1	—
Black Bass	1	—	1	—	—
Unknown Bass	1	—	1	—	—
Channel Catfish	7	1	4	1	1
Unknown Catfish	1	—	—	—	1
Carp	2	1	—	—	1
Unknown Centrarchid	1	—	1	—	—
Unknown Fish	36	10	8	15	3
Total	67	17	23	21	6

* These fish were probably dying on the reservoir surface from spawning stress when taken by the eagle.

Carp fed in the shallows of Willow Springs Cove, so some of the unidentified fish may have been of this species.

Upper Reservoir (Zone 905). In upper Saguaro Reservoir, the primary foraging area was on the north shore of the reservoir, upstream from Ship Rock and extending approximately from Kms 27.8 to 28.8 and SKms 12–13. This area was fairly well defined, encompassing an area of shallow water with numerous dead mesquite snags around Km 28.8. This area was shallow, with a mud bottom and sparse, submerged vegetation.

Fifteen of 35 recorded strike point depths were greater than 200 cm (Figure B4.2-15). The range of temperatures at strike points recorded in 1987 and 1988 ranged from 11–26°C, with an average of 17° (n = 40).

Yellow bass were the most numerous observed prey species in the upper reservoir, and almost all were taken in the "drowned mesquites" area of SKms 12–13. Of six taken in this area, one was live, two were carrion, and the status of three was unknown. One carrion yellow bass was taken in SKm 6, directly across the reservoir from the "drowned mesquites." Three of four channel catfish taken were in the "drowned mesquites" area; all were carrion fish. One live channel catfish was taken from SKm 11, upstream from the mesquites, and one carrion black bass was also taken there. One carrion centrarchid of unknown species was taken from the "drowned mesquites," as were almost all the fish which could not be identified to species. Of the latter, five were alive when taken, three were carrion, and status for four was unknown.

Forages for Waterfowl. In two years of observation at Blue Point, we observed 31 forages for waterfowl, generally between October and April. All but two were on the reservoir; only eight were successful. American coots and eared grebes were the most common prey: eagles attempted forages for 12 American coots, 10 eared grebes, one pied-billed grebe, one grebe unidentified to species, one green-winged teal, and six unidentified waterfowl. In the eight successes, five coots, two eared grebes, and one pied-billed grebe were identified. We twice saw eagles feeding on waterfowl when no forage had been observed; one was an eared grebe, the other an American coot.

We observed eagles attempting to take waterfowl both in the air and from the surface of the water. Aerial forages involved both tail chases and stoops from above; forages on the water surface involved both single and multiple stoops on the prey. Of the four aerial forages, none was successful. Three of these occurred on 18 October 1987 and involved stoops and/or tail chases for short distances by the female. On 17 October 1987, the male tail-chased a coot for about 50 m until it hit the water hard; he then broke off the attack.

When hunting waterfowl on the water surface, eagles usually dove repeatedly on their prey, forcing the birds to submerge, then diving on them again when they returned to the surface. We saw this type of

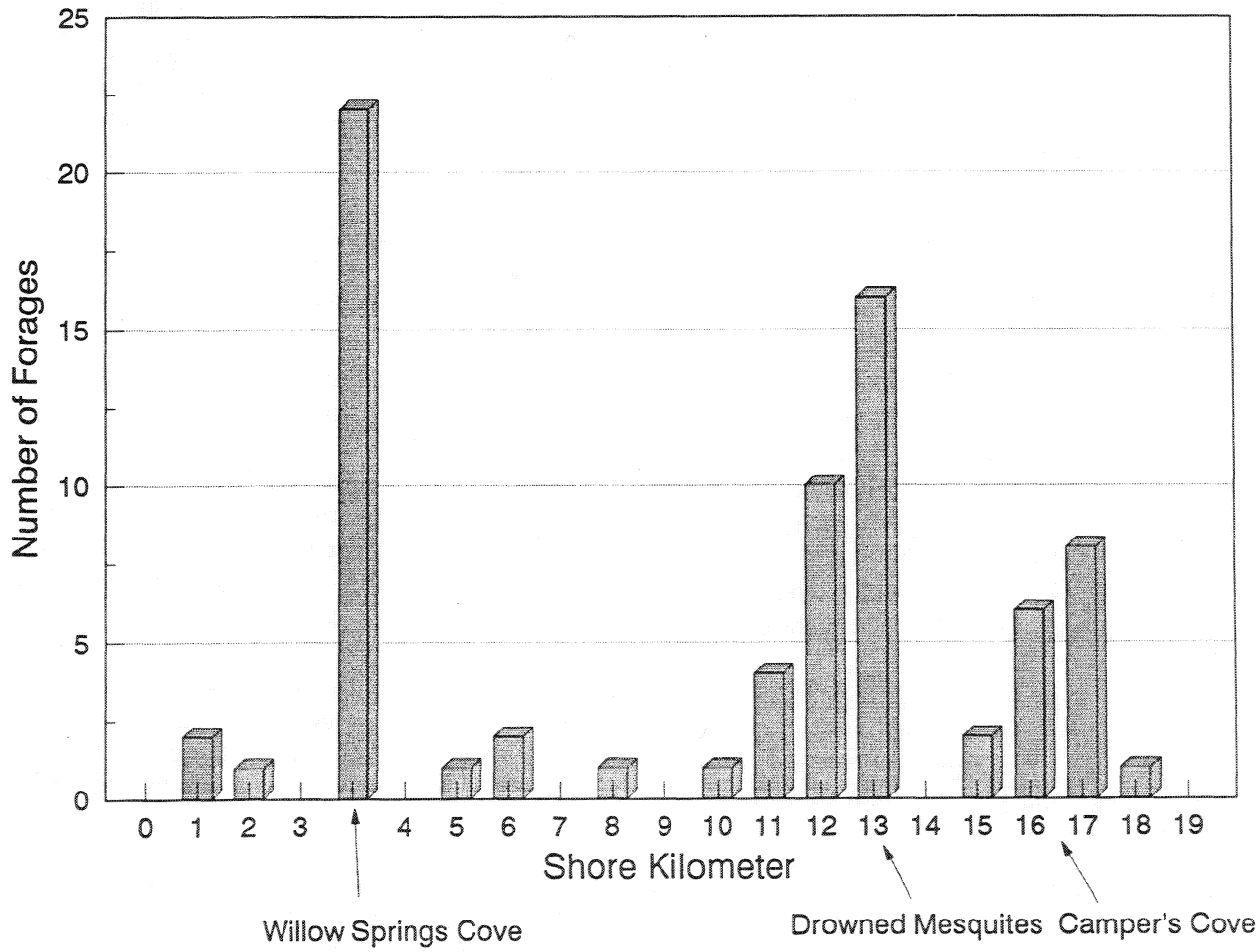


Figure B4.2-14. Frequency of forages on Saguaro Reservoir, by shore kilometer. Data do not include forages for waterfowl. Refer to B4.2-9 for geography of shoreline kilometers (SKm).

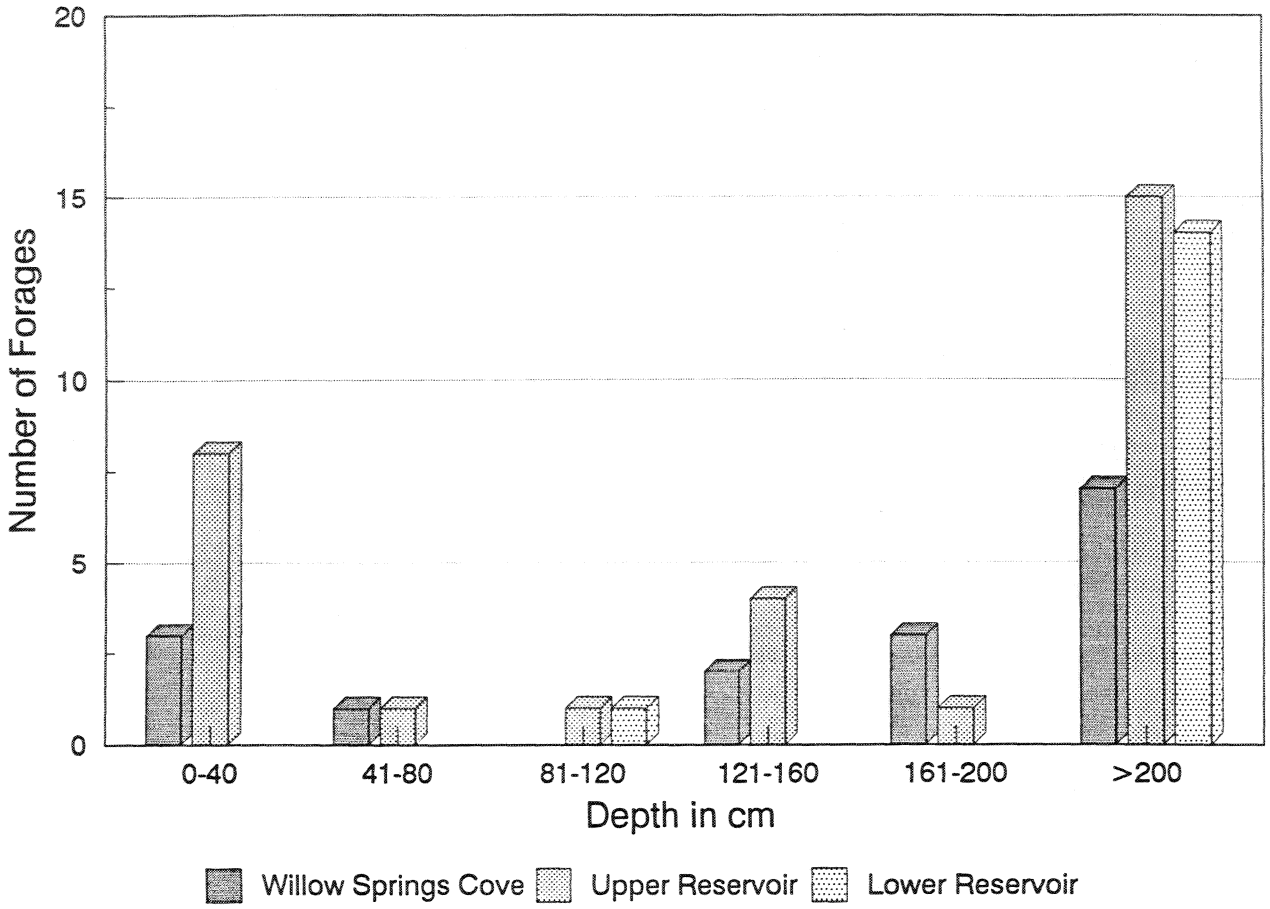


Figure B4.2-15. Depth profile of observed forage points in Saguaro Reservoir, Blue Point territory.

attack 16 times. These attacks usually lasted for between two and seven dives, with the eagle maintaining position above the submerged waterfowl by circling or almost hovering, flapping vigorously.

AM01 attempted to capture an eared grebe from the river below the dam at Km 20.4. The eagle flew approximately 100 m from his perch, then dove repeatedly on the grebe from a low altitude, forcing it to dive below the water. The eagle maintained position above the grebe when it was underwater, almost hovering in place. Surprisingly, when AM01 broke off the attack, he was only about 1.5 m directly above the grebe, which had just surfaced, and the attack seemed a certain success.

AM01 was successful in an attempt on the reservoir, making seven dives at a group of unidentified waterfowl, "tossing up" after each dive but not circling. All the waterfowl were underwater after the seventh dive. The eagle then circled low over the water so that as the waterfowl surfaced, he was approaching them in level flight over the water at an altitude of one meter or less. He took one of the birds by lowering his legs and grabbing it.

Attacks were often broken off after no more than five or six dives, suggesting that eagles may only be able to maintain this pattern of circling or "hovering" flight, punctuated by attacks on the prey, for only a limited period. However, attacks sometimes continued for a longer period. On 11 January 1988,

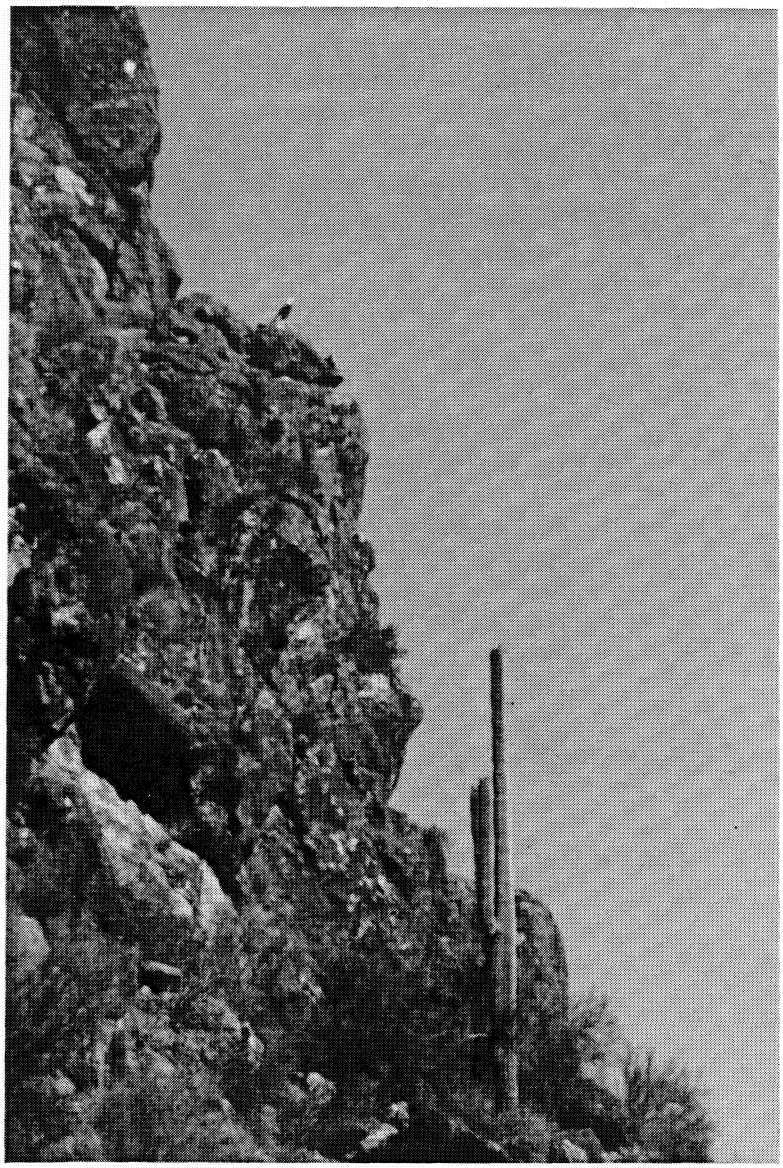


Plate B11. Blue Point male (AM01) perched on cliff overlooking Willow Springs Cove (photo by P. Becker).

AM01 stooped unsuccessfully 12 times on an eared grebe, and on 5 April 1988 dove twenty times on a loosely scattered group of about 40 eared grebes, harassing one individual and finally taking it.

We also observed eagles attacking waterfowl by making a single dive or pass. We observed this type of attack nine times, although three of these were part of a quick sequence of attacks on an eared grebe in which the eagle used the same perch between attacks, and the grebe was finally taken on the second stoop of the last attack.

Walter and Garrett (1981:14) state that waterfowl taken in single passes are carrion. In one forage by this method, we definitely identified the prey as carrion (a dead grebe), but the waterfowl were identified as live in others (also on Roosevelt Reservoir, Section B4.6.2). In one attack, AM01 flew directly

Table B4.2-9. Location of fish species taken during observed forages in Saguaro Reservoir, Blue Point territory. Zone 906 is the Lower Reservoir; 905 is the Upper Reservoir; and Zone 916 is Willow Springs Canyon.

	Zone			
Species	Zone 906 Lower Res.	Zone 916 Willow Spgs.Canyon	Zone 905 Upper Res.	Total
Yellow Bass	7	—	7	14
Largemouth Bass	1	—	3	4
Unknown Bass	1	—	—	1
Channel Catfish	1	1	5	7
Unknown Catfish	—	1	—	1
Carp	2	—	—	2
Unknown Centrarchid	—	—	1	1
Unknown Fish	8	14	14	36
Total	20	16	30	66

toward a grebe of unknown status 200 m from his perch, banked, and plucked it from the water. He then lowered his head in flight and bit the grebe, suggesting that it was alive when taken, then killed in the air.

Forages for Birds Other Than Waterfowl. On 14 April 1987, we observed AM01 flying towards the nest with a large, long-legged bird. We did not see the attack, but it occurred downstream of the observer's position at Km 14.5. We could not positively identify the prey, but it appeared to be a juvenile great blue heron. There was a great blue heron rookery at Km 13.4 (see Norman *et al.* 1989).

On 19 October 1987, a radio tracker in a boat on the reservoir pulled a cactus wren from the water. A little more than one-half hour later, the wren was dry enough to hop onto the bow, then attempt to fly to shore. It fell into the water again about 25 m from the boat. AM01 immediately left his perch on a cliff face, flew 100 m directly to the wren, and then made five passes on it before picking it from the water.

Forages For Mammals. We observed only one attack on a mammal during the two years of observation. On 3 April 1988, AM01 flew from a perch on a boulder-covered hillside above Km 18.5, circled twice above busy traffic on the Bush Highway, then dove into an area of bushes near the road, emerging with a rock squirrel. We could not determine if the prey was taken alive or as carrion.

Piracies. We observed five piracies, four successful, in the two years of observations. One occurred on the river and the others on the reservoir. A fifth "piracy" involved a flying juvenile taking prey from

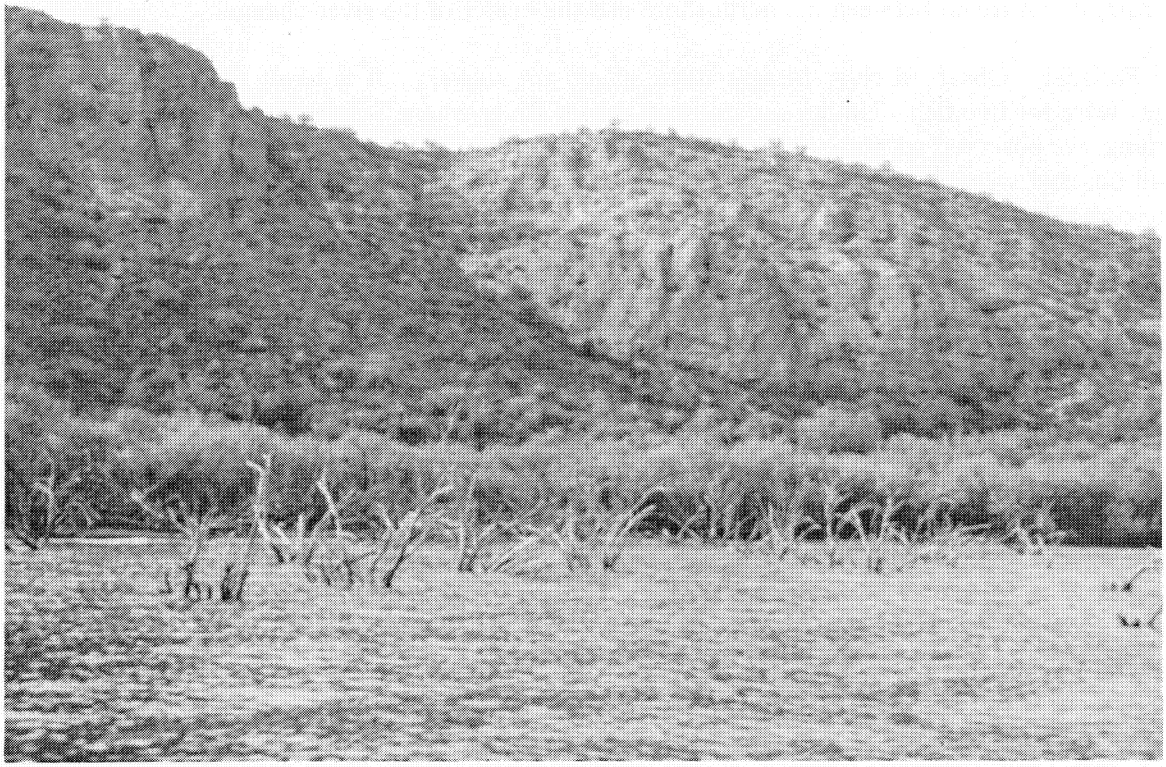


Plate B12. The "drowned mesquites" on upper Saguaro Reservoir was an important foraging area for the Blue Point eagles (photo by P. Becker).

its parent. On 30 June, 1987, AM01 foraged successfully in Willow Springs Canyon, then flew to a perch on a beach near the mouth of the canyon. One of the Blue Point juvenile bald eagles flew to him, took his prey, and flew with it further into the canyon, out of sight. AM01 followed him, walking, also out of sight.

On 18 April 1987, the male pirated a fish from an osprey while both were flying over the river around Km 12. The eagle harassed the osprey until it dropped the fish, which AM01 then caught while it was falling through the air. The male and female both attempted to pirate catfish from great blue herons in Willow Springs Canyon. On 23 May, 1987, AM01 took prey from a heron within two minutes after it had foraged. On 15 June 1987 the female attempted to pirate a small catfish from a great blue heron, but was unsuccessful.

The male also successfully pirated a carrion channel catfish from a group of turkey vultures, and another carrion fish from a number of turkey vultures and ravens.

Summary of Observed Forages. Despite the large potential foraging area at Blue Point breeding area, observed foraging locations were concentrated in only four areas, one on the river and three on the reservoir. The main river forage area was at Km 20: roughly half of all observed river forages occurred here in the Bulldog Cliff area. The forage areas in the reservoir were the "drowned mesquites," in the upper reservoir, the lower portion of Willow Springs Canyon off the narrow channel area, and a

relatively large portion of the lower reservoir running from the narrow, upstream end of the lower reservoir, downstream between the north shore and the center of the river channel.

River Forages. Observed river forages were mainly for suckers. It is likely that almost all of these forages were for live fish. Unlike our study on the Pit River where Sacramento suckers often died after spawning, we observed no post-spawn die-offs among Sonora or desert suckers in Arizona. The die-offs we did observe were associated with stranding and oxygen depletion caused by flow reductions before the nesting season.

Figure B4.2-10 shows that over half the observed river forages below Stewart Mountain Dam occurred at Km 20, below Bulldog Cliff. Forages in this area also continued over a longer time span each year than did downstream forages; the latter terminated earlier in the year because of reduced sucker spawning in these areas (Section B4.2.3), increased human activity, and/or because fish became more easily available on the reservoir.

Reservoir Forages. Although there was a high percentage of fish taken as carrion on the reservoir, and the species taken were susceptible to post-spawning die-off, shallow water areas were important to eagles foraging on the reservoir. This is shown by the concentration of foraging activity at Willow Springs Canyon and the "drowned mesquites" area of the upper reservoir. In the lower reservoir, however, all recorded foraging depths were over 200 cm, strongly suggesting that these fish were taken as carrion or in post-spawn moribund condition.

B4.2.3 Prey Studies

During the 1988 fisheries research at the Blue Point breeding area, we wanted to determine: (1) distribution and habitat utilization of potential forage fish in the Salt River (Kms 9.2–21.2) from January-June; (2) changes in the physical habitat of the Salt River due to flow and its effect on prey availability; (3) dynamics of sucker spawning in the study area; and, (4) factors contributing to fish carrion production on the river and reservoir.

B4.2.3.1 Salt River Fisheries Methods. We determined the distribution and habitat utilization of suckers in the Salt River between Km 10.2 and Km 20.0 using comprehensive visual surveys in January, March, April, and May 1988. On 20–21 January 1988 (13–14 cfs) and 29 April–1 May 1988 (9.5–24 cfs), two fisheries biologists conducted visual surveys by walking in tandem on opposite banks. Binoculars enhanced observations at longer distances; polarized sunglasses, used as needed, reduced glare. Fish were identified, counted, and their approximate lengths estimated as they were passed or flushed downstream. We determined fish locations to the nearest 0.1 km. We counted and identified carrion.

Consistent with the fact that bald eagles do not go deeper than 0.6 m to forage, we confined our surveys to habitats less than 1.2 m deep; this allowed for complete surveys of all habitats except medium-depth and deep pools (see Glossary) in January and April. We ceased observation if visibility was impaired. We also stopped surveys because of unfavorable weather conditions or interruptions by recreational activity. We designed surveys to characterize fish abundance and distribution in shallow water only; they do not characterize the entire fish community in these river sections.

We snorkeled two medium-depth and two deep pools in January to determine fish densities, but we could not accurately count fish due to the large number of suckers present, their tendency to swarm when

alarmed, and low illumination. Later in the spring, however, additional snorkeling surveys helped characterize fish abundance and their behavior in deep water.

Due to high flows, two fisheries biologists used a canoe to visually survey on 3 March 1988 (1730 cfs) and 7 April 1988 (1350 cfs). While floating downriver, the biologist in the bow of the canoe identified and counted fish along a 10-m-wide transect. To augment the floating surveys, we visually surveyed from elevated points on the river bank during high flows. During float trips, we identified, counted, and measured carrion fish, and inspected them internally for cause of death. On 1 April 1988 two biologists snorkeled in tandem between Km 19.5 and Km 18.7 to identify fish abundance and activity in habitat greater than 1.2 m deep.

To record habitat changes due to flow, we mapped aquatic habitat between Kms 15.8–19.8 on 20 January 1988 (14 cfs) and 3 March 1988 (1730 cfs) using habitat-type categories described in Section E8 (methods). Two biologists visually estimated habitat widths during each survey. If independent estimates were within 1.5 m of each other, we calculated an average width. If independent width estimates differed by more than 1.5 m, we measured the widths with a fiberglass tape. We measured habitat lengths to the nearest 0.35 m.

Biologists made depth profiles and width measurements under the upstream edge of Blue Point Bridge on 17 March (1140 cfs), 19 April (253 cfs), and 28 April (9.7 cfs) 1988 to further record changes in river morphometry with flow. We took depths at regular intervals along a transect using either a stadia rod (to the nearest 0.01 ft) or weighted tape (to the nearest 0.1 ft).

On survey days, we collected water and air temperatures three times daily using standardized alcohol or mercury thermometers.

During late April, two people electroshocked with a Smith Root Model 15A backpack shocker to verify visual observations of spawning suckers. We identified all fish captured, weighed them to the nearest gram, measured them to the nearest mm, and checked gonad condition.

We determined sucker courtship and spawning mainly from behavioral observations. We documented the duration of the sucker spawning season and seasonal availability of fish to avian predation with visual observations at three permanent locations on the Salt River (Km 15.3, Km 17.3, Km 18.8), as well as from numerous observations at scattered locations between Km 10.2 and Km 22.4. We further verified sucker spawning throughout the field season by collecting fish eggs from redds immediately following observed spawning behavior.

B4.2.3.2 Fish Population Studies. During our investigations of fish and other prey in the Blue Point breeding area we attempted to identify: (1) relative abundance of potential prey fish in the Salt River and Saguaro Reservoir; (2) seasonal changes in distribution and abundance of prey vulnerable to eagles (*i.e.*, in shallow water); (3) timing and duration of sucker spawning in the Salt River and its effect of fish availability; (4) effect of water management on prey availability; and, (5) availability of other food sources specifically carrion and water birds.

Relative Abundance of Fish in Saguaro Reservoir. Bluegills, yellow bass, and largemouth bass were by far the most abundant fish collected during AGF surveys in Saguaro Reservoir (1985, 1988) making up 87 percent of fish captured (31%, 29%, and 27% respectively). Only three other potential prey species

were abundant in the reservoir: carp (5%), channel catfish (5%) and walleye (3%). Species collected, but comprising less than 2 percent of the fish community, included yellow bullhead, yellow perch, green sunfish and rainbow trout. The relative abundance of yellow bass, which utilize the pelagic zone of the reservoir, may have been under-represented in the surveys due to greater sampling effort along the shallow margins of the reservoir.

Relative Abundance of Fish in the River. In 1973, the USFWS (U.S. Fish and Wildlife Service 1976) conducted fisheries surveys in the Lower Salt River from Stewart Mountain Dam to Granite Reef Dam (Km 0.0–21.9). They used a combination of techniques, including electrofishing, gill-netting, and seining. Based on their data, suckers comprised about 50 percent of the potential prey fish present in the Lower Salt River (U.S. Fish and Wildlife Service 1976). Desert suckers were only slightly more abundant than Sonora suckers (30% to 20% respectively). Green sunfish, carp and largemouth bass comprised between 11 percent and 15 percent of the catch (15.5%, 11.5% and 11.0% respectively). Only yellow bullheads (7%) and bluegills (3.7%) accounted for more than one percent of the remaining potential prey fish caught.

In 1989, we collected 469 potential prey fish in gill nets set overnight in pools and in floating gill nets and throw nets used in riffle and run habitat in the daytime. Relative abundance of fish caught in the Lower Salt River (Blue Point breeding area) was almost identical to fish caught in Lower Verde River (Bartlett Dam to the confluence)(see Section B4.1). Desert suckers and Sonora suckers accounted for 94 percent of fish collected (58% and 36% respectively). Roundtail chub, largemouth bass, green sunfish, carp, rainbow trout, and flathead catfish cumulatively accounted for only 6 percent of fish collected. To summarize the differences in results between our surveys in 1989 to USFWS surveys in 1973, there was (1) a greater proportion of suckers in the catch in 1989 compared to 1973 (94% compared to 50% respectively); (2) desert suckers increased in abundance relative to Sonora suckers in 1989; and, (3) fewer carp, green sunfish and largemouth bass were collected in 1989.

The observed changes in relative abundance of potential prey fish in the Lower Salt River from 1973 to 1989 mirrors changes we observed in the Lower Verde River from Bartlett Dam to the confluence of the Salt and Verde rivers (see Section B4.1). Dissimilarities in abundance data in 1973 and 1989 may have resulted from differences in sampling techniques or may have reflected actual changes in the fish community. In the visual surveys we conducted in the Lower Salt River in 1988 and 1989, suckers were by far the most abundant fish observed whereas carp were relatively rare. Furthermore, we recorded that the male eagle (AM01) in the Blue Point Breeding area in 1988 took 35 suckers from the river but failed to take a single carp from the river. All carp recorded taken by the male eagle in 1988 came from Saguaro Reservoir. The female eagle in 1988 caught only one carp compared to nine suckers (origin of carp was unknown). The fact that we rarely observed carp in the lower Salt River and that the eagles rarely foraged on carp in the territory suggests that our relative abundance data probably represents current conditions.

Size and Sex Distribution of Suckers. Desert suckers collected in our nets appeared to separate bimodally into size classes ranging from 200–270 mm TL and from 290–490 mm TL (Figure B4.2-16). The largest desert sucker collected in this territory measured 483 mm TL. Similarly, the Sonora sucker collected could be separated into two size classes ranging from 220–280 mm TL and from 350–570 mm TL (Figure B4.2-16). The largest Sonora sucker collected measured 564 mm TL. Adult Sonora suckers grow larger than desert suckers in the Lower Salt River; 14 percent of the Sonora suckers captured were larger than the largest desert sucker. Fish smaller than 200 mm TL of both sucker species are under-

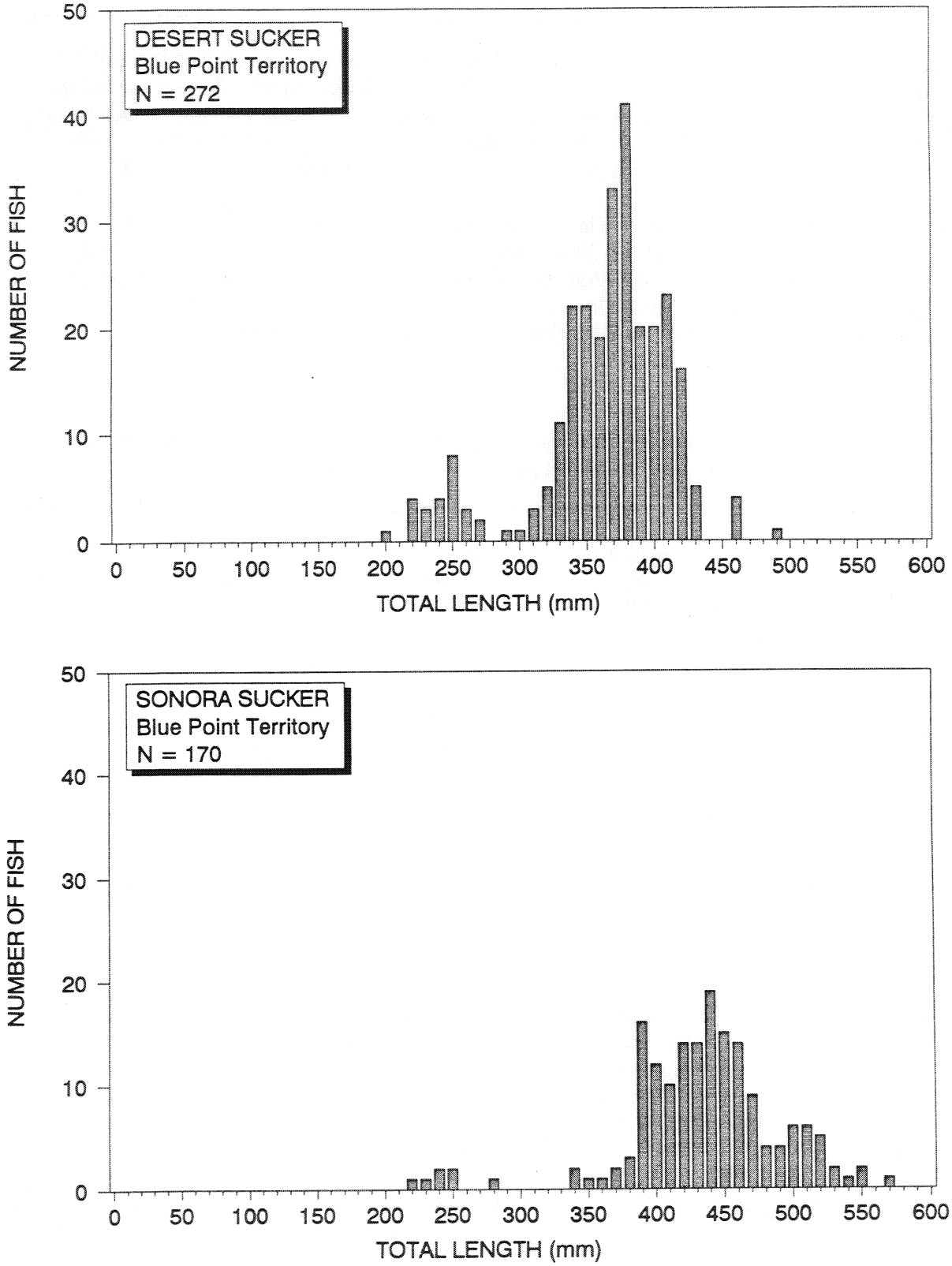


Figure B4.2-16. Size distribution in samples of desert suckers and Sonora suckers in the lower Salt River (Blue Point territory, 1989).

represented in out data due to gear selectivity. However, since we never recorded the eagles foraging on a sucker smaller than 200 mm TL at Blue Point or Bartlett (see Section B4.1.3), our data is representative of prey availability. We sexed 188 desert suckers collected in our nets; male desert suckers made up 70 percent of the catch (n = 132) while female suckers comprised 30 percent (n = 56). Of the 127 Sonora suckers sexed, 46 percent were males (n = 58) and 54 percent were females (n = 69).

B4.2.3.3 Habitat Changes With Flow. We mapped instream habitat in the Salt River below Stewart Mountain Dam (Km 10.0–20.0) on 20–22 January, 1988. Mean daily flow in the river was 12–14 cfs during the survey. Pools comprised approximately 80 percent of total habitat area in the river (Table B4.2-10). Runs accounted for 17 percent of total habitat area, while riffles made up less than 3 percent of the area. Low flow in the river resulted in a preponderance of pools from January through mid-February 1988.

Table B4.2-10. Habitat summary for the Salt River below Stewart Mountain Dam (Km 10.2–20.0) on 20–22 January 1988 when flow was 12–14 cfs.

Habitat Type	Habitat Length (m)	Percent of Total Length	Habitat Area (m^2)	Percent of Total Area
A1 Pool (<4′ deep)	560	6.0	18,021	6.2
A2 Pool (4–8′ deep)	1,107	11.8	35,181	12.0
A3 Pool (>8′ deep)	3,639	38.8	182,418	62.4
Riffle	727	7.7	7,211	2.5
Low-velocity Run	3,352	35.7	49,617	17.0
Totals	9,385	100.0	292,448	100.0

In late February, habitat in the river substantially changed as a result of increasing flows (see Figure B4.2-4). To identify changes in instream habitat with flow, we habitat-mapped the river from Km 15.8 to 19.8 on 3 March 1988 when flow was 1730 cfs. We compared the results with data collected at the same locations on 20 January 1988 when flow was 14 cfs (Tables B4.2-11 and B4.2-12). Changes in instream habitat with flow include a shift from predominately pools (75.7% total habitat area) at low flow (14 cfs) to predominately runs (94.7% total habitat area) at high flow (1730 cfs). Interestingly, while the total percent (by area) of riffles in this river segment did change considerably at the two flows (3.6% compared to 4.5%), total area (m^2) of riffle habitat more than doubled at the higher flow (10,108 m^2 compared to 4,751 m^2). Overall, habitat length and area increased considerably in the river segment between Km 15.8 and Km 19.8 at the higher flow (Table B4.2-12) due to an increase in river width and the filling of a side channel between Km 16.5 and Km 17.2 at the higher flow.

Table B4.2-11. Habitat summary for the Salt River below Stewart Mountain Dam (Km 15.8–19.8) on 20 January 1988 when flow was 14.0 cfs.

Habitat Type	Habitat Length (m)	Percent of Total Length	Habitat Area (m^2)	Percent of Total Area
A1 Pool (<4′ deep)	137	3.4	9,599	7.2
A2 Pool (4–8′ deep)	549	13.5	12,456	9.3
A3 Pool (>8′ deep)	1,144	28.2	79,010	59.2
Riffle	458	11.3	4,751	3.6
Run	1,775	43.7	27,587	20.7
Totals	4,063	100.0	133,403	100.0

Table B4.2-12. Habitat summary for the Salt River below Stewart Mountain Dam (Km 15.8–19.8) on 3 March 1988 when flow was 1,730 cfs.

Habitat Type	Habitat Length (m)	Percent of Total Length	Habitat Area (m^2)	Percent of Total Area
Riffle	267	5.8	10,108	4.5
Low-velocity Run	2,672	57.7	157,843	69.6
High-velocity Run	1,614	34.9	56,963	25.1
Eddy	46	1.0	1,150	0.5
Cascade	31	0.7	650	0.3
Totals	4,630	100.0	226,714	100.0

Figure B4.2-17 compares our data on the relative abundance of river habitat with habitat use by the foraging eagles. Note how pools disappear in high flows while percent riffles do not change significantly with changes in flow. As we also found at Bartlett, the idea that eagles selected riffles disproportionate to their availability is suggested by Chi-Square ($\chi^2 = 4.80$, df = 1, $p < 0.05$).

To further characterize habitat changes at different flows, we also determined changes in river width, mean depth, and maximum depth in the river at the upstream edge of Blue Point Bridge (Km 15.8) at three flows (9.7 cfs, 253 cfs, and 1140 cfs). As flows increased from 9.7 cfs to 1140 cfs, river width almost tripled at the site although mean depth increased by only 0.3 m (Table B4.2-13). These observed changes in river morphology should be used as a reference only, since changes at other locations in the river with flow may differ depending on bank slope.

Daily flows and water temperatures in the lower Salt River below Stewart Mountain Dam (Km 15.1–17.0) in 1988 and 1989 are illustrated in Figure B4.2-18. In general, temperatures from 1 January–21 February 1989 are higher than temperatures during the same period in 1988 due to lower flows in 1989 (mean of 0 cfs in 1989, mean of 10.9 cfs in 1988). Flows and temperatures for the rest of the nesting season (March–June) in 1988 and 1989 were similar (flows > 1000 cfs, temperature 14.5–18.5°C) except on the 24 April–1 May. On 24 April–1 May 1988, flows were less than 50 cfs and temperatures reached 23°C in the lower river. However, on 24 April–1 May 1989, flows averaged 1498 cfs and temperatures never exceeded 19°C.

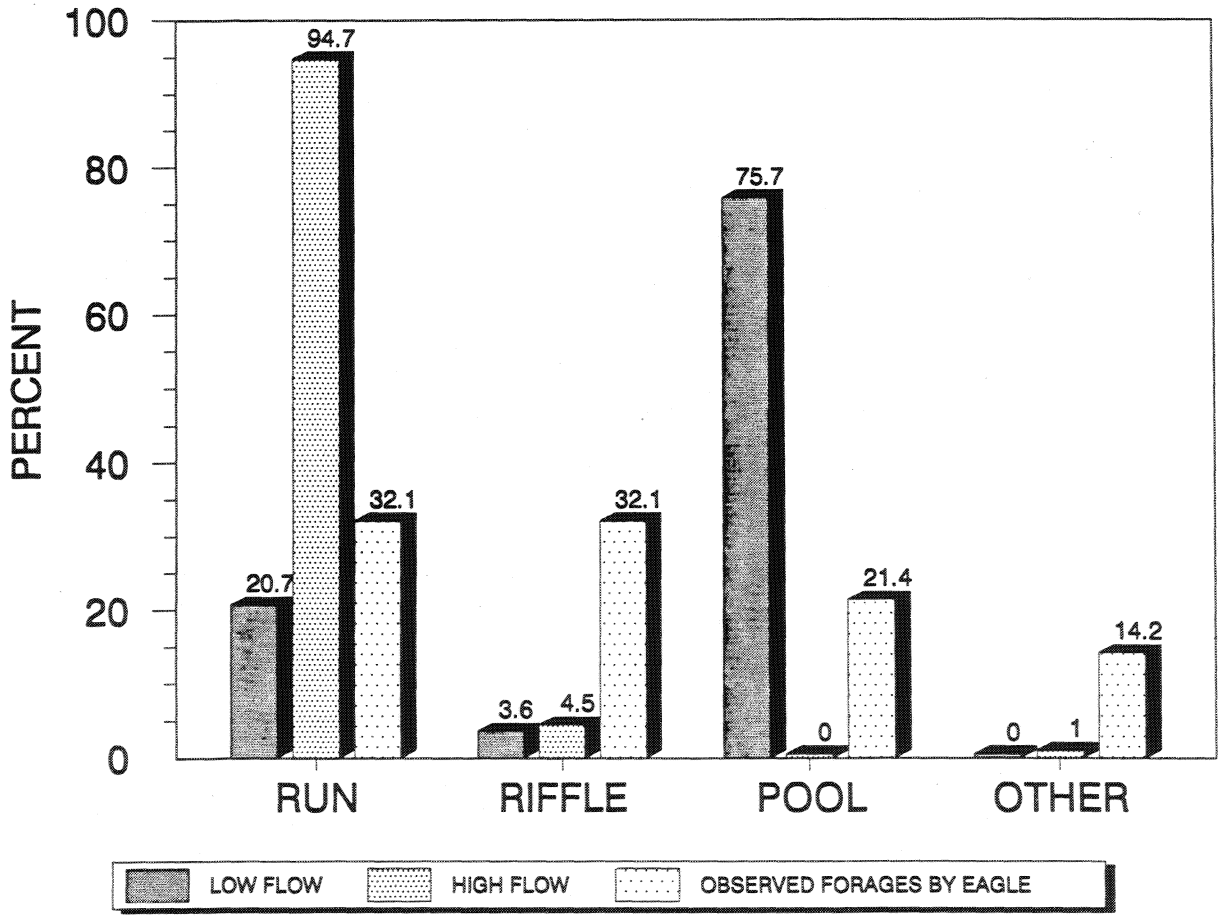


Figure B4.2-17. River habitat selection by foraging bald eagles at Blue Point compared to habitat availability.

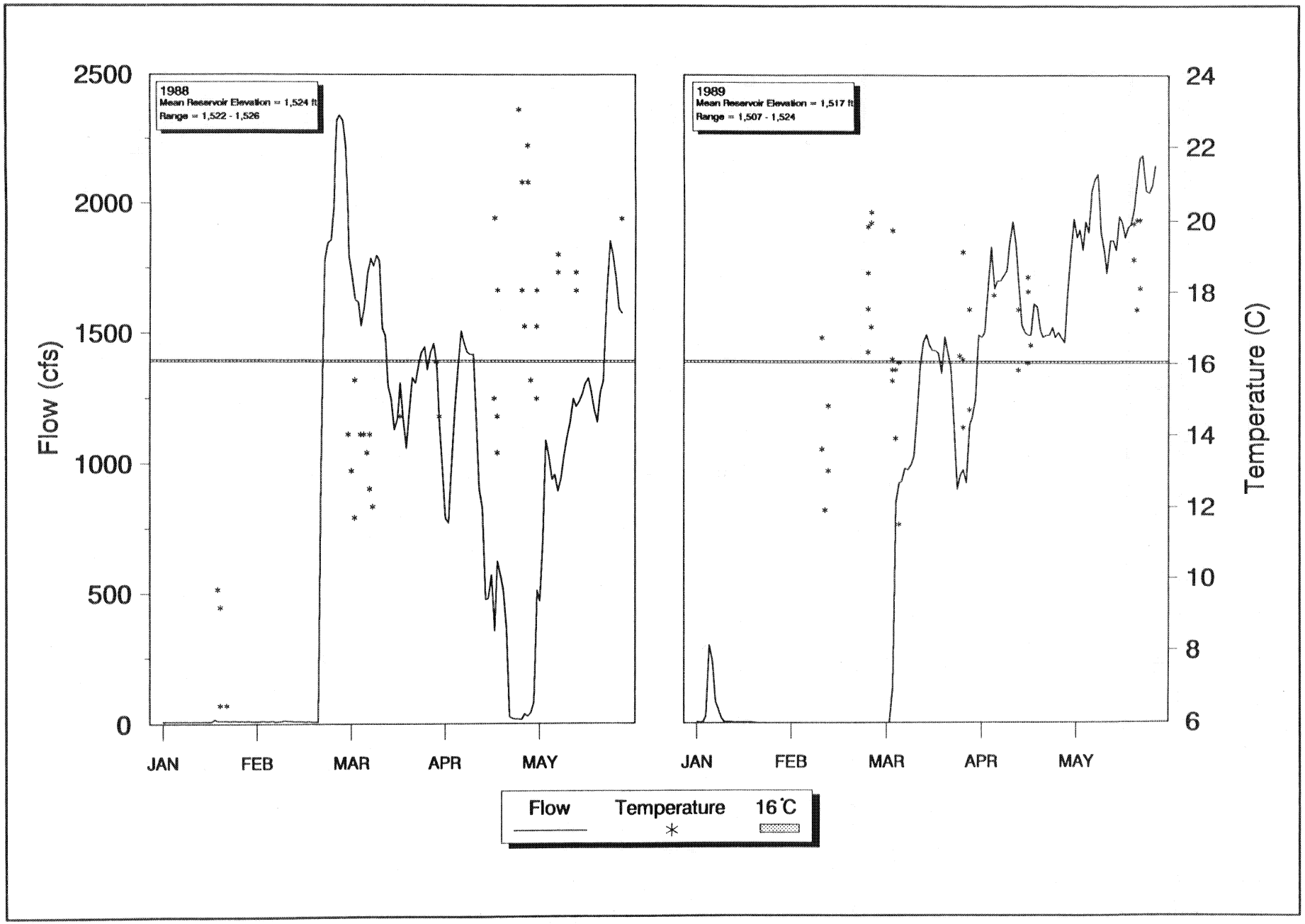


Figure B4.2-18. Mean daily flow and temperature measurements in the Salt River below Stewart Mountain Dam from January–June, 1988 and 1989. Mean and range of Saguaro Reservoir elevation are also provided for these months.

Table B4.2-13. Length and depth measurement taken in the Salt River at the upstream edge of Blue Point Bridge (Km 15.8) at 3 flows in 1988.

Date	Flow (cfs)	Width (m)	Mean Depth (m)	Maximum Depth (m)
4/27/88	9.7	25	0.4	1.1
4/19/88	253.0	32	0.6	1.4
3/17/88	1,140.0	72	0.7	1.9

B4.2.3.4 Distribution, Relative Abundance and Spawning Chronology of Suckers in 1988. In 1988, we conducted visual surveys on Salt River downstream of Stewart Mountain Dam on 20–22 January, early March, early April, late April, early May, mid-May to record the relative abundance, distribution, availability and spawning activity of potential prey fish in the Blue Point eagle breeding area. During these surveys we observed considerable changes in distribution, availability and spawning activity of prey fish which may explain the foraging behavior of the Blue Point pair.

Late January. Our visual surveys conducted from Km 10.0 and Km 20.0 in the Salt River in late January revealed that suckers were by far the most abundant fish species in the river, comprising over 99 percent of the fish observed. Visual surveys were quite accurate at this time due to low flow in the river (12–14 cfs). Pools made up over 75 percent of total habitat in the river in late January; runs accounted for over 20 percent of total habitat. Suckers exhibited great affinity for pool habitat in late January. Every pool examined (n = 18) from Km 10.0–20.0 contained from several hundred to tens of thousands of suckers. Total area of pools in the river in January was 235,620 m^2; individual pool area ranged 740 m^2 to 72,844 m^2. We could not estimate sucker numbers in pools due to the large numbers of suckers present, their tendency to swarm when disturbed, and low illumination in the deeper pools. To get an idea of the number of suckers that may inhabit a pool, the USFWS in 1975 (U.S. Fish and Wildlife Service 1976) used rotenone to sample a pool (2,613 m^2) just below Blue Point Bridge (approximately Km 15.2–15.4); it contained over 34,000 desert suckers and over 12,000 Sonora suckers.

Despite their abundance in pools, suckers were rarely observed in run habitat in late January. Only two runs we surveyed (n = 30) contained suckers. We estimated that 4,593 suckers inhabited the two runs. The two runs containing suckers comprised only 6.4 percent of total run habitat (by area) in the river and only 1.1 percent of total aquatic habitat. These two runs containing suckers were distinct from all the other runs in that they contained habitat over 0.8 m deep. Shallow runs (< 0.8 m deep) were apparently not used by suckers in January. Similarly, suckers were not observed in any of the riffles we examined (n = 26) in January. We did not observe any courtship or spawning behavior by suckers in either pool, run, or riffle habitat in late January. Afternoon water temperatures in January ranged from 8.7–10.5°C, well below the preferred spawning temperatures (14–18°C) of the suckers (see Section E3).

Based on the preference of suckers for deep water habitats (> 0.8 m) in late January, bald eagle foraging would probably not have been effective in the Salt River at this time. Eagle tracking during January revealed that the Blue Point male (AM01) was on the river only 12.5 percent of the time he was away from the nest; the remainder of his time was spent on Saguaro Reservoir where he foraged on waterfowl (Table B4.2-14). Further, we did not record any successful foraging in the river by the male eagle in January 1988.

Table B4.2-14. Number and percent of visitation hours to nest, reservoir, and river habitats by AM01 throughout the breeding season, 1988. The two right hand columns refer only to those periods when AM01 was away from the nest.

	Nest		Reservoir		River		Total Hrs.	Habitat Selection	
Date	Hrs	%	Hrs	%	Hrs	%	Observed	% Reserv	% River
6-14 Jan	9.0	20.0	31.5	70.0	4.5	10.0	45.0	87.5	12.5
2-11 Feb	62.0	65.6	23.5	24.9	9.0	9.5	94.5	72.3	27.7
2-10 Mar	40.5	48.5	36.5	43.7	6.5	7.8	83.5	84.9	15.1
16-24 Mar	54.0	40.8	40.5	30.6	38.0	28.7	132.5	51.6	48.4
19 Mar-7 Apr	62.0	43.7	30.0	21.1	50.0	35.2	142.0	37.5	62.5
13-21 Apr	50.0	38.3	44.5	34.1	36.0	27.6	130.5	55.3	44.7
26 Apr-5 May	43.5	31.0	66.5	47.3	30.5	21.7	140.5	68.6	31.4
12-19 May	62.5	49.0	64.0	50.2	1.0	0.8	127.5	98.5	1.5
26 May-1 Jun	7.5	35.7	13.5	64.3	0.0	0.0	21.0	100.0	0.0
TOTAL	391.0	42.6	350.5	38.2	175.5	19.1	917.0		

Early March. In early March 1988, visual surveys (two float trips and several snorkeling surveys) between Km 9.2-21.1 revealed changes in the distribution, habitat utilization and spawning activity of suckers compared to surveys conducted in late January. Flows of over 1000 cfs resulted in considerable changes in instream habitat. Pools were absent in the river; runs were by far the most abundant habitat type, followed by riffles. Observations from Km 9.2-21.2 in early March revealed three basic trends: (1) suckers comprised almost the entire potential forage base for eagles in the river; (2) suckers were abundant in shallow water (15-60 cm); and, (3) suckers were observed spawning in shallow water, preferring the broad tailwaters of low gradient runs adjoining swift, high gradient habitats (runs or cascades) and the upstream portion of riffles. We occasionally observed spawning along the margins of runs but sucker activity was considerably greater in the tailwaters of runs and the upstream edge of riffles. Afternoon water temperatures in the river ranged from 13.0-16.0°C in early March; optimum spawning temperature for suckers is 14-18°C (see Section E3).

Visual observations indicated that approximately 100 suckers per km were available (at depths <0.6m) to foraging eagles in the survey area (Km 9.2-21.1). Two exceptions were noted: (1) available sucker densities were noticeably higher in the expansive shallows between Km 17.1-17.4, with nearly 100 suckers per 100 m available; (2) suckers were almost absent from shallow water (<0.6m deep) between Km 19.9 and Km 21.2. Locations of extensive shallow water areas containing spawning suckers during early March 1988 are shown in Figure B4.2-19. Despite the abundance of spawning suckers available to the eagles in early March 1988, we did not record a successful forage by the Blue Point male (AM01) on the river until 18 March. However, between 18-24 March, we recorded seven successful forages by the male eagle on the river.

Early April. In early April, we conducted visual surveys (floating, snorkeling and fixed point observations) in the Salt River between Km 9.2 and Km 21.2. Flows during the early April surveys were similar to flows in early March (over 1000 cfs). Suckers were still available at spawning sites throughout the entire study area as in early March, however their distribution changed slightly (Figure B4.2-19). In general, sucker spawning activity was more vigorous in the upper river in early April compared to early March, particularly in Km 18.6-19.5. Spawning activity was also observed between Kms 20.0-21.0 for the first time in 1988. The majority of suckers observed in shallow water in early April were in spawning colors. Snorkeling surveys in habitats greater than 0.9 m deep between Kms 18.7 and Km 19.5 revealed that suckers in deep water did not display spawning colors or spawning behavior. Afternoon water temperatures in the Salt River from Km 12.0-21.2 in early April were similar ranging between 14.0 and 14.5°C; preferred spawning temperatures of suckers range from 14.0-18.0°C (see Section E3).

Based on the distribution of spawning suckers in early March and early April, potential prey were available to eagles from Kms 10.0-19.8. In early April, we observed that spawning activity was more vigorous at upstream sites (Km 18.6-21.2). The eagles' preference for river sites above Km 17.0 during 1-21 April 1988 may reflect the enormous abundance of spawning suckers at upstream sites, thus making downstream foraging trips inefficient from an energetics standpoint. Bald eagle perching opportunities are also better near the upstream sites.

Late April. We conducted visual surveys in late April (27 April-1 May) in the river from Km 9.2-21.2 at considerably lower flows than the early March and April surveys (9-23 cfs compared to over 1000 cfs). The late April surveys revealed that spawning suckers were only found in the river above Km 15.4, although spawning habitat was present at downstream sites (Figure B4.2-19). Despite efforts to flush fish, we observed low numbers of suckers from Km 9.5-Km 15.5; only 34 adult suckers were observed in water less than 60 cm deep. Snorkeling surveys in deeper runs and pools below Km 15.5 identified only 40 additional adult suckers. Previous surveys in this river reach in January, March and early April revealed thousands of suckers per Km.

In the Salt River above Km 15.4, we observed higher numbers of suckers spawning and feeding in shallow habitat (<0.6 m deep)in late April than in previous surveys in January, early March or early April. The higher numbers of suckers observed in the river above Km 15.4 in late April may be due to migration of suckers upstream as flows decreased and temperatures increased. Two regions of the river above Km 15.4 contained the greatest concentration of spawning suckers, namely Kms 15.4-16.0 and Kms 20.8-21.2. We collected 42 suckers in these areas in late April to assess reproductive status; all the suckers released gametes when handled.

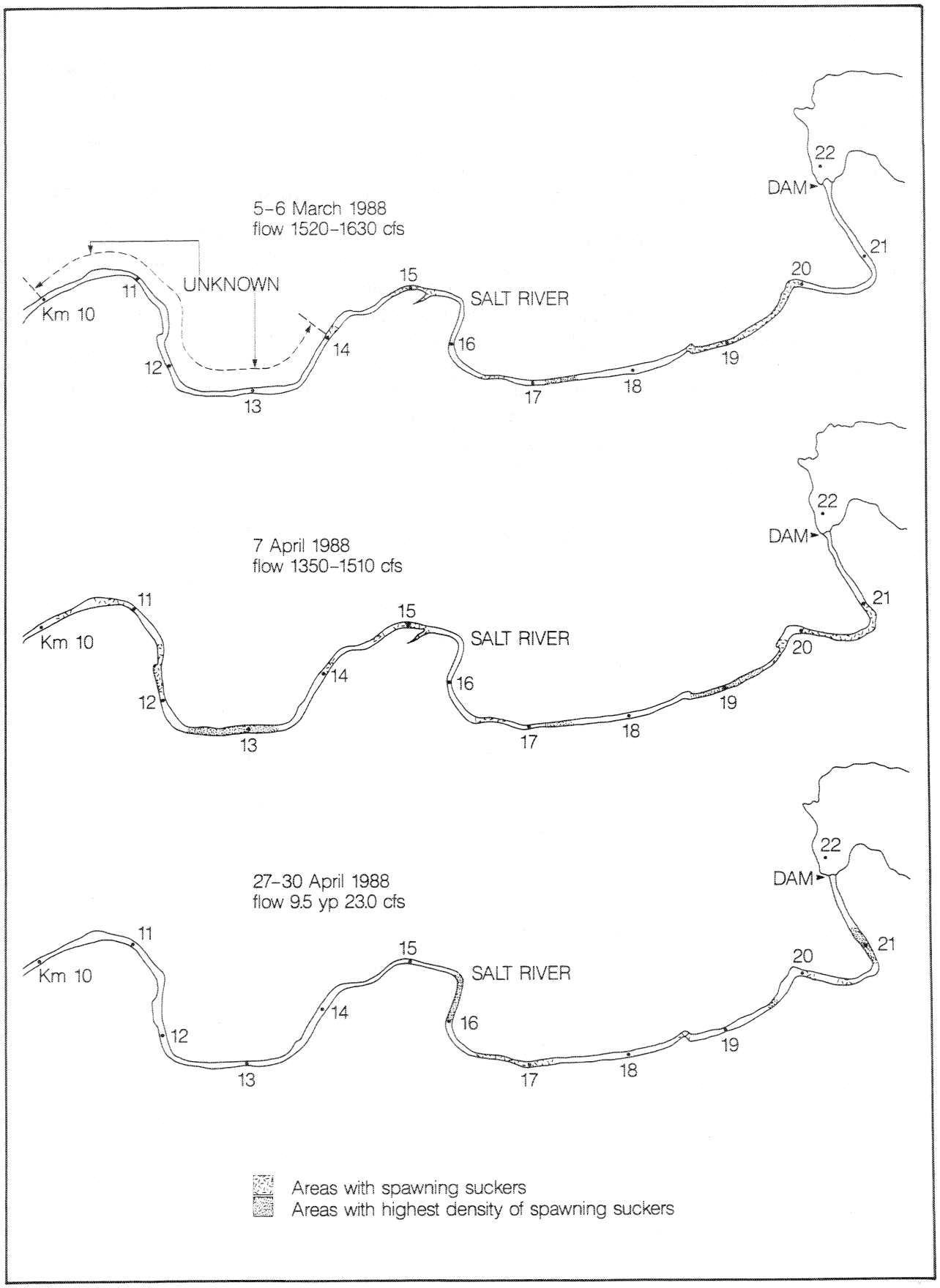


Figure B4.2-19. Seasonal changes in the distribution of spawning suckers as recorded in visual surveys.

The large number of spawning suckers observed between Km 20.8–21.1 in late April, where previously only a small number were present, may be related to habitat changes as flows decreased from over 1000 cfs to less than 24 cfs. This section of river from Km 20.8–21.2 has steeper banks than other portions of the river, therefore, velocities and depths in the area are more sensitive to flow changes. During high flows, velocities and depths may be above those preferred by spawning suckers. As flows decreased in late April to less than 24 cfs, water depth and velocity decreased considerably in the area.

The absence of spawning suckers downstream of Km 15.4 during the late April surveys may be related to temperature. We recorded that the preferred spawning temperatures of suckers in the Salt and Verde rivers range from 14°C and 18°C (see Section E3). Afternoon water temperatures varied considerably in the study reach (Km 10.0–21.0) during the last week in April. Low flows in the river combined with high air temperatures led to significant warming of the water in downstream areas. Afternoon water temperatures at Km 20.2 in late April ranged from 17.0–19.5°C; near the preferred spawning temperatures of the suckers. However, at the Blue Point Bridge (Km 15.8), afternoon temperatures ranged from 20.5–21.0°C, higher than the preferred spawning temperatures of the suckers. Afternoon temperatures further downstream (Km 9.5) were 23°C. We hypothesize that as water temperatures increased in the downstream reaches above the temperatures preferred by suckers for spawning (14–18°C), the fish migrated upstream seeking cooler water.

The flow reduction in late April not only concentrated spawning suckers in the river above Km 15.4 but also led to an increase in the availability of carrion suckers. We conducted nine carrion surveys between Kms 9.5–21.1 from 21 January to 1 May (Table B4.2-15). Prior to 29 April, we found few dead fish during these surveys (0–2.2 fish/km). Many of these fish were at depths greater than 60 cm and, therefore, unavailable to the eagles. Carrion surveys conducted 29 April to 1 May revealed between 1.3 and 7.2 fish/km. This does not include the large braided section of the river located between Km 16.8 and Km 17.2.

At Kms 16.8–17.2 a large braided portion of the river was isolated from the main channel and dewatered on 24 April, when flow decreased from 341 cfs to only 14 cfs. Mean daily flows continued to drop below 10 cfs on 26–28 April. On 29 April, we conducted a carrion survey in the dewatered section of the river (Table B4.2-15). Filamentous algae grew in dense, profuse mats over most of the remaining water in the braid. An estimated 750 suckers were found floundering in the braid in isolated pools less than 60 cm deep; 256 suckers had already died there. Desert suckers made up 69 percent of the carrion, followed by Sonora suckers (23%). Dead desert suckers ranged 33.7 cm to 39.4 cm in size while Sonora suckers were 27.7 cm to 52.1 cm. Many of the dead or dying suckers had open wounds ventrally at the base of their pelvic and pectoral fins, apparently from struggling to get into deeper water. By 3 May, flow had increased to 499 cfs, fully inundating the braid and restoring it to a deep run. As flow increased, dead and dying suckers were flushed from the area.

Given the abundance of spawning suckers in late April above Km 15.4, especially between Kms 15.4–16.0 and between Kms 20.8–21.2, bald eagles should have concentrated their foraging in the upper Salt River. The abundance of carrion between Kms 16.8–17.3 at this time should also have also drawn eagles to forage on the upper Salt River. However, we saw AM01 capture only two suckers, one largemouth bass and one unidentified fish on the river during late April. These captures were made between Kms 20.0–20.8. We recorded no foraging by eagles on the dead or dying suckers in the dewatered braid. The large amount of yellow bass carrion present at this time in Saguaro Reservoir apparently provided sufficient food nearer to the nest, thereby reducing dependency on the resources of the Salt River.

Table B4.2-15. Summary of carrion surveys in the Salt River below Stewart Mountain Dam (1988).

Date	Method of Travel	Number of: Desert Sucker	Sonora Sucker	Unknown Sucker	Other Fish	Total Number of Fish	Reach (Km)	Distance (km)	Fish/km
21 January	Walked	8	2	7	2	19	10.2–20.0	9.8	1.9
5 March	Canoed	0	0	5	0	5	15.8–19.9	4.1	1.2
6 March	Canoed	0	0	1	0	1	15.8–19.9	4.1	0.2
1 April	Walked	1	1	0	0	2	12.4–13.3	0.9	2.2
1 April	Snorkeled/ Walked	0	0	0	0	0	18.7–19.5	0.8	0.0
7 April	Canoed	1	1	3	2	7	9.5–21.1	11.6	0.6
29 April*	Walked	197	63	31	1	292	15.4–20.4	5.0	58.4
30 April	Walked	2	1	1	0	4	12.4–15.4	3.0	1.3
1 May	Walked	18	7	4	5	34	9.5–15.5	6.0	5.7
* Breakdown of carrion observed from Km 15.4 to Km 20.4 on 29 April 1988:									
Main river channel		20	5	10	1	36	15.4–20.4	5.0	7.2
Right braid of river with stranded suckers		177	58	21	0	256	16.8–17.2	0.4	640.0

However, in late April we noted higher numbers of anglers, RV enthusiasts, and sunbathers utilizing the river (see Section B4.2-4). This increase in recreational activity may have discouraged the eagles, because in late April their foraging on the river was confined to the Bulldog Cliff area, which was closed to the public. After flows increased in early May, tubing activity substantially increased, with as many as 70 tubers per hour passing Blue Point Bridge.

Sucker courtship and spawning in the Salt River markedly decreased after 1 May and remained low for the remainder of the field season (3 May–2 June). Modified flow and temperature regimes in the river after 1 May probably hastened the termination of sucker spawning. Flow increased from 24 cfs on 1 May to 499 cfs by 3 May, and fluctuated between 455–1820 cfs for the remainder of the month. Afternoon water temperatures in the river decreased by as much as 4°C after flows increased, despite warmer ambient temperatures.

On 3 May, just after flow increased to 499 cfs, we observed suckers only rarely in shallow water (<60 cm deep). We walked the river section between Km 20.8 and Km 21.2 without flushing a single sucker. When flow was low five days earlier, we had observed more than 100 suckers. Similarly, observations on 3 May at a downstream riffle at Km 15.2 revealed no suckers, despite the presence of numerous spawning individuals in March–April at this site. We only observed suckers in water deeper than 0.76 m; none exhibited spawning colors or courtship activity.

Later in May (10, 16, and 31 May) when flows had stabilized, we saw only moderate numbers of suckers in shallow water at Kms 14.9–15.2 and at Kms 17.1–17.4. In these areas we noted courtship activity only occasionally, and the majority of fish were not in spawning colors. In other areas of the river, most suckers were holding in water well below the striking depth of bald eagles. These fish were not in spawning colors and exhibited no courtship or spawning behavior.

Tracking data revealed that the Blue Point male bald eagle rarely foraged on the river in late May, spending only one percent of his time away from the nest on the river between 12–19 May. Further, this eagle completely avoided the river late in the month (26 May–1 June), preferring instead to forage on Saguaro Reservoir.

Summary of 1988 Observations. In 1988, we observed that suckers were not found in shallow water (<0.6 m deep) early in the nesting season but preferred to inhabit pools and deep runs. However, by early March, the suckers had begun spawning and they were quite abundant in shallow water habitat, preferring the upstream edge of riffles and tailwaters of shallow runs, from Km 10.0–21.2. As the nesting season progressed, the distribution of adult suckers became more restricted. By late April, adult suckers were only observed upstream of Km 15.4. Spawning in May was only observed near Bulldog Cliffs (Km 21.0). We hypothesize that suckers migrated upriver during the nesting season to seek out areas with water temperatures near the optimum range for spawning (14–18°C).

Distribution, Health and Spawning Chronology of Suckers in 1989. We observed considerable differences in the distribution, spawning chronology, and health of suckers in the Salt River below Stewart Mountain Dam in 1989 compared to 1988. These differences appear to be the result of differences in flow releases between the two years. Although flows in both years were relatively low for most of January and February (<18 cfs); in 1989, no water (0 cfs) was released from the Saguaro Reservoir between 22 January and 5 March, a factor which may have affected the health of the suckers. This stoppage of flow below Stewart Mountain Dam was apparently unprecedented and was only recently made possible due to dam repairs in 1988. Prior to 1988, the dam leaked approximately 9–10 cfs at all times. Flows were similar in the spring (March–June) of 1988 and 1989, generally fluctuating between 1000–2000 cfs, except for one period in 1988 (24 April–2 May) when flows dropped between 17–81 cfs resulting in high instream temperatures.

Visual surveys (fixed point and snorkeling) in 1989 revealed differences in sucker behaviors between the two years. We conducted visual surveys in 1989 on 11–15 February, 26–27 February, 6–9 March, 23–31 March, 16–19 April, and 24–25 May. Sucker activity is summarized in Figure B4.2-20. To highlight differences in sucker activity within the breeding area in 1989, we separated the area into two reaches: a downstream reach (Km 6.6–12.5) and an upstream reach (Km 15.0–22.0).

February Surveys (No Flow). During our February surveys in the Salt River from Km 6.0–21.2, no water was being released form Saguaro Reservoir, although in isolated sections of the river downstream of Km 13.0, we observed some flow between pools. However, the majority of suckers at this time were isolated in pools of varying water quality (Table B4.2-16). Water temperatures and dissolved oxygen varied considerably in these isolated pools, even pools only a short distance apart. In general, the shallower the pool, the higher the water temperature and the lower the dissolved oxygen.

We observed a wide range of activity and health of suckers in pools. In pools with water temperatures in the preferred spawning range of the suckers, we observed vigorous courtship and spawning by the

suckers at the upstream and downstream edges of the pools despite no perceivable flow. In other pools, with high temperatures and low dissolved oxygen, the suckers were quite lethargic, rarely moving for hours at a time. Carrion suckers were observed in many of the pools. No courtship or feeding behavior was observed in pools with high temperatures (> 19°C) or low dissolved oxygen.

We snorkeled five pools containing lethargic suckers to observe the fish closer. When we approached the suckers and spooked them, many of the fish swam a short distance and then began vigorously spinning between the water surface and the bottom before coming to rest on the bottom and often died a short time later. We also observed the same behavior in fish snagged by anglers in several pools (*i.e.*, dying after a short fight). We attribute the stressed condition of suckers to low oxygen concentrations.

To assess reproductive status in the upstream reach (Km 15.0–20.5), we examined adult desert and Sonora suckers collected in pools and exhibiting courtship behavior during 12–27 February. Fifty-eight of 74 desert suckers (78%) and 18 of 42 Sonora suckers (43%) were releasing gametes. The remaining fish examined were pre-spawners (containing developing gametes). We also examined suckers at downstream sites (Km 7.0–12.5) between 12–27 February. Almost 95 percent of the desert suckers examined (n = 37) were releasing gametes at this time. Similarly, 14 of 18 Sonora suckers examined were releasing gametes.

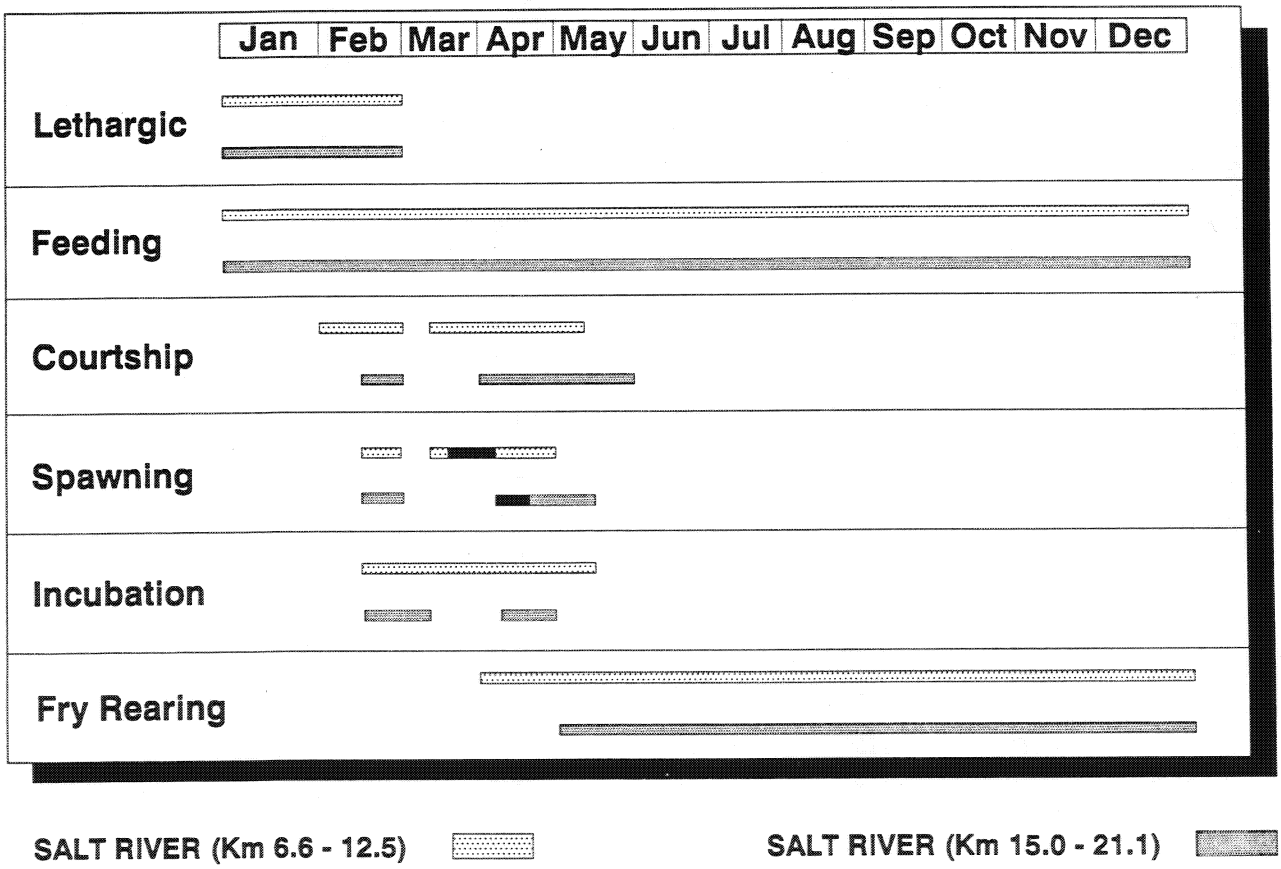
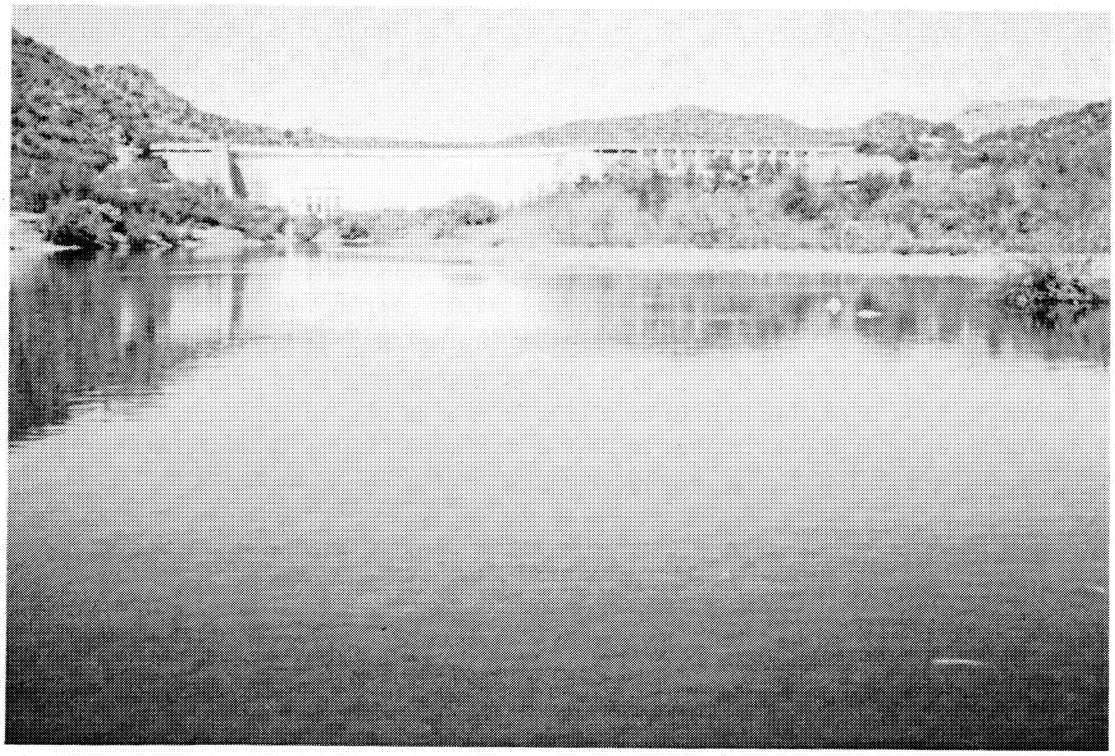


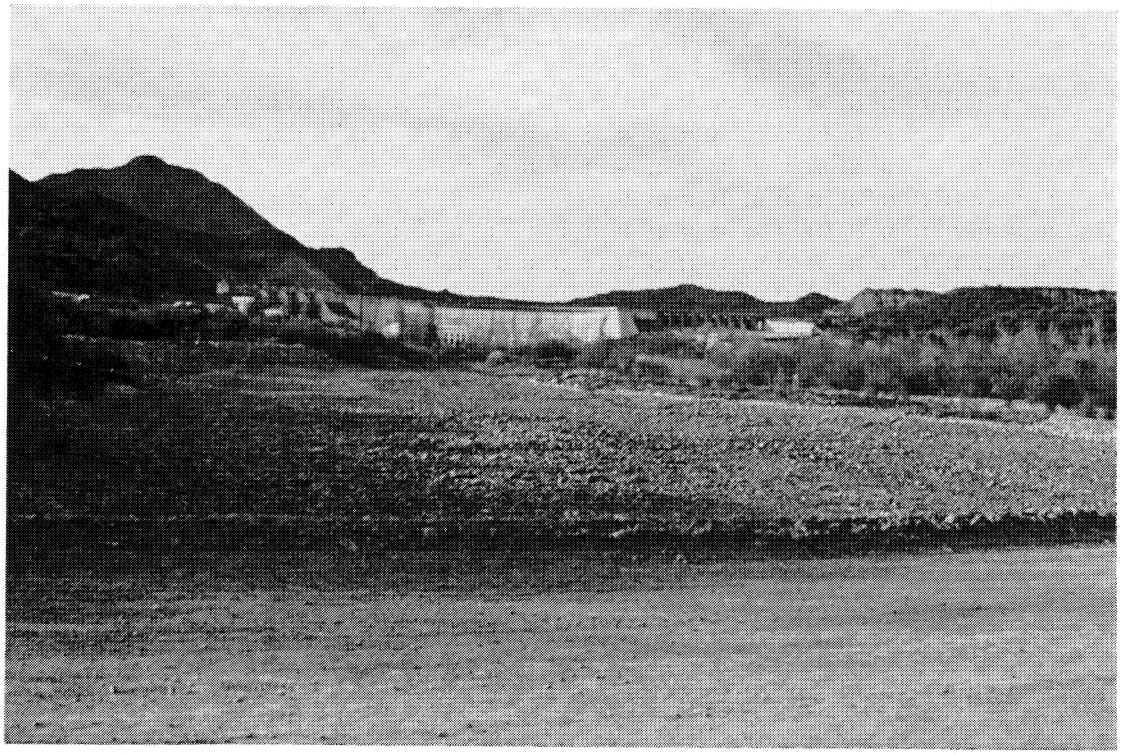
Figure B4.2-20. Sucker activity in two reaches of the Salt River within the Blue Point eagle territory in 1989. Activity of desert and Sonora suckers are not differentiated in this figure.

Table B4.2-16. Temperature and dissolved oxygen measurements in the Salt River below Stewart Mountain Dam in February and March 1989.

Date	Flow	Time	Km	Water Temp. (°C)	D.O. (ppm)
2/12/89	0	912	12.3	13.2	5.8
2/12/89	0	840	15.8	14.1	1.7
2/12/89	0	850	16.0	11.9	7.4
2/13/89	0	1355	12.3	14.3	6.8
2/13/89	0	1325	15.8	14.8	3.4
2/13/89	0	1332	16.0	13.0	7.3
2/13/89	0	1306	17.0	13.8	9.0
2/13/89	0	1300	17.1	15.0	4.5
2/26/89	0	1206	12.3	17.2	5.4
2/26/89	0	1206	12.3	15.5	4.6
2/26/89	0	1644	12.3	16.0	4.7
2/26/89	0	1640	12.3	19.6	7.8
2/26/89	0	1130	15.8	17.0	2.1
2/26/89	0	1658	15.8	19.8	3.0
2/26/89	0	1133	15.8	17.0	2.1
2/26/89	0	1707	16.0	18.5	4.6
2/26/89	0	1707	16.0	17.5	3.2
2/26/89	0	1142	16.0	16.3	3.1
2/26/89	0	1140	16.0	17.3	3.7
2/26/89	0	1740	17.0	19.5	9.5
2/26/89	0	1734	17.1	20.3	6.4
2/26/89	0	1734	17.1	19.0	5.8
2/26/89	0	1820	19.2	19.6	10.7
3/07/89	850	1630	7.0	17.0	9.6
3/07/89	850	820	12.3	12.6	9.3
3/07/89	850	1646	12.3	16.5	9.9
3/07/89	850	1705	15.8	15.8	10.0
3/07/89	850	840	15.8	12.9	9.3
3/07/89	850	1720	19.5	15.0	9.8
3/07/89	850	855	19.5	13.1	10.2
3/08/89	926	1150	7.0	15.1	10.2
3/08/89	926	1150	7.0	15.1	10.2
3/08/89	926	1210	12.2	15.7	10.3
3/08/89	926	1215	12.3	15.7	10.3
3/08/89	926	1235	15.8	16.0	11.4
3/08/89	926	1230	15.8	16.0	11.4
3/08/89	926	1245	19.2	16.0	9.5

Plate B13. Stewart Mountain Dam with flow terminated but leakage of 7 cfs from dam into lower Salt River, 7 November 1986 (top), and with flow terminated (0 cfs) and dry riverbed, after leaks in dam were repaired, 21 March 1990 (bottom)(photos by D. Driscoll).





The effects of flow cessation and low oxygen conditions in some of the isolated pools have mixed effects on the availability of bald eagle prey. In the short term, food accessibility for eagles may increase in the form of carrion. However, in the long term, sucker numbers may decrease due to direct mortality from poor water quality and reduced spawning success as suckers are stimulated to deposit eggs in areas where survival is questionable (i.e., habitats with no flows). We recommend further studies to address this issue.

Early March Surveys (1–4 days after initial flow releases). Flow releases resumed on the Salt River below Stewart Mountain Dam on 6 March 1989. We conducted visual surveys on 6–9 March 1989 from Km 21.2–7.0; flows during the surveys ranged from 850 cfs to 933 cfs. On 6 March, just prior to flow releases, we observed vigorous spawning activity by suckers in the lower reach. However, in the upper reach, the majority of suckers (>90%) were lethargic. Minor courtship was observed at only one pool (Km 19.2) in the upper reach. On the 7–9 March, after flow resumed, no courtship or spawning activity was observed in either the upper or lower reach. Most of the suckers observed appeared to be foraging. We hypothesize that the resumption of flow improved water quality conditions in the upper reach but stopped spawning until temperatures stabilized. We doubt if many of the eggs laid earlier in the season, when no flow was present in the river, would have survived the sudden increases in flow.

Late March Surveys. Visual surveys conducted from 23–31 March 1989 revealed considerable differences in spawning intensity in the two reaches. In the upper reach (Km 15.0–22.0), we observed only minor courtship, and that most suckers were concentrating on feeding. While in the lower reach (Km 6.6–12.5) intense courtship and spawning by suckers occurred in shallow water habitat, particularly Km 6.4–7.0. Interestingly, we measured only slight differences in water temperatures in the upper and lower reaches. The water temperatures in both reaches ranged between 15–19°C, within the preferred spawning temperatures of the suckers. We examined 27 Sonora suckers from the upper reach, of which six had spawned out, 19 released gametes when handled, and two contained developing eggs. We examined only four Sonora suckers in the lower reach in late March, of which three had spawned out and one contained developing gametes.

Mid-April Surveys. In visual surveys conducted in mid-April (16–19 April) we observed a shift in the location of peak spawning activity from the lower reach to the upper reach. Fry were quite abundant in the lower reach at this time, suggesting successful spawning had occurred earlier. In the upper reach, spawning suckers were observed in all suitable habitat. While in the lower reach, the areas previously utilized by spawning suckers in March were used almost exclusively by foraging suckers. We did observe some courtship activity in these areas in mid-April, however, the groups of courting suckers always broke up prior to spawning. This behavior (breaking up prior to spawning) is characteristic of suckers near the end of the spawn.

We examined 44 desert suckers and 15 Sonora suckers in the upper reach to assess reproductive status. Over 93 percent of the desert suckers (n = 41) and 40 percent of the Sonora suckers (n = 6) released gametes when handled; the rest of the fish were spawned out. In the lower reach, we obtained more variable results. Only 4 of 9 desert suckers examined released gametes when handled; the remaining fish were either spawned out (n = 1) or contained immature gametes (n = 4). The majority of Sonora suckers examined (n = 5) contained immature gametes although one was spawned out.

May Surveys. The last surveys conducted on the river in 1989 were on 24 and 25 May. At this time, we did not observe any courtship or spawning activity by suckers in the lower reach (Km 6.6–12.5); rather all the fish observed were feeding. None of the feeding suckers were in spawning colors in the lower reach. In the upper reach, spawning activity was greatly reduced from the previous survey although an occasional group of suckers did spawn. The majority of suckers exhibiting courtship behavior broke up prior to spawning. Sucker fry were quite abundant in the upper reach in late May (the first time in 1989). Sixteen desert suckers were examined in the upper reach in late May to assess reproductive status, of which 15 were spawned out and 1 released gametes when handled. Interestingly, we did not observe a migration of adult suckers out of the lower reach in 1989 as we noted in 1988.

Migration of Suckers. To further verify that adult suckers did not make a major migration to upstream areas in the spring of 1989, we conducted snorkeling surveys in five reaches of the Salt River in late March and late May (Table B4.2-17). We hypothesized that if a sucker migration had occurred in 1989 as in 1988 then significantly different numbers of suckers should have been observed in the reaches in late March compared to late May. Our data revealed that sucker numbers were not significantly different in the five reaches during the two survey times (paired sample t-test, $p = 0.05$).

Table B4.2-17. Number of suckers observed during snorkeling surveys in five reaches of the lower Salt River in 1989.

	Number of Suckers Observed			
	River Left Transect		River Right Transect	
km	30 March	24 June	30 March	24 June
7.0–6.0	375	182	359	376
9.7–9.0	162	68	231	106
13.25–12.35	188	340	295	343
17.2–15.55	652	378	700	440
19.8—18.65	316	215	268	279

Comparison of 1988 and 1989 Observations. In both 1988 and 1989 we observed that suckers spawned earlier in downstream areas of the Salt River (Km 6.0–12.5) than further upstream, with peak spawning in the lower reach occurring in March. As the nesting season progressed, the distribution of spawning suckers shifted upstream, with peak spawning occurring in April in above Km 15.8. By May in both years, sucker spawning was essentially concluded in the Salt River, although courtship was occasionally observed near Bulldogs Cliffs (Km 20.7). The main differences in sucker activity in the two years was: (1) the majority of adult suckers migrated upriver in late April 1988 when flows decreased and

temperatures increased to 23°C, concentrating them in the river above Km 15.5. No such migration was observed in 1989 when flows remained high (> 1000 cfs) and temperatures remained below 19°C in the lower river; and, (2) stopping all flow in January and February 1989 resulted in poor water quality in some pools that led to carrion and early spawning by some suckers.

Saguaro Reservoir Fisheries Methods. Fisheries studies on Saguaro Reservoir in 1988 were directed toward determining: (1) seasonal and diel abundance of fish in shallow cover; (2) location of shallow areas in the reservoir (water depth < 0.9 m) where fish were vulnerable to eagle predation; and, (3) fish behaviors and mortality factors which increase food availability to bald eagles.

Willow Springs Cove was selected for detailed study in 1988 based on substantial eagle foraging in the cove late in the 1987 field season. For comparison, we selected another cove, Peregrine Cove (Figure B4.2-9) where one successful forage was recorded in 1987. Visual surveys in these two coves began in March 1988 before the mid-April switch of eagle foraging efforts from the Salt River to Saguaro Reservoir. We conducted additional visual surveys in the coves on 5 April, 2 and 17 May, and 1 June to observe seasonal trends in fish abundance.

Fisheries biologists watched the shallow areas of the coves from elevated observation points. Information collected included fish species, abundance, approximate length, fish depth distribution, and specific responses to recreational activity. We only surveyed areas of the coves less than about 1.2 m deep. Two observation points per cove were established, overlooking the rear (shallow) areas of both coves. The observation points in Willow Springs Cove were on a cliff approximately 12.2 m above the water surface. The terrain around Peregrine Cove was less steep than at Willow Springs Cove, offering a lesser viewing angle and interference from vegetation, a problem no doubt shared by eagles attempting to forage there. Sampling the two coves no more than one day apart, the fisheries biologist alternated between the two observation points every 0.5 hours, from 2 hours after sunrise until 2 hours before sunset. Low light intensity in the early morning and late evening precluded meaningful sampling. We grouped observations in the coves into three periods, and the mean numbers of fish observed per time period was calculated. Binoculars (7 × 35 and 10 × 50), a spotting scope (20×), and polarized sunglasses aided observations.

On 4 April 1988 (reservoir elevation = 1524 ft) two fisheries biologists surveyed the shoreline of Saguaro Reservoir by boat, noting areas less than 1 m deep as potential eagle foraging areas. We noted fish presence and availability of bald eagle perch sites in these areas.

Fisheries biologists conducted carrion surveys by boat on 5 and 30 April and on 2 May 1988 in the early morning between SKms 16.4 and 17.7, a section of the reservoir where we had observed foraging on dead or dying fish. The latter team measured fish, inspected them for cause of death and gonad development, and returned each sample to the reservoir.

We set four experimental gill nets overnight between SKms 16.4 and 17.7 on 5 and 7 April and on 2 May 1988. Gill nets measured 26.5 m long by 2 m deep and contained four 6.7-m sections of mesh size 8.9, 6.4, 3.8 and 1.3 cm. Seven gill nets (45.7 m long) were also set by personnel of the Arizona Game and Fish Department on 3 May 1988. All fish collected were weighed and measured, and reproductive status was also noted in April and May. We also conducted qualitative snorkeling surveys between Peregrine Cove and Willow Springs Cove to try to locate yellow bass spawning areas.

B4.2.3.5 Saguaro Reservoir Fisheries. In 1987 AM01 shifted foraging intensity from the Salt River in March and April to Saguaro Reservoir in May and June. Foraging concentrated in Willow Springs Cove and in the area of drowned mesquites. In 1988, successful foraging by AM01 at Saguaro Reservoir increased in late March and remained high through May. Prior to 21 April 1988, AM01 used the reservoir and river about equally, but after 21 April foraging concentrated in Saguaro Reservoir. Willow Spring Cove and the area of the drowned mesquites were not used as extensively by eagles in 1988 compared to 1987. Instead, open water areas of the reservoir were hunted more successfully. Two fish species, yellow bass and largemouth bass, comprised the majority of prey taken in 1988 (Table B4.2-5).

Bald eagles preyed upon spawning yellow bass from 30 March to 19 May 1988, with 39 individuals delivered to the nest. The eagles did not take yellow bass until they began spawning. Prior to spawning, yellow bass in reservoirs occur in schools in mid-water regions of the pelagic zone; they rarely feed on the surface or enter shallow water. The majority of yellow bass were taken (all presumably moribund or as carrion) by the eagles in open water areas of the reservoir rather than in coves or shallow shoreline areas.

Two reasons appear possible as to why yellow bass are more available to eagles during spawning: (1) schools of spawners move into shallow water (0.6–1.0 m deep) for several hours, providing time for the eagles to locate and capture the fish; and, (2) yellow bass suffer high post-spawning mortality, which provides carrion for the eagles. The second possibility clearly explains the preponderance of open water forages, and it may be that virtually all are taken as dead or dying post-spawn fish.

Our first observations of dead and moribund yellow bass at Saguaro Reservoir occurred on 30 March 1988. This was also the date of the first delivery of a yellow bass to the nest. During limited surveys on 30 March and 4 April, six dead or dying yellow bass were found in the lower arm of Saguaro Reservoir. We also observed carrion yellow bass drifting into Peregrine Cove (2 and 18 May) and Willow Springs Cove (17 May) on three of the four days that fisheries biologists surveyed these coves in May. On 3 May, when we observed AM01 take a yellow bass in the pelagic zone of Saguaro Reservoir, an immediate survey of the area revealed one floating dead yellow bass.

During 30 March–18 May, we found 13 yellow bass, 2 largemouth bass and 1 bluegill floating in the lower arm of Saguaro Reservoir. The majority of carrion yellow bass handled during this period released gametes. The majority of yellow bass examined from gill nets in May were also reproductively active. Yellow bass were the most abundant species captured in gill nets and the most numerous fish noted during carrion surveys on the reservoir. Among the total carrion counted were 29 yellow bass, 21 threadfin shad, 4 largemouth bass, 4 carp, 4 channel catfish, 3 walleyed pike, 3 bluegill, 1 green sunfish, and 1 coot.

In addition to yellow bass, bald eagles used largemouth bass in 1988 at Saguaro Reservoir. The eagles delivered 22 largemouth bass to their nest from 17 March–19 May. This species reportedly spawns from April through June (Minckley 1973). We observed them defending nests in Saguaro Reservoir in late March, a circumstance suggesting a connection between spawning and vulnerability to eagles. Although the largemouth bass frequently occurs in shallow water prior to spawning, its availability to eagles is probably limited due to the fish's propensity for hiding in cover and its adaptation as a sight-feeder which presumably renders it alert to a predator's approach. We are unaware of significant post-spawning mortality in largemouth bass populations, but carrion may be frequently available from angler-induced mortality.

Potential Foraging Habitat. In our survey on 4 April 1988 of the perimeter of Saguaro Reservoir to identify shallow areas (we omitted boat launches and swimming beaches), we identified four extensive shallows: Peregrine Cove, Willow Springs Cove, the area of drowned mesquites, and Bass Cove (Figure B4.2-9). Of these, the eagles extensively used only Willow Springs Cove and the area of drowned mesquites in 1987 or 1988.

Fish Availability in Peregrine Cove and Willow Springs Cove. We studied these two coves from March to early June 1988 to determine if eagles were responding to prey availability when selecting foraging sites (Table B4.2-18). In both coves, we most commonly observed bluegill and largemouth bass. In April 1988, more bluegill and largemouth bass appeared to be available to eagles in higher numbers in Willow Springs Cove than in Peregrine Cove. We saw relatively few carp in both coves in April. Tilapia were observed in Peregrine Cove, the first known occurrence of this species in the reservoir. Using a gill net in 1989, we caught one Tilapia in the cove (identification confirmed by J. Warnecke (AGF).

In Willow Springs Cove, the mean number of bluegills increased during daytime in April, with over 90 individuals in shallow water by late afternoon. The number of bluegills available earlier in the day ranged from 30–60 fish. In Peregrine Cove, bluegill numbers were also higher in late afternoon, but we observed only 20 fish near the water surface. Earlier in the day, 0–10 individuals were observed. Similarly, largemouth bass abundance in Willow Springs Cove peaked in late afternoon, with a mean of over 19 fish appearing vulnerable to eagle predation. Mean numbers of bass observed earlier in the day ranged from 7–11 individuals. In Peregrine Cove, bass numbers also peaked in late afternoon, but only 11 appeared to be available to eagles. Earlier in the day we noted less than three individuals.

In May and early June, fish availability dramatically changed in Willow Springs and Peregrine coves. The mean number of bluegills in Willow Springs Cove lowered substantially in May and June, but increased in Peregrine Cove, peaking in the early morning at over 60 individuals. In May and June, largemouth bass numbers in both coves were significantly lower than those in April. Conversely, mean numbers of carp in both coves substantially increased in May and June, higher in Willow Springs Cove than in Peregrine Cove. In May, in Willow Springs Cove, the number of carp available to eagles increased during the day and peaked in the late afternoon, with an estimated 31 carp observed in shallow water. In Peregrine Cove, carp availability was low in May, with less than eight carp observed at all times. In June, carp abundance increased in Willow Springs Cove, with over 70 carp observed in shallow water during mid-day. Tilapia numbers in both coves were relatively low in both months. In general, numbers were higher in the afternoon than in the morning.

In general, four species of potential fish were observed in shallow water in Peregrine Cove and Willow Springs Cove in 1988: bluegill, largemouth bass, carp and Tilapia. Although bluegill were often the most visible species in the two coves, they were rarely taken by the bald eagles. Largemouth bass tended to be more available to eagles in both coves in April, while carp were considerably more vulnerable to eagles in the coves in May and June. In general, Willow Springs Cove contained higher numbers of both largemouth bass and carp in shallow water in the spring 1988. Bald eagles may have preferred to forage in Willow Springs Cove compared to Peregrine Cove due to differences in prey availability, perch sites, and distance from nest between the two coves.

B4.2.3.6 Waterbird Surveys. Table B4.2-19 shows the results of waterbird surveys at the Blue Point breeding area in late winter and spring 1988. Eared grebes and American coots were the most commonly observed waterbirds on Saguaro Reservoir and were also the most frequently taken by the eagles.

Table B4.2-18. Mean number of fish observed in two coves of Saguaro Reservoir (Peregrine Cove and Willow Springs Cove) in April and May, 1988.

	Peregrine Cove				Willow Springs Cove			
	Bluegill	Largemouth Bass	Carp	Tilapia	Bluegill	Largemouth Bass	Carp	Tilapia
3/18/88								
0500–0800 Hr					—	—	—	—
0800–1100 Hr					0.0	0.7	3.0	0.0
1100–1400 Hr					0.0	1.3	3.7	0.0
1400–1700 Hr					Numerous	8.3	6.0	0.0
4/05/88								
0500–0800 Hr	—	—	—	—	0.0	0.0	0.0	0.0
0800–1100 Hr	12.0	2.0	0.0	0.7	32.0	7.5	0.7	0.0
1100–1400 Hr	0.0	1.3	0.0	3.0	58.5	11.0	0.0	0.0
1400–1700 Hr	22.3	11.3	0.3	5.7	98.5	19.5	4.8	0.0
5/02/88								
0500–0800 Hr	3.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
0800–1100 Hr	8.3	0.7	0.7	1.0	7.0	0.3	7.7	0.0
1100–1400 Hr	7.5	0.3	1.0	3.7	30.0	4.0	13.0	0.5
1400–1700 Hr	12.5	0.0	0.0	5.7	9.0	1.5	34.5	0.5
5/18/88								
0500–0800 Hr	96.0	0.0	10.3	1.0	0.0	0.0	6.7	0.0
0800–1100 Hr	100.3	0.0	2.0	4.7	2.0	0.0	5.0	0.0
1100–1400 Hr	7.0	0.0	2.0	7.3	0.0	0.0	12.7	0.0
1400–1700 Hr	0.0	0.0	0.3	4.0	0.0	0.0	23.0	0.0
6/01/88								
0500–0800 Hr					0.5	0.0	3.5	0.0
0800–1100 Hr					2.3	0.0	7.0	0.0
1100–1400 Hr					21.0	2.8	73.7	0.0
1400–1700 Hr					0.0	0.0	30.0	0.0

Table B4.2-19. Water birds observed in surveys at Blue Point breeding area in 1988. Asterisk denotes occurrence in prey remains.

Species	Avg. No. Individuals		February		March		April		May	
	Res	Riv	% Res	% Riv	% Res	% Riv	% Res	% Riv	% Res	% Riv
Eared Grebe*	15 (n=91)	—	16.3	—	42.4	—	66.7	—	—	—
Pied-billed Grebe	4 (n=26)	2 (n=4)	16.3	—	12.9	3.0	4.8	—	—	—
Northern Shoveler	—	1 (n=2)	—	—	—	1.5	—	—	—	—
Common Merganser	1 (n=6)	1 (n=2)	11.6	4.7	0.8	—	—	—	—	—
Snowy Egret	<4 (n=2)	—	—	—	—	—	4.8	—	—	—
Great Blue Heron*	4 (n=26)	5 (n=9)	2.3	2.3	1.5	6.1	9.5	—	76.0	—
American Coot*	11 (n=65)	2 (n=3)	46.5	—	28.8	2.3	14.3	—	4.0	—
Shorebirds	1 (n=5)	—	—	—	—	—	—	—	20.0	—
Gull sp.	<1 (n=1)	—	—	—	0.8	—	—	—	—	—
			n = 43 (one survey)		n = 132 (two surveys)		n = 42 (one survey)		n = 25 (two surveys)	

B4.2.4 Human-Impacts

The Blue Point pair incurs the highest public use of any of the breeding territories in Arizona because Saguaro Reservoir and the Lower Salt River are the largest and closest recreation areas to metropolitan Phoenix whose population is over one million (1990 census). Detrimental effects caused by the high amount of public use at Blue Point are suggested by the unusually high turnover (mortality) of adults there (see Sections C3.7 and D4.4.3) where at least one adult male and four different females have nested during our study. Moreover, there have been nest failures clearly associated with disturbance, and a relocation of the pair from the Bull Dog Cliff area to obviously (to us) less favorable nest sites away from the river. Some of the highest public use areas are in prime foraging habitat.

The area is popular for many recreational activities and is easily accessible, being as little as a 40-minute drive from the east side of greater Phoenix. The facilities at the reservoir include: (1) a marina with a store supplying fishing and boating supplies and boat rental and repair; (2) two paved boat ramps; (3) a restaurant and snack bar; (4) a picnic area; and, (5) a helipad for medical emergencies and access by the media. Facilities and improvements on the river include: (1) Salt River Recreation, a concessionaire of the Forest Service who rents tubes and provides bus service for floating this section of the river; (2) a newly finished public parking lot with toilets just downstream from two eagle nests near Bulldog Cliffs; and, (3) a picnic area with grills at Blue Point cliffs. In addition, just across from the picnic area located at Blue Point bridge is an area popular for riding all-terrain vehicles. Other uses of these areas include camping, fishing, and shooting along the river.

Tubing and rafting are the most popular recreational activities on the Lower Salt River. Salt River Recreation (SRR), a lessee of the Forest Service, rents inner-tubes to the public and includes bus service in the cost. SRR operates their service beginning about the last week of April and continues until mid-September; although, the river is usually without flow by 1 August (P. Libby, USFS, pers. comm.) because of dam regulation. The numbers of tubers increases in May with peaks of 40,000 people in a weekend. According to data provided by the Mesa Ranger District, based on year-end revenue figures provided by SRR, some 87,144, 100,612, and 118,044 inner-tubes were rented during the late spring and summers of 1987, 1988, and 1989, respectively. These figures represent only commercial use and do not include private parties who bring their own tubes. The Forest Service data indicate an average of 16 percent annual increase in the number of people tubing. However, actual increase of tube rental is estimated at 5 percent; the remaining increase is from people choosing to use the SRR bus shuttle rather than using their own vehicles (P. Libby, USFS, pers. comm). Numbers of clients guided down the Lower Salt River in rubber rafts by permitted Outfitter/Guides were 500 in 1987 and 1988 and 1300 in 1989, according to data provided by the Mesa Ranger District. The Mesa Ranger District no longer conducts public use surveys on the lower Salt River; estimates of public use data are apparently extrapolated from data collected in the early 1980s.

On 16 January 1984, the Forest Service enacted a closure extending from about Km 18.2 to Km 20.7 and parallelling the river approximately 200 m up from the shore on river left, and then going south into the Goldfield Mountains. No entry is permitted from 1 December to 30 June, but we were unaware of any signs to that effect. This closure does not include the river itself or the opposite bank. The closure was evidently intended to protect the Bulldog Cliffs nests.

The data in Table B4.2-20 were recorded by BioSystems in 1987 and 1988 on an incidental basis throughout the breeding area wherever an incident occurred within 100 m of an eagle. The data do not represent the actual distribution of public use but rather depend on the location of the observer and the

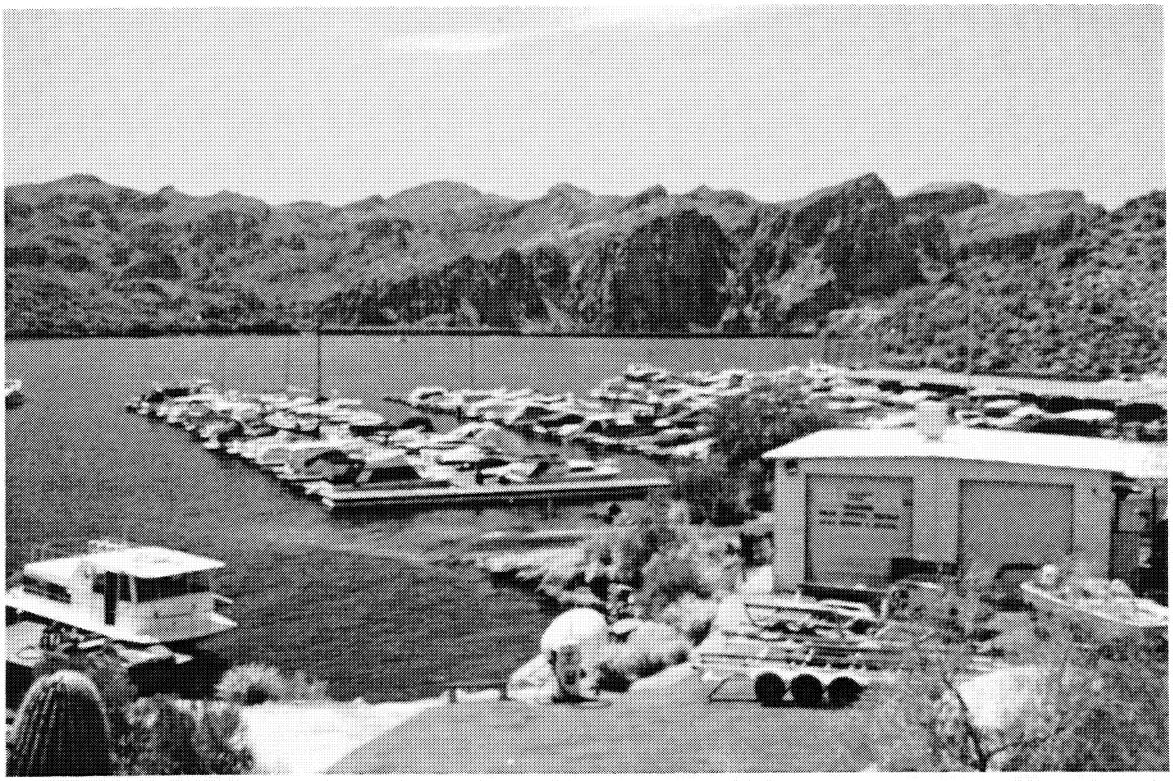


Plate B14. Marina on Saguaro Reservoir. Bulldog Cliffs, containing two previous nests of the Blue Point eagles, can be seen in the background behind the dam (photo by P. Becker).

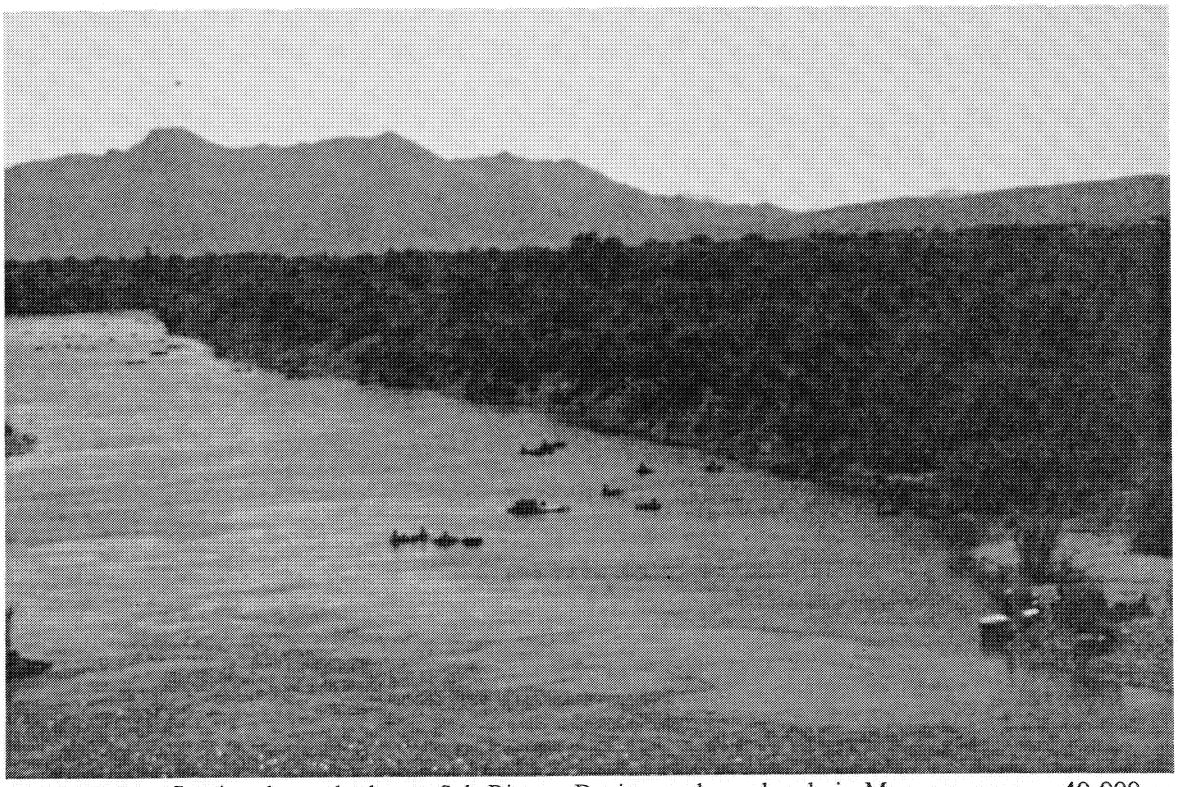


Plate B15. Tubers floating down the lower Salt River. During peak weekends in May, as many as 40,000 people are on the lower Salt River (photo by P. Becker).

Table B4.2-20. Summary of public use incidents and eagle responses at Bluepoint territory in 1987 and 1988.

Type Public Use	No. Public Use Incidents	Percent of Total Incidents	Duration (min)	Percent Duration	Response to Public User				
					N	W	S	C	F
Fishing:									
On foot	1	1.3	14	1.1	—	—	—	1	—
Not using motor	4	5.1	111	8.5	2	1	—	—	1
Using motor	13	16.7	181	13.8	2	3	—	—	8
Hiking	1	1.3	23	1.8	—	—	—	—	1
Picnicking:									
On foot	1	1.3	4	0.3	—	—	1	—	—
Wading	1	1.3	28	2.1	1	—	—	—	—
Outside auto	1	1.3	14	1.1	1	—	—	—	—
Boating:									
Non-motorized	8	10.3	105	8.0	5	2	—	—	1
Not using motor	7	9.0	319	24.3	6	—	—	—	1
Using motor	28	35.7	403	30.7	16	4	—	—	8
Helicopter	4	5.1	10	0.8	1	—	—	—	3
Low-level Flight (military)	1	1.3	1	0.1	—	—	—	—	1
Tubing	6	7.7	51	3.9	4	1	—	—	1
Jetski	2	2.6	46	3.5	1	—	—	—	1
TOTAL	78		1310		39	11	1	1	26

N = No response; W = Watching; S = Probable avoidance of area; C = Certain avoidance of area; F = Flush.

telemetered eagle. Water traffic constituted the sole source of public use on the reservoir. Modes of travel included 96 percent boats and 4 percent jetskis (n = 56). Of 19 public use incidents on the river, tubing and rafting made up 68 percent; the remaining events included two records of picnicking, and single incidents involving a hiker, a helicopter, a low-flying military aircraft, and an angler. We recorded three public use events at the nest; all involved helicopters and all three caused an eagle to flush. In only three places did the number of public use events exceed 3; these are: (1) the "Drowned Mesquites" (10 events); (2) Km 13, 1-2 Km downstream from Blue Point Cliffs (12 events); and, (3) Willow Springs Cove (35 events), accounting for 13, 15, and 45 percent, respectively, of the total public use events recorded (n = 78). Ninety-one percent of the incidents recorded in Willow Springs Cove occurred in June after the young fledged.

Eight flushing incidents were not included in the table because they occurred at distances greater than 100 m from an eagle. These included: (1) two anglers using motor boats in the area of the "drowned mesquites"; (2) three boaters, one each at the coves by Tom Cat Cliffs, Willow Springs Cove, and the lower third of the lower reservoir; (3) two helicopters at Bulldog Cliffs; and, (4) one waterskier at Km 27.7 in the upper reservoir.

During the 1987 breeding season, Willow Springs Cove proved to be a major foraging area for the Blue Point pair and was also a popular recreation site. The adults spent a considerable amount of time in the cove loafing and hunting. The importance of the cove increased after 1 June when the adults and juveniles spent most of their days in Willow Springs Cove, probably roosting nearby. A small sample of observations there suggested a possible relationship between the number of public user incidents and the number of foraging attempts. During 27 May–4 June, we requested boaters and jetskiers to remain in the front portion of the cove. During this period, 11 forage attempts were recorded for an average of 1.2 forages per day, while 10 forages (48%) occurred elsewhere on the reservoir. On 12 June and during 24-30 June, we did not discourage public-users from entering the cove. We observed only two foraging attempts in the cove during these eight days or 0.25 attempts per day; six forages (75%) occurred on other parts of the reservoir. We observed six flushing incidents in Willow Springs Cove during periods when we did not discourage boat entry. The cove was not used by eagles with the same intensity in 1988 probably due to the death of the young in the third week of May.

Another important foraging area, the "drowned mesquites" at Km 27.9–28.6, is also popular among campers. The area is also favored by bass anglers who visit the area or troll near it in motorboats, sometimes flushing eagles perched there.

We do not know to what extent increased recreation on the river in late April and May contributed to the shift in visitation on the part of the eagles during that period from the river to the reservoir. The shift is readily explained by the availability of carrion yellow bass increasing on the reservoir, but the increase in public use was substantial. In addition to the tubers, we noted higher numbers of anglers, RV enthusiasts, and sunbathers utilizing the river. After flows increased in early May, rafting activity increased, with as many as 70 rafters per hour passing Blue Point Bridge. In late April, eagle foraging on the river was mainly confined to the Bulldog Cliffs area, which was closed to the public because of dam repairs and spillway construction.

There is considerable noise associated with certain recreational activities, although we are unable to speculate on its effects on foraging eagles. Unlike Horseshoe Reservoir, where waterskiing was not permitted and boats were usually quiet, many of the watercraft used on Saguaro Reservoir, such as ski boats, jetboats, and jetskis were (in our opinion) noisy. Recreational activities on the river were often

also loud. All-terrain vehicles and dirt bikes were in common use, and traffic along Bush Highway was often congested on weekends and holidays, with highway accidents being fairly common.

The nest used in 1987 and 1988 (Nest No. 6) is located far away from all the public use on the reservoir and river and is subject to very little public disturbance. However, three disturbances were recorded in 1988, all by helicopters, and all of which caused an eagle to flush. The other two nest sites used since 1983 (Nest Nos. 1 and 5) located near Bulldog Cliffs directly above the river, are highly visible to the public.

B4.2.5 Discussion

Based on telemetry tracking of the adult male eagle (AM01) in 1987 and 1988, visual observations of the female, records of prey deliveries to the nest in 1988, and fisheries data obtained from both the river sections and reservoir, we can speculate about the yearly cycle of habitat and prey use by the pair. In winter, the birds frequented Saguaro Reservoir where they foraged mainly on waterfowl, including coots and eared grebes; these prey birds departed in late winter. In March and April, suckers left deeper water where they had been inaccessible to eagles, to spawn in river shallows downstream of the Stewart Mountain dam. The distribution of spawners was largely dependent on water temperatures which varied in relation to distance from the dam. Since water from the depths of the reservoir is released from the bottom of the dam, it gradually warms as it moves downstream, a process called thermal loading. In March, suckers attracted foraging eagles to areas somewhat downstream of the dam, but in April considerable spawning occurred nearer the dam, and the eagles began preferentially foraging there. We believe that less human activity and better perches possibly enhanced the area for eagles also. Carrion suckers also became available to eagles during their spawning, and when portions of the river were dewatered by dam operations, fish were killed from standing and oxygen depletion.

As nesting season progressed, foraging by the adults increased on the reservoir. By mid-April, yellow bass were frequently brought to the eagles' nest, and these fish simultaneously appeared in significant numbers dead or dying on the surface of Saguaro Reservoir. The yellow bass mortality was associated with spawning, and this species continued to appear in the eagles' nest through mid-May. During their spawning period in late April and early May, largemouth bass were also taken by eagles on the reservoir. Whether spawning in largemouth bass actually influences their vulnerability to eagles is unknown.

Had the 1988 juvenile eagles survived at Blue Point past mid-May, we believe that carp would have become an important part of the diet. Increasing water temperatures and increases in aquatic vegetation in shallow areas, particularly those in Willow Springs Cove, attracted carp in 1987 and 1988. In 1987, both adult eagles and their young frequented the cove during this period of abundant food resources.

B4.2.6 Management Recommendations

Why the Blue Point eagles nested in a dry canyon well away from the river or reservoir in 1987 and 1988 (and possibly in other years) is unknown; the site is certainly atypical. Traditional sites on the river appear to us better suited to the eagles' needs. Bulldog Cliffs, for example, is adjacent to preferred foraging areas on both the river and the reservoir, and would offer the eagles more energy efficiency in feeding the young and defending the nest; admittedly, however, the pair successfully fledged young in both 1987 and 1988. The Bulldog Cliffs nest is shaded during portions of the day, while the Willow Springs Canyon nest is constantly in the sun. Heat apparently caused or contributed to the deaths of three eaglets there in 1988.

It is tempting to speculate that the eagles moved in response to the extraordinary levels of human disturbance near the traditional nest sites, the highest amounts of disturbance known in any bald eagle breeding area in Arizona. The only known nesting attempt on the river since 1985 evidently failed as a result of intrusion by public users. It may be that the Willow Springs nest location may be of net benefit to the eagles in insulating them from disturbance, but the question remains concerning the effects of heat on nestling survivorship.

Data are currently insufficient to show whether the location of the Willow Springs Canyon nest seriously compromises breeding success and survivorship of the eagle pair. We therefore recommend continued observation during nesting, with emphasis on the effects of heat, disturbance, and other factors at the nest site, including observations of post-fledging juveniles. If heat impacts on nest success prove chronic, management might include (1) reductions in disturbance along the river, especially near Bulldog Cliffs (the construction-related enclosure seemed effective); and/or, (2) providing artificial nests with shade structures in Willow Springs Canyon.

Further research is also needed to resolve the problem of an extremely high turnover rate among breeders at Blue Point (also Bartlett and Orme). Currently, the most parsimonious explanation is that they are being shot or poisoned. We are at a loss to suggest a method of investigation other than monitoring the movements of adults with telemetry.

The most important foraging areas for the Blue Point eagles are: (1) the river section between Kms 13 and 20; (2) the area of drowned mesquites (SKms 12 and 14); (3) Willow Springs Cove (SKm 3); and, (4) the Camper's Cove area (SKms 16 and 17). The eagles' use of these areas suggests their protection, particularly during spring in years the eagles are successful in nesting. The most important months for foraging on the river are March and April, while most of the reservoir forages are in winter, and in April, May, and early June. While ambient public disturbance levels in these areas in 1987 and 1988 did not prevent the eagles from successfully foraging and raising young to advanced ages, we recommend that the areas remain free of further development of facilities (e.g., roads, picnic grounds, etc.) that would draw greater numbers of people to them. Perch availability is generally good in areas 1, 3, and 4, but the mesquite perches in Area 2 may eventually disintegrate. The provision of natural or artificial perches in Area 2 or other shallow shorelines on the upper reservoir might someday be warranted, but not at this time.

B4.3 LADDERS BREEDING AREA

The Ladders breeding area is located 115 km north of Phoenix on the Verde River near Camp Verde (Figure B4.3-1). The agencies directed us to study this territory (and the East Verde territory) mainly because the upper Verde River is *unregulated*, and thus offers an opportunity of comparison with the ecology of bald eagles nesting on *regulated* river reaches, such as Bartlett and Blue Point. Such comparisons would broaden the conclusions which can be drawn about the effects of water projects on eagle foraging. Another reason for selecting the Ladders breeding area was that proposed water diversion projects upstream of the breeding area may divert enough water to affect fish populations in the section of river where the Ladders eagles forage. Lastly, it was recognized that the Ladders territory has been moderately productive, and that information pertaining to its management would be of benefit to the Arizona bald eagle population.

Ladders is within the Upper Sonoran Life Zone (C. H. Merriam 1890,1898; in Lowe 1964), and surrounding habitat is of the Semidesert Grassland Biome (Brown and Lowe 1980, Brown 1982). The riparian habitat includes Fremont cottonwood, Goodding willow, Arizona sycamore, mesquite spp., tamarisk, and some emergent vegetation. From Camp Verde to Beasley Cliffs, the Verde River meanders through agricultural bottomland lined with large cottonwoods. There is no reservoir in the Ladders breeding area; several ponds exist on both sides of the river near the confluence of West Clear Creek. Below the confluence, promontory cliffs bound some sections of the east bank as the river flows south to Beasley Cliffs. South of Beasley Cliffs, the Verde River flows through rugged country, bounded by steep slopes and large promontory cliffs, some set back from the river. During the course of our study, the eagles occupied two different cliff nests approximately 1 km apart and 10 airline km (six miles) south of Camp Verde. See Section D4.17 for further information on this breeding area.

In studying the Ladders breeding area, we have endeavored to: (1) determine the home range of the pair; (2) quantify prey selection; (3) identify foraging areas; (4) analyze foraging habitat selection; (5) study prey fish availability; and, (6) collect information on human disturbance. These data will be applicable to management decisions regarding the Ladders Territory and, by comparing with the ecologies of other pairs, the Ladders data will contribute to a fuller understanding of the ecology of the entire population. Whether or not fish populations would be effected by the diversions is a question beyond our scope of work.

History of Reproduction

The Ladders breeding area, discovered in 1972, currently contains five cliff nests on the free-flowing Verde River. The pair failed in 1972, but at least one young fledged in 1973 (Rubink and Podborny 1976). The breeding area remained unoccupied at known nest sites during 1974-76. In 1978, the breeding area was occupied, but the pair apparently did not lay eggs. Eggs were laid in 1977, 1979, 1982, 1984, and 1990, but failed to hatch. Two young were fostered into the Ladders nest in 1982 from the inundated Horseshoe nest site, and subsequently fledged. Two young also fledged in 1980, 1981, 1983, 1985, 1986, 1988, and 1989. Two young hatched in 1987, but died prior to fledging. Since 1972, the Ladders eagles have laid at least 25 eggs and fledged 15 young. See Section D4.17 for details on annual productivity and mortality at Ladders.

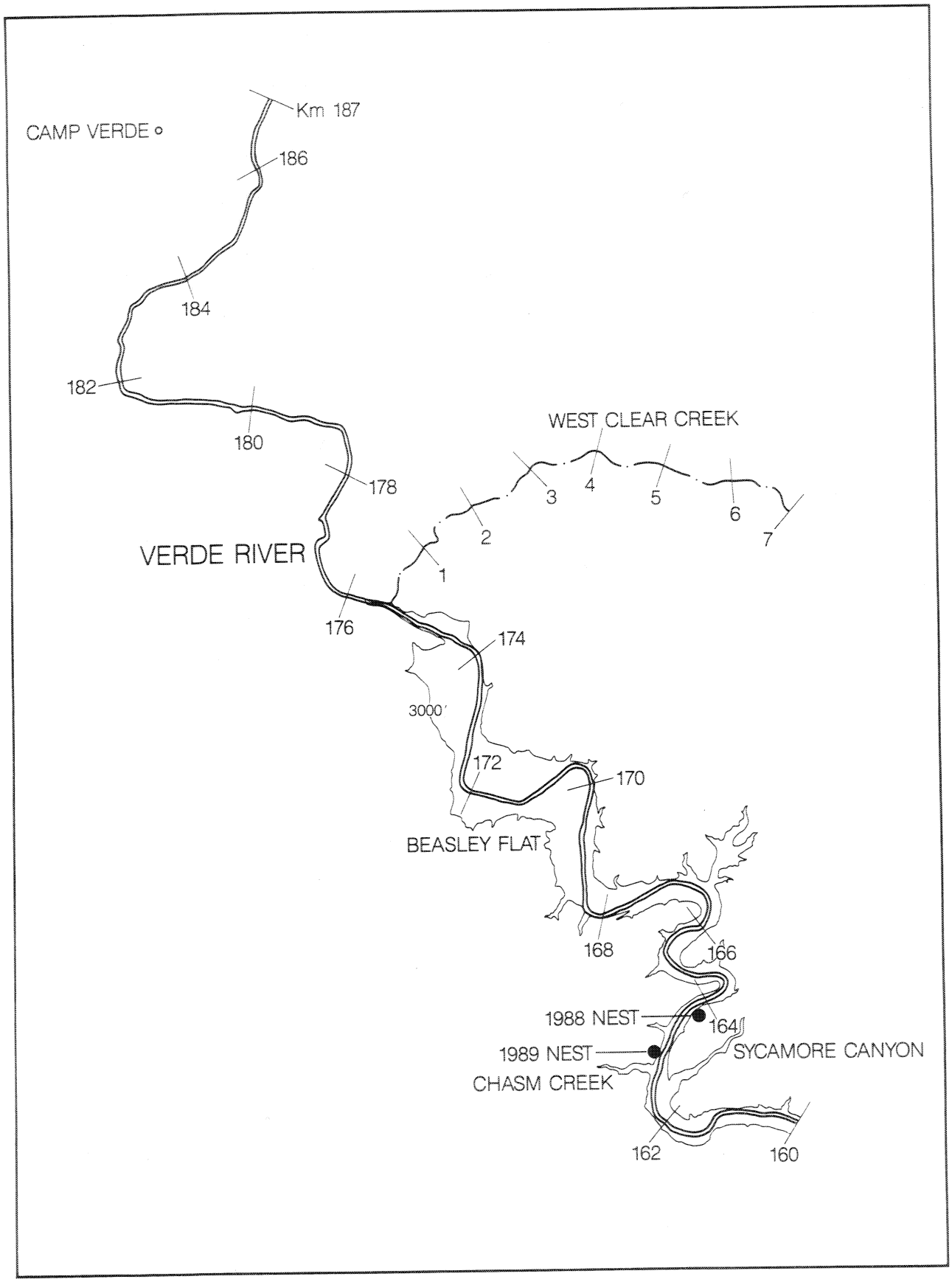


Figure B4.3-1. The Ladders bald eagle breeding area.

Plate B16. Ladders nest cliffs along the free-flowing Verde River, April 1990 (photo by D. Driscoll).

Verde River (Ladders Territory)

Flow in the Verde River at Camp Verde during 1987, 1988 and the first six months of 1989 is detailed in Figure B4.3-2. Mean annual flows were similar in 1987 and 1988 averaging 220 cfs and 246 cfs, respectively. However, the timing and magnitude of peak flows differed between years. Peak flows in 1987 occurred in March (2,089 cfs) and November (4,270 cfs), while, peak flows in 1988 occurred in February (3,975 cfs) and April (5,756 cfs). In the first 6 months of 1989, flows were relatively low and ranged from 450 cfs in March to 44 cfs in June.

Mean monthly flow were higher in 1987 and 1988 compared to 1989 (Figure B4.3-2). In 1987, mean monthly flows ranged from 22 cfs (July) to 819 cfs (March), while in 1988 they varied from 26 cfs (June) to 1144 cfs (April). Mean monthly flows during the first 6 months of 1989 ranged from only 29 cfs (June) to 198 cfs (March).

Water Projects

Proposed water diversion projects on the upper Verde River, if constructed, will affect water flows in the Ladders territory. Three diversion sites have been proposed, all upstream from the breeding area (U.S Fish and Wildlife Service 1989a). The City of Prescott and the Yavapai–Prescott Indian Community plan to divert water through an infiltration gallery located approximately 4 km downstream of Sullivan Lake. The Cottonwood Water Company intends to divert water through wells or an infiltration gallery,

and the Camp Verde Water Company would divert water through an infiltration gallery. Table B4.3-1 lists these flow reductions and their possible effects on flows (data from U.S. Fish and Wildlife Service 1989a)

Schedule of Study

We studied the Ladders pair in both 1988 and 1989. We telemetered the adult female (AF04) on 1 April 1988, and radio-tracking began on 13 April. During the 1988 breeding season, the nest overlook was located at Km 163.8 across the river from the nest and was used for observations of prey deliveries and as a center of communications for radio-tracking. In 1989, we observed the nest, which was located at Km 162.8, from a vantage point on the other side of Chasm Creek.

Trackers also followed AF04's movements from an upriver observation point at Km 169.3 (Beasley Flats), where roads were available along the river, and from a third observation point, at Km 161.8, downriver from the nest. One or more "rovers" tracked the female's activities between observation points.

We used only a partial tracking team in 1988. The reason is that we hoped to tag the male early in the 1989 nesting season and obtain a full complement of data on both members of the pair. We succeeded

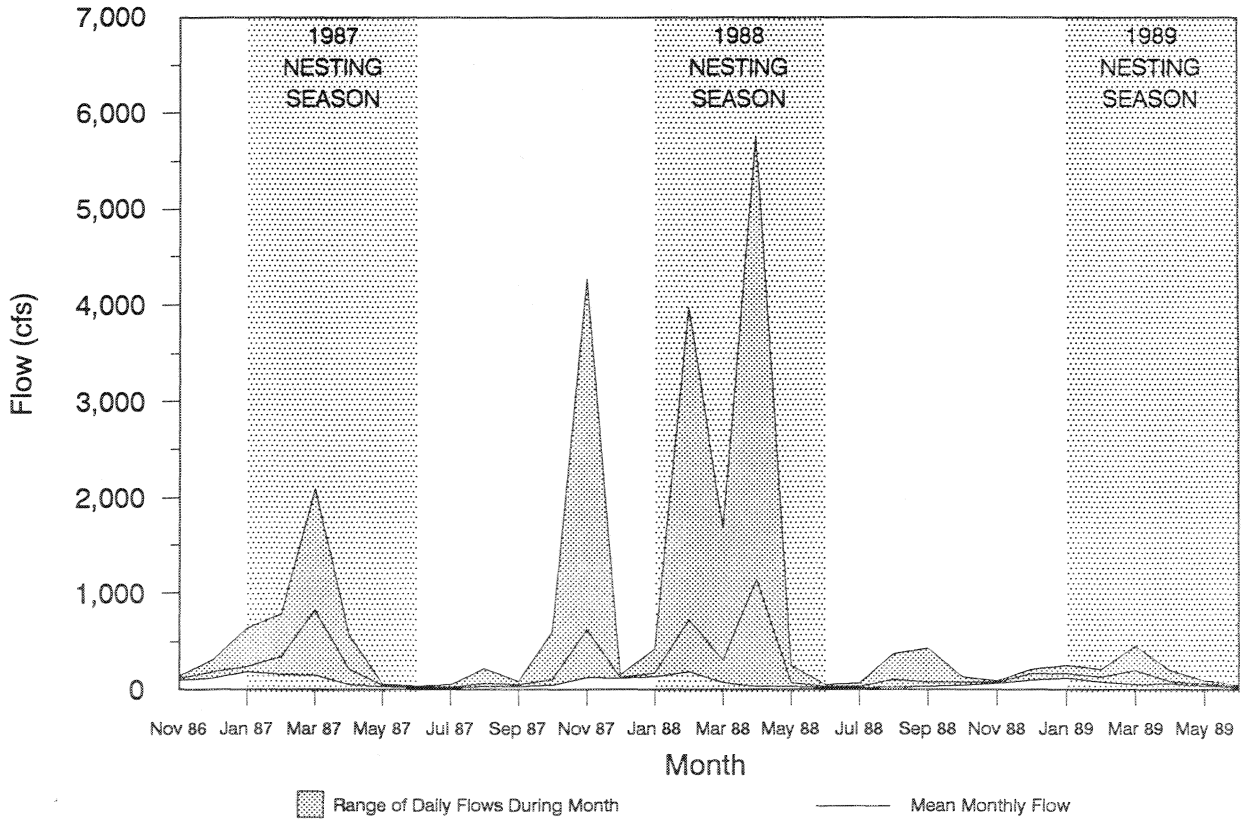


Figure B4.3-2. Mean monthly flows and range of daily flows in the Verde River at Camp Verde from November 1986–June 1989.

Table B4.3-1. Proposed water diversions (cfs) from the Verde River (data from U.S. Fish and Wildlife Service, 1989a) compared with measured flows in 1987–1989 at Camp Verde (Km 180).

	March		April		May		June	
	Normal	(Peak)	Normal	(Peak)	Normal	(Peak)	Normal	(Peak)
Verde River								
Planned Diversions from the Verde River	11.7	(15.2)	17.0	(23.2)	20.4	(28.7)	26.5	(37.8)
Measured Flows at Camp Verde Mean (Min.–Max.)	441.6	(45–2089)	476.2	(31–5756)	55.5	(28–246)	27.0	(17–47)
Mean Resulting Flow[1]	429.9		459.2		35.1		0.5	
Minimum Resulting Flow[2]	29.8		7.8		−0.7		−20.8	

[1] *Mean resulting flow* was calculated by subtracting normal diversion from mean monthly flow.
[2] *Minimum resulting flow* was calculated by subtracting peak diversion from measured minimum flow.

in catching him on 2 April 1989. The following day, he was struck by a peregrine and appeared weakened for the next eight days (see discussion). He resumed foraging on 14 April, but died during the first week of May, possibly from complications associated with the peregrine attack. Although we obtained better data on the Ladders pair in 1989 when we had a full tracking team available, our results for the Ladders breeding area were less satisfying than those obtained at some of the other territories because the female did not forage extensively during the early part of the season.

B4.3.1 Home Range

During the 1988 and 1989 breeding seasons, the radio-tagged female AF04 perched at various locations along the Verde River from Km 160 to Km 181, a span of 21 river Kms (Figure B4.3-3). We frequently observed AF04 foraging in the general nest area (see Section B4.3.2); there were super-riffles near both nest locations and cliffs along both sides of the river. A second area AF04 frequented in both years of study was the Beasley Flats area. Cliffs measuring about 30 in height extend from Km 165.4 to Km 168.4 along the south side of the river where AF04 would often perch; there were super-riffles at 167.2, 168.2, and 168.7–168.9. In both years, AF04 also visited a 4-Km stretch of river from Km 171 through Km 174. This area is characterized by flat terrain, slow runs with an occasional riffle, and tree-lined banks. Her use of this area was evenly distributed, indicating no particular focus on a riffle or other feature, and trees provided well-distributed perches; AF04 foraged several times in this area. AF04 also perched in a tree-top snag at Km 177.8 on the edge of Camp Verde. The snag extended out over a moderate run in the river. At low flows, the run was shallow and slow, with a shallow backwater on the east side below the snag where fish were probably exposed to predation. AF04's avoidance of Km 165 can be explained by "The Falls," a narrow section of river with high velocity runs and large rapids. AF04's home range was skewed upstream of the nest. During both years, AF04's downstream perches were within 3 Km of the nest whereas she perched up to 18 Km upstream of the nest.

AF04 usually soared over land within the home range end-points determined by tracking data; however, she once soared to Km 188 which is within the city limits of Camp Verde. She often soared well away from the river and occasionally foraged off the river, once on a deer carcass.

B4.3.1.1 Seasonal Shifts. Early in the breeding season, AF04 remained in the nest area even when she was not brooding her young. She left the nest area two times during the initial 28-day study period in 1989. We located her with telemetry once at Km 171 and once between Km 169 and Km 181. In both 1988 and 1989 AF04 expanded her range in April and the first half of May but continued to spend a majority of her time (over 60%) at the nest. When AF04 left the nest area she perched at Beasley Cliffs or a stretch of river from Km 171 to Km 177.

B4.3.1.2 Home Range Observations in 1988. In mid-April, AF04 could be found roosting in the nest area at about 0600 hr. In the early morning (between 0730 and 0900), she would fly upriver about 4 km and perch on the cliffs at Km 168.1 overlooking a small super-riffle. Typically, in late morning and early afternoon from 1100–1300 hr, AF04 returned to the nest area and perched along the nest cliff. During these hours, the Ladders male (PM01) brought prey to the nest, and the female, AF04, fed the young and herself, remaining in the nest area until later in the afternoon. Around 1600 hr, AF04 would fly upriver and perch either at the Km 168.1 cliffs at Beasley Flats or in a snag at Km 177.8 on the edge of Camp Verde.

On 20 April AF04 appeared to changed her routine, flying downriver at first light to perch on the cliffs at Km 161. Over the next two weeks, she continued to do this, remaining on the cliffs for most of each

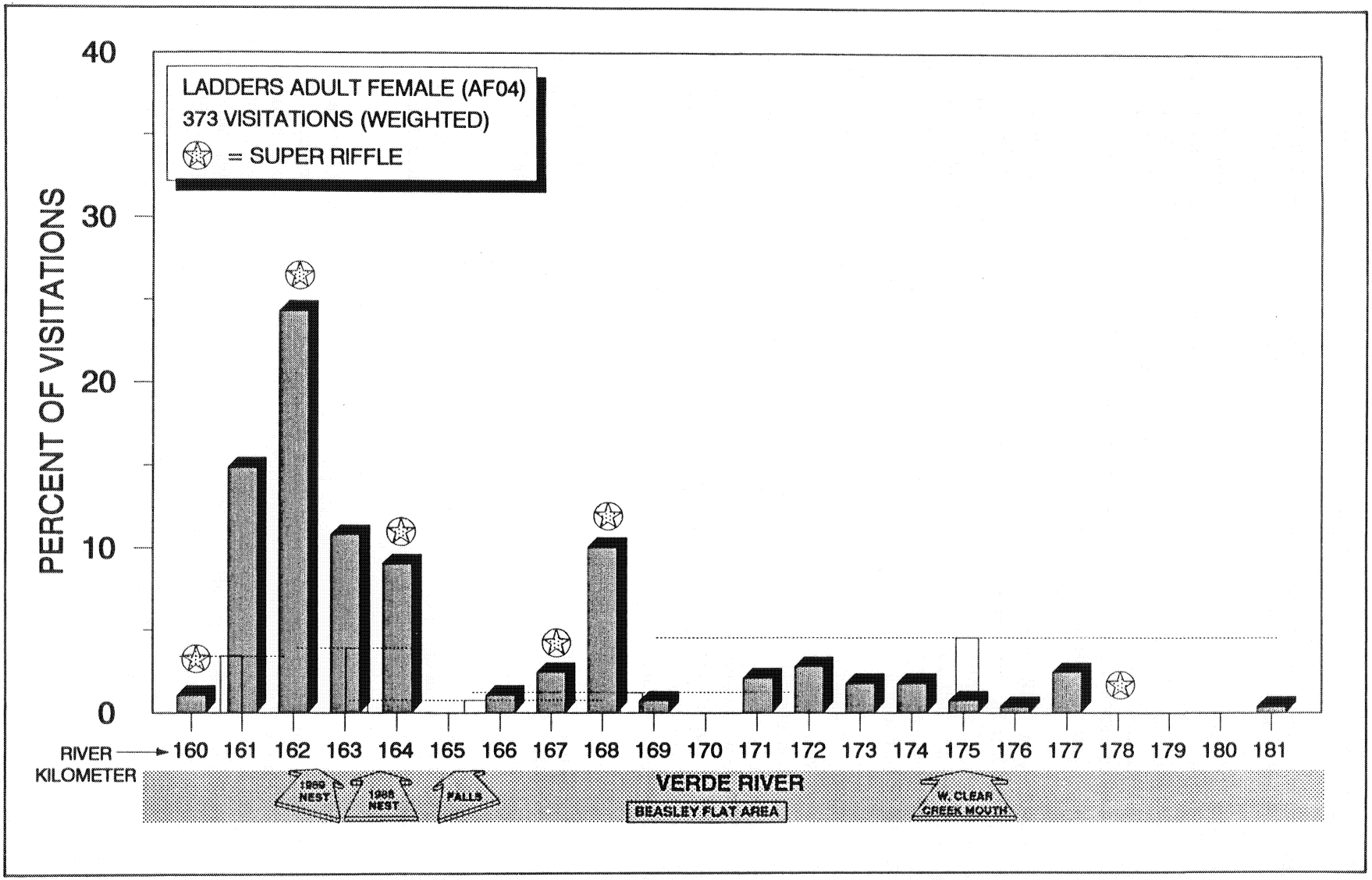


Figure B4.3-3. The home range of the telemetered Ladders adult female (AF04) during the 1988 and 1989 breeding seasons. Visitation percentages at the nest area (Km 161-163) were weighted according to the proportion of total prey deliveries by the female from that segment. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from those bars indicate zones of eagle occupancy for the imprecise locations.

day, although she periodically returned to the nest for short periods. She occasionally soared along the boundaries of the Ladders breeding area but seldom perched upriver for any length of time.

Around fledging time, 14-16 May, AF04 continued to favor areas downriver of the nest, including cliffs at Km 161 and Km 162. As the young (telemetered 19 April) began to venture away from the nest area, they gradually moved downriver. Until migration of the surviving juvenile on 7 July, the radio-tagged Ladders eagles were usually downriver of the nest area, from Km 160.0–Km 163.5. This pattern of extending the foraging range to include downstream areas in April and May was also noted by nestwatchers (Poelker and Palmiotto) in 1985 (see Section D4.17).

In summary, telemetry in 1988 revealed a home range extending from Km 160.0, 2 km downriver of Sycamore Canyon, to Km 185.0 in the community of Camp Verde. During the early part of the brood cycle AF04 spent most of her time in the nest area (Km 163.9), but as the young matured, AF04 began frequenting Beasley Flats (Km 167.5-Km 171.6), 4 km upriver of the nest. After the young fledged, AF04 utilized an area downriver of the nest from Km 160.0–Km 163.0. On occasion AF04 would soar along the boundaries of her home range.

B4.3.1.3 Home Range Observations in 1989. The patterns of home range use in 1989 are illustrated in Figure B4.3-4 and discussed under Geography of Foraging, below. The patterns of home range use were similar to those observed in 1988, with far larger use of upstream areas in the early part of the nesting season and a concentration of foraging near the nest late on. However, the reader should note that after AF04's mate was found dead on 10 May 1989, AF04's home range dwindled in size until she spent almost all of her time in the nest vicinity. During the final 28-day study period, to bolster the loss of the foraging male, we supplemented her food supply by placing carrion fish in the nest vicinity. The female's drastically reduced range may have been influenced by this readily available food in the nest area.

B4.3.1.4 Soaring Range. The soaring range for the telemetered Ladders female extended from Km 157 north to Km 187, a total of 15 airline km. AF04 soared for up to about 6 km east and west of the river within those 15 km. Her soaring range appeared to follow the mountains surrounding the Verde Valley.

B4.3.2 Foraging Studies

We studied foraging by the Ladders pair from 27 March–21 May 1988 and 26 February–17 June 1989. Our objectives were to identify prey taken by the eagles seasonally, the location, structure, and dynamics of forage sites, the significant of perches, and other foraging-related factors.

We used two methods to study foraging. The first was the observation of prey deliveries to the nest, combined with the results of radio tracking, a method which allowed us to identify prey and to approximate the location of a forage even if it was not directly observed. We used this combined data to analyze overall prey selection and the geography of foraging, below. The second approach involved the direct observation of forages which afforded information on eagle foraging perches, attack strategies, specific forage locations, and their microhabitat. We combined these data with the prey identifications from the nest observer, and used it to analyze the conditions under which eagles take different prey species. These data are discussed under Observed Forages for Fish at the end of this section.

B4.3.2.1 Prey Selection. Fish species dominated the prey deliveries to the Ladders nest during our relatively brief observation periods in 1988 (Table B4.3-2). We calculated that 85 percent of the biomass

brought in by the male was fish, including carp (40%), suckers (26%), channel catfish (7%), and bass (4%). In addition, the female eagle (AF04) contributed two carp (714 g) in mid-April, and two suckers (491 g) and an unidentified fish (163 g) in early May 1988 (no table). Mammals contributed significantly to the diet in April 1988 (35% of prey numbers); AM08 brought in a cottontail and five small, unknown mammals on 18–20 April.

In terms of biomass delivered to the nest by the male eagle, fish comprised over 96 percent of the delivered prey for all 28-day study periods in 1988 and 1989 (Table B4.3-3), except in April 1988 when fish comprised 73 percent of delivered prey. Suckers were the primary forage fish of AM08 in 1989 (57% of biomass delivered), followed by carp (34%), and catfish (6%). Fish comprised over 95 percent (numerically) of all prey taken by the female bald eagle in 1989 and 97 percent of biomass delivered to the nest (Table B4.3-4). The female eagle captured fish in these proportions: sucker (43% of biomass delivered to nest), carp (31%), and catfish (22%). Fish were exclusively taken by the female in all the 28-day study periods except 26 March–22 April 1989 when mammals made up 15 percent of the prey

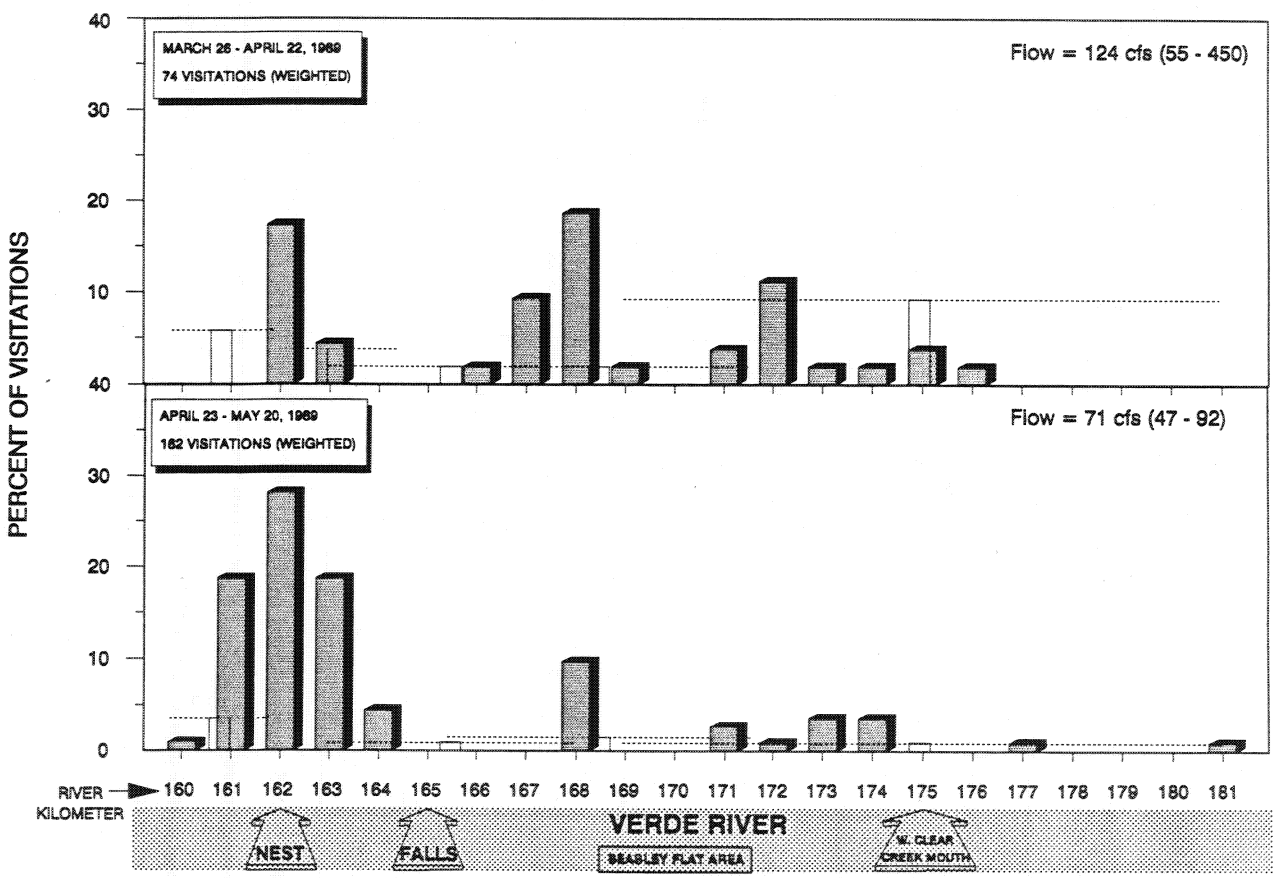


Figure B4.3-4. Seasonal changes in the distribution of visitations (%) by the telemetered Ladders adult female (AF04) during 26 February to 17 June 1989. Visitation percentages at Km 161–163 (nest vicinity) were weighted according to the proportion of total prey deliveries from those segments during each period. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from these bars indicate zones of eagle occupancy for the imprecise locations.

Table B4.3-2. Prey taken and prey delivered to nest by the male bald eagle (AM08) from Ladders breeding area in 1988. Column A indicates number of prey from observed forages plus prey deliveries to nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass of prey (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

Species	A. Number of Individuals 28-Day Period: 3/27/88–4/23/88		A. 4/24/88–5/21/88		A. Total		B. Whole Biomass (grams) 28-Day Period: 3/27/88–4/23/88		B. 4/24/88–5/21/88		B. Total		C. Biomass Delivered to Nest (grams) 28-Day Period: 3/27/88–4/23/88		C. 4/24/88–5/21/88		C. Total	
Fish Species																		
Sucker	1	6%	2	40%	3	14%	421	9%	855	35%	1,276	18%	421	*(1) 15%	855	(2) 40%	1,276	(3) 26%
Carp	4	24%	2	40%	6	27%	2,407	52%	1,392	58%	3,799	54%	828	(3) 30%	1,114	(2) 52%	1,942	(5) 40%
Channel Catfish	2	12%			2	9%	338	7%			338	5%	338	(2) 12%			338	(2) 7%
Unknown Bass	2	12%			2	9%	438	10%			438	6%	192	(2) 7%			192	(2) 4%
Unknown Fish	2	12%	1	20%	3	14%	249	5%	163	7%	412	6%	249	(2) 9%	163	(1) 8%	412	(3) 8%
Subtotal	11	65%	5	100%	16	73%	3,853	84%	2,410	100%	6,263	89%	2,028	(10) 73%	2,132	(5) 100%	4,160	(15) 85%
Other Species																		
Cottontail Rabbit	1	6%			1	5%	500	11%			500	7%	500	(1) 18%			500	(1) 10%
Unknown Mammal	5	29%			5	23%	250	5%			250	4%	250	(5) 9%			250	(5) 5%
Subtotal	6	35%			6	27%	750	16%			750	11%	750	(6) 27%			750	(6) 15%
TOTAL	**17**	**100%**	**5**	**100%**	**22**	**100%**	**4,603**	**100%**	**2,410**	**100%**	**7,013**	**100%**	**2,778**	**(16) 100%**	**2,132**	**(5) 100%**	**4,910**	**(21) 100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

Table B4.3-3. Prey taken and prey delivered to nest by the male bald eagle (AM08) from Ladders breeding area in 1989. Column A indicates number of prey from observed forages plus prey deliveries to nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass of prey (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Total Number of Individuals				B. Whole Biomass (grams)			
	28-Day Period:				28-Day Period:			
Species	2/26/89 3/25/89	3/26/89–4/22/89	4/23/89–5/20/89	Total	2/26/89–3/25/89	3/26/89–4/22/89	4/23/89–5/20/89	Total
Fish Species								
Sucker	9 90%	8 67%	4 33%	21 62%	5,154 91%	4,525 51%	4,835 45%	14,514 57%
Carp		3 25%	4 33%	7 21%		4,074 46%	3,903 36%	7,977 31%
Flathead Catfish			1 8%	1 3%			860 8%	860 3%
Channel Catfish			1 8%	1 3%			169 2%	169 2%
Unknown Fish	1 10%			1 3%	512 9%			512 2%
Subtotal	10 100%	11 92%	10 83%	31 91%	5,666 100%	8,599 97%	9,767 91%	24,032 95%
Other Species								
Unknown Mammal		1 8%		1 3%		281 3%		281 1%
Subtotal		1 8%		1 3%		281 3%		281 1%
Unidentified Carrion			2 17%	2 6%			1,024 9%	1,024 4%
TOTAL	**10 100%**	**12 100%**	**12 100%**	**34 100%**	**5,666 100%**	**8,880 100%**	**10,791 100%**	**25,337 100%**

Table B4.3-3. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 2/26/89 3/25/89	3/26/89–4/22/89	4/23/89–5/20/89	Total
Fish Species				
Sucker	4,219 *(9) 97%	3,545 (8) 48%	1,375 (3) 32%	9,139 (20) 57%
Carp		3,579 (3) 48%	1,908 (4) 44%	5,487 (7) 34%
Flathead Catfish			860 (1) 20%	860 (1) 5%
Channel Catfish			169 (1) 4%	169 (1) 1%
Unknown Fish	128 (1) 3%			128 (1) 1%
Subtotal	4,347 (10) 100%	7,124 (11) 96%	4,312 (9) 100%	15,783 (30) 98%
Other Species				
Unknown Mammal		281 (1) 4%		281 (1) 2%
Subtotal		281 (1) 4%		281 (1) 2%
Unidentified Carrion				
TOTAL	**4,347 (10) 100%**	**7,405 (12) 100%**	**4,312 (9) 100%**	**16,064 (31) 100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

Table B4.3-4. Prey taken and prey delivered to nest by the female bald eagle (AF04) from Ladders breeding area in 1989. Column A indicates number of prey from observed forages plus prey deliveries to the nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals					B. Whole Biomass (grams)				
	28-Day Period:					28-Day Period:				
Species	2/26/89–3/25/89	3/26/89–4/22/89	4/23/89–5/20/89	5/21/89–6/17/89	Total	2/26/89–3/25/89	3/26/89–4/22/89	4/23/89–5/20/89	5/21/89–6/17/89	Total
Fish Species										
Sucker	6 86%	17 63%	12 32%	1 9%	36 44%	3,106 84%	8,696 49%	7,883 27%	614 11%	20,299 36%
Carp		6 22%	15 41%	1 9%	22 27%		7,403 41%	17,976 61%	696 12%	26,075 46%
Flathead Catfish			1 3%	1 9%	2 3%			767 3%	767 13%	1,534 3%
Channel Catfish	1 14%		9 24%	8 73%	18 22%	608 16%		2,740 9%	3,658 64%	7,006 12%
Subtotal	7 100%	23 85%	37 100%	11 100%	78 95%	3,714 100%	16,099 90%	29,366 100%	5,735 100%	54,914 97%
Other Species										
Dead Deer		3 11%			3 4%		1,500 8%			1,500 3%
Unknown Mammal		1 4%			1 1%		300 2%			300 1%
Subtotal		4 15%			4 5%		1,800 10%			1,800 3%
TOTAL	**7 100%**	**27 100%**	**37 100%**	**11 100%**	**82 100%**	**3,714 100%**	**17,899 100%**	**29,366 100%**	**5,735 100%**	**56,714 100%**

Table B4.3-4. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 2/26/89–3/25/89	3/26/89–4/22/89	4/23/89–5/20/89	**5/21/89–6/17/89	Total
Fish Species					
Sucker	2,651 *(6) 81%	7,139 (16) 68%	4,925 (10) 30%	614 (1) 11%	15,329 (33) 43%
Carp		2,434 (4) 23%	7,852 (12) 48%	696 (1) 12%	10,982 (17) 31%
Flathead Catfish			767 (1) 5%	767 (1) 13%	1,534 (2) 4%
Channel Catfish	608 (1) 19%		2,740 (9) 17%	3,658 (8) 64%	7,006 (18) 20%
Subtotal	3,259 (7) 100%	9,573 (20) 91%	16,284 (32) 100%	5,735 (11) 100%	34,851 (70) 97%
Other Species					
Dead Deer		700 (2) 7%			700 (2) 2%
Unknown Mammal		300 (1) 3%			300 (1) 1%
Subtotal		1,000 (3) 9%			1,000 (3) 3%
TOTAL	**3,259 (7) 100%**	**10,573 (23) 100%**	**16,284 (32) 100%**	**5,735 (11) 100%**	**35,851 (73) 100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

** Fish provided to supplement diet after male died are not included in table.

items taken; AF04 delivered one unknown mammal and two portions of a deer carcass to the nest during this time. Both carp and catfish were taken extensively by AF04 in 1989, but we hypothesize that if the male eagle had not died in early May, he would have taken greater numbers of carp and catfish due to their increased availability in May and June. Prey remains analyses of items collected from the Ladders nesting area are described in Section B5.1.6.

Interestingly, in 1988 and 1989, mammals were present in the diet of the eagles only from late March to mid-April. In both years, the eagles began foraging on mammals within two days after sudden increases in flow. During 1–17 April 1988, flows ranged from 79 to 105 cfs but suddenly increased to over 700 cfs on 18 April (Figure B4.3-5). Flows remained high for about two weeks, peaking at over 5,700 cfs. The only time during the nesting season that the male eagle foraged on mammals was on 18–20 April just after the sudden flow increase. Late in the day on 20 April, AM08 captured a large carp possibly feeding in a newly flooded backwater at KM 172.0.

In late March 1989, river flows ranged from 45 to 151 cfs, but increased to 400 cfs on 29 March (Figure B4.3-5). High flows ranged from 315 to 450 cfs until 1 April. All four mammals taken by the eagles in 1989 were delivered from 30–31 March. Under these high water conditions, fish availability

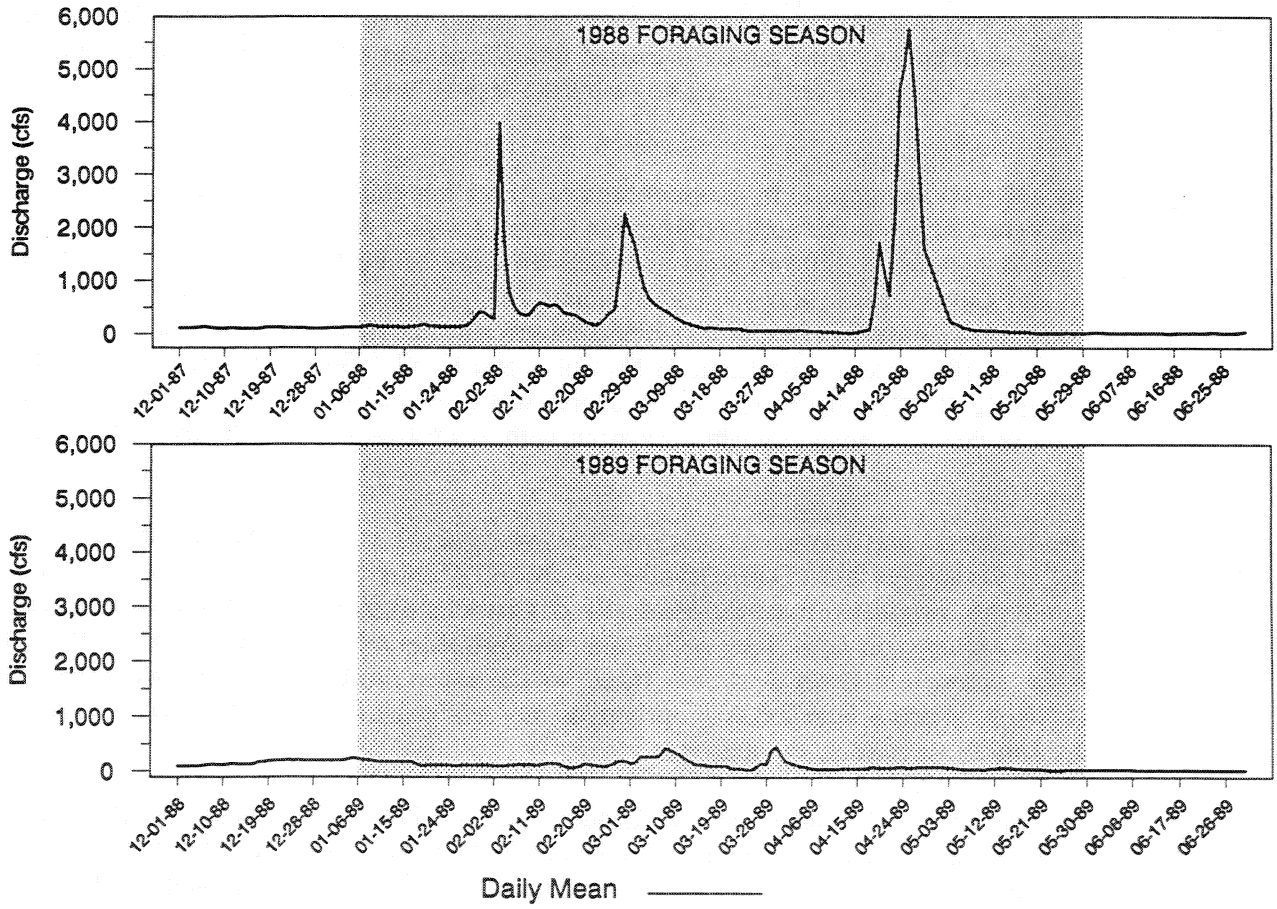


Figure B4.3-5. Mean daily flow in the Verde River from December 1987 through June 1989 (Ladders territory).

was no doubt temporarily reduced by increased turbidity and possibly changes in fish distributions. The shift at Ladders to terrestrial species was similar to the pattern observed at East Verde in 1987 when high, turbid flows apparently resulted in increased reliance on carrion cattle (Section B4.4).

During the nesting season in 1989, foraging emphasis by both male and female eagles was directed toward different species as the season progressed (Table B4.3-5). The general pattern of prey selection was: (1) specialization on suckers in March and early April; (2) continued use of suckers through April but with carp becoming more important; (3) a more diverse fish diet in late April and May with almost equal use of suckers, carp and catfish; and, (4) specialization on catfish by the end of May and into June. Data were too limited in 1988 to make comparisons of seasonal prey utilization with the 1989 results (Table B4.3-5).

We believe that bald eagles in the Ladders breeding area foraged selectively on spawning fish during the nesting season. Our fisheries surveys indicated the peak of sucker spawning activity in the Ladders territory in 1989 occurred in late February through March (Section B4.3.5). During this time, 90 percent of fish taken by the eagle were suckers. Utilization of carp and catfish by the Ladders pair also tracks the probable peak in spawning activity of these fish species. Optimum spawning temperature for carp is 21°C while the optimum temperature for catfish is 25°C. Therefore, carp should have become vulnerable to the eagles earlier in the spring than catfish. We found that carp accounted for 41 percent of prey numbers taken by the female eagle in May 1989 but only 9 percent of prey individuals in June. Also in 1989, catfish utilization by the female increased from 27 percent of the prey items taken in May to 82 percent in June. Only one catfish was taken by the eagles in the Ladders territory prior to 1 May 1989.

B4.3.2.2 Geography of Foraging. In previous studies, most foraging by the Ladders eagles were observed on the Verde River in the nest vicinity near Chasm Creek. Although the eagles were seen flying and perched in other areas, little foraging was recorded away from the nest (Haywood and Ohmart 1980, Haywood and Ohmart 1981, Haywood and Ohmart 1983, Grubb *et al.* 1983, Chorpenning and Crane 1984, Poelker and Palmiotto 1985, Grubb 1986a, Warrick and Hardwick 1986, Morgan and Sudar 1987, Collie and Knoll 1988, Collie and Knoll 1989, Collie and Knoll 1990). Poelker and Palmiotto (1985) and Collie and Knoll (1988) both noted that most prey was delivered from upriver of the nest from February to April and that the eagles brought prey from both downstream and upstream in April and May.

In the present study, based on foraging records, the location of successful hunting areas of the eagles varied depending on the species taken (Tables B4.3-6 and B4.3-7). Over 75 percent of the suckers taken by bald eagles (n = 56) originated from the Verde River upstream of the nest, with half of these fish known to have been captured between Beasley Flat and the confluence of West Clear Creek. Although we do not know the capture location of all suckers taken, we did not record any foraging between Beasley Cliffs and the Falls or at more than 2.5 Km upriver of the confluence West Clear Creek. Eighteen percent of the suckers were taken in the nest area.

The majority of carp (22 of 29) taken by the Ladders pair in 1989 were caught by the female (Table B4.3-6). These carp were almost exclusively taken from the Verde River near or just downstream of the nest (Km 164.3–160.0)(27 of 28 known forage locations). Similarly, the majority of catfish (20 of 22) taken in 1989 were caught by the female. Almost all the catfish were captured in the nest area (19 of 20 known forage locations).

Table B4.3-5. Summary of estimated biomass (grams) of prey delivered to Ladders bald eagle nest in 1988 and 1989 by both male and female adults. Numbers in parentheses refer to number of individuals delivered to the nest. Some species are grouped for analysis. Percentages expressed as percent of column total rounded to nearest whole number.

	OBSERVATION PERIOD/NUMBER OF OBSERVATION DAYS								
Species	4/10-4/23/88 6 days	4/24-5/7/88 4 days	3/12-3/25/89 8 days	3/26-4/8/89 9 days	4/9-4/22/89 9 days	4/23-5/6/89 9 days	5/7-5/20/89 9 days	5/21-6/3/89* 9 days	**TOTAL** **63 days**
Fish Species									
Sucker sp.	421 12% (1)	1,346 48% (4)	6,870 90% (15)	7,115 72% (15)	3,569 44% (9)	2,777 30% (7)	3,523 31% (6)	614 11% (1)	26,235 45% (58)
Carp	1,542 44% (5)	1,114 40% (2)		1,424 15% (1)	4,589 56% (6)	4,795 52% (9)	4,965 44% (7)	696 12% (1)	19,125 33% (31)
Catfish sp.	338 10% (2)		608 8% (1)			1,697 18% (5)	2,839 25% (7)	4,425 77% (9)	9,907 17% (24)
Unknown bass	192 5% (2)								192 0% (2)
Unknown fish	249 7% (2)	326 12% (2)	128 2% (1)						703 1% (5)
Subtotal	2,742 79% (12)	2,786 100% (8)	7,606 100% (17)	8,539 87% (16)	8,158 100% (15)	9,269 100% (21)	11,327 100% (20)	5,735 100% (11)	56,162 97% (120)
Other Species									
Cottontail	500 14% (1)								500 1% (1)
Unknown mammal	250 7% (5)			581 6% (2)					831 1% (7)
Carrion				700 7% (2)					700 1% (2)
Subtotal	750 21% (6)	0 0% (0)	0 0% (0)	1,281 13% (4)	0 0% (0)	0 0% (0)	0 0% (0)	0 0% (0)	2,031 3% (10)
TOTAL	**3,492 100%** **(18)**	**2,786 100%** **(8)**	**7,606 100%** **(17)**	**9,820 100%** **(20)**	**8,158 100%** **(15)**	**9,269 100%** **(21)**	**11,327 100%** **(20)**	**5,735 100%*** **(11)**	**58,193 100%** **(130)**

* Fish provided to supplement diet in this time period after male died are not included in this table (n=16; 7,754 grams supplemented biomass delivered).

Table B4.3-6. Origin of prey taken by the female bald eagle (AF04) in Ladders Territory in 1989.

DATE Km	SPECIES	NUMBER TAKEN	NEST AREA 162.0–164.3	GENERAL AREA: DOWNSTREAM OF NEST 161.9–157.0	GENERAL AREA: UPSTREAM OF NEST 162.8–182.0	GENERAL AREA: BEASLEY CLIFFS 165.4–168.4	SPECIFIC AREAS UPSTREAM OF NEST: BEASLEY FLAT 168.5–171.6	SPECIFIC AREAS UPSTREAM OF NEST: WHITE CLIFFS 171.7–174.0	SPECIFIC AREAS UPSTREAM OF NEST: WEST CLEAR CREEK AREA 174.1–178.0	UNKNOWN
3/26/89–3/25/89	Sucker	6	2		1					3
	Channel Catfish	1								1
	Total	7	2		1					4
	Percent		29%		14%					57%
3/26/89–4/22/89	Sucker	16	4		4		2	3	3	
	Sonora Sucker	1				1				
	Carp	6	5					1		
	Unknown Mammal	1						1		
	Dead Deer	3					3			
	Total	27	9		4	1	5	5	3	
	Percent		33%		15%	4%	19%	19%	11%	
4/23/89–5/20/89	Sucker	12		2	2	2	1	3	2	
	Carp	15	12	3						
	Channel Catfish	9	8	1						
	Flathead Catfish	1		1						
	Total	37	20	7	2	2	1	3	2	
	Percent		54%	19%	5%	5%	3%	8%	5%	
5/21/89–6/17/89	Sucker	1		1						
	Carp	1	1							1
	Channel Catfish	8	2	4	1					
	Flathead Catfish	1	1							
	Total	11	4	5	1					1
	Percent		36%	45%	9%					9%
TOTAL		**82**	**35**	**12**	**8**	**3**	**6**	**8**	**5**	**5**
Percent		**100%**	**43%**	**15%**	**10%**	**4%**	**7%**	**10%**	**6%**	**6%**

Table B4.3-7. Origin of prey taken by the male bald eagle (AM08) in Ladders Territory in 1989.

DATE Km	SPECIES	NUMBER TAKEN	DOWNRIVER 157.0–164.3	DOWNSTREAM OF NEST 161.9–157.0	NEST AREA 162.0–164.3	GENERAL AREA: UPSTREAM OF NEST 162.8–182.0	SPECIFIC AREAS UPSTREAM OF NEST: BEASLEY CLIFF 165.4–168.4	BEASLEY FLAT 168.5–171.6	WEST CLEAR CREEK 174.1–178.0	OFF-RIVER: WINDFIELD MESA	UNKNOWN
2/26/89–3/25/89	Sucker	9			3	4	1				1
	Unknown Fish	1									1
	Total	10			3	4	1				2
	Percent				30%	40%	10%				20%
3/26/89–4/22/89	Sucker	8			1	4		1		1	1
	Carp	3	1		2						
	Unknown Mammal	1				1					
	Total	12	1		3	5		1		1	1
	Percent		8%		25%	42%		8%		8%	8%
4/23/89–5/20/89	Sucker	4				2			2		
	Carp	4		1	2						1
	Channel Catfish	1			1						
	Flathead Catfish	1			1						
	Unidentified	2			1				1		
	Total	12		1	5	2			3		1
	Percent			8%	42%	17%			25%		8%
TOTAL		**34**	**1**	**1**	**11**	**11**	**1**	**1**	**3**	**1**	**4**
Percent		**100%**	**3%**	**3%**	**32%**	**32%**	**3%**	**3%**	**9%**	**3%**	**12%**

We concluded in our fisheries surveys that habitat was more favorable for suckers in the Verde River from Beasley Flats to just upriver from the confluence of West Clear Creek compared to the nest area (see Section B4.3.5). Further, our netting surveys confirmed suckers were less abundant in the nest area than in upriver areas. Habitat conditions near the nest appeared better suited for carp and catfish and may explain why (in this and previous years), the eagle foraged closer to the nest in the late spring when these species were spawning and more vulnerable.

West Clear Creek, a substantial tributary of the Verde River in the Ladders breeding area, was apparently not used by the eagles for foraging. Our fisheries surveys in 1989 revealed that prey fish populations in the creek were probably too small to attract the eagles. However, flows in the creek in 1989 were lower than normal, due to drought conditions, which may explain the low abundance of fish in the creek. In normal water years, suckers from the Verde River may migrate into the creek to spawn, providing foraging opportunities for the eagles. We detected three radio-tagged itinerant eagles along West Clear Creek during winter and early spring 1989 (January–March), suggesting a food source (spawning suckers?) existed during this period.

Data on seasonal changes in the distributional patterns of foraging are generally supported by telemetry visitation data (Figure B4.3-4). These show that in late February through mid-April 1989, the female eagle made numerous visits to the river section from Beasley Flats to just upriver of the confluence of West Clear Creek, presumably attracted by spawning suckers there. Visitation to these upriver areas decreased substantially in May and did not occur in early June. Our fisheries surveys showed that the availability of carp and catfish increased in the nest area in late spring.

B4.3.2.3 Observed Forages for Fish. During 1988 and 1989, we observed 103 forages (94 observed forages occurred in 1989). Seventy-four of these were by the radioed female (AF04), 15 by the radioed male (AM08), and 14 by the male before he was radio-tagged (his code at that time was PM01). All observed forages were on the river between segments 161 and 177, inclusive. Eighty-six observed forages were for fish, two were for mammals, and 13 were for unknown prey. Five forages were piracies, and one of these (for a great blue heron) was the only observed forage for a bird.

The status of fish taken (alive or carrion) are summarized in Table B4.3-8. Almost all suckers taken were identified as live, while carp were almost evenly split between live and carrion fish. The two species of catfish taken, channel and flathead, were primarily taken as live fish.

Observed forages for fish in the Ladders breeding area were primarily near the nest in river segments 161 to 163 (in 1989 the nest was located close to the segment 162/163 boundary), and this is true for both the male and female eagles (Figure B4.3-6). However, the distribution of forages varies for different fish species (Figure B4.3-7). We observed sucker forages both in segments 162 and 163 and further upstream in segments 167 and 171 to 174, while other prey species were primarily taken between segments 161 and 164. This distribution is fairly consistent with the prey delivery/eagle tracking data in Table B4.3-6, but should not be regarded as a true picture of foraging distribution because of chance factors in observer location.

We noted temporal changes in prey taken during the 1989 observation period, which ran from 15 March to 31 May. Figure B4.3-8 shows the number of forages for the three main fish species (suckers, carp, and channel catfish) for the 1989 tracking periods. Suckers were taken throughout the season (from

Table B4.3-8. Fish taken at observed forages in Ladders territory in 1988 and 1989. Data do not include piracies or retrievals of previously killed fish.

Species	Total	Live	Carrion	Unknown
Sucker spp.	21	17	2	2
Sonora Sucker	1	0	1	0
Carp	19	9	8	2
Channel Catfish	8	7	0	1
Flathead Catfish	3	1	1	1
Total	52	34	12	6

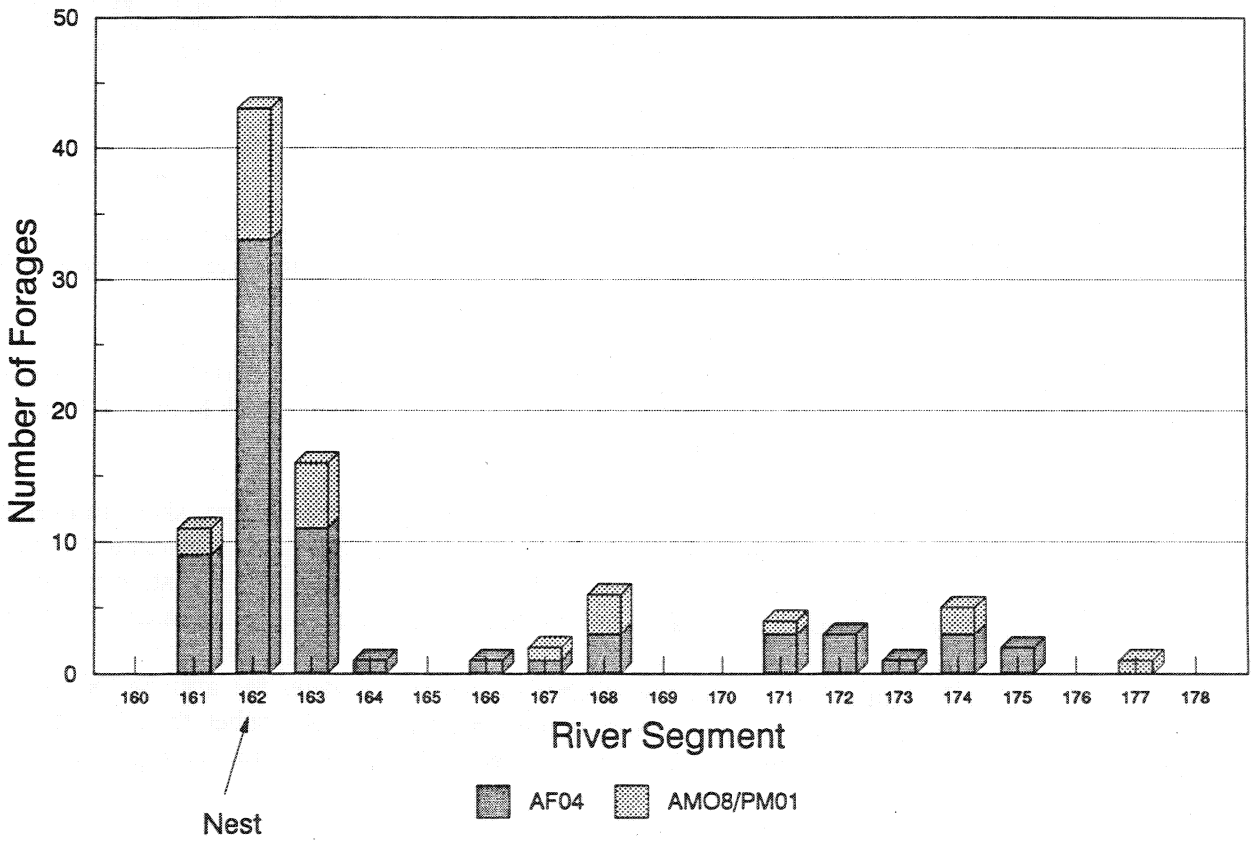


Figure B4.3-6. Distribution of observed forage attempts for fish in the Ladders territory in 1989. Forages are shown for the radio-tagged female AF04 and for the male both when he was radioed (AM08) and previously (PM01). This graph does not give a true picture of foraging distribution, because of chance factors of observer location.

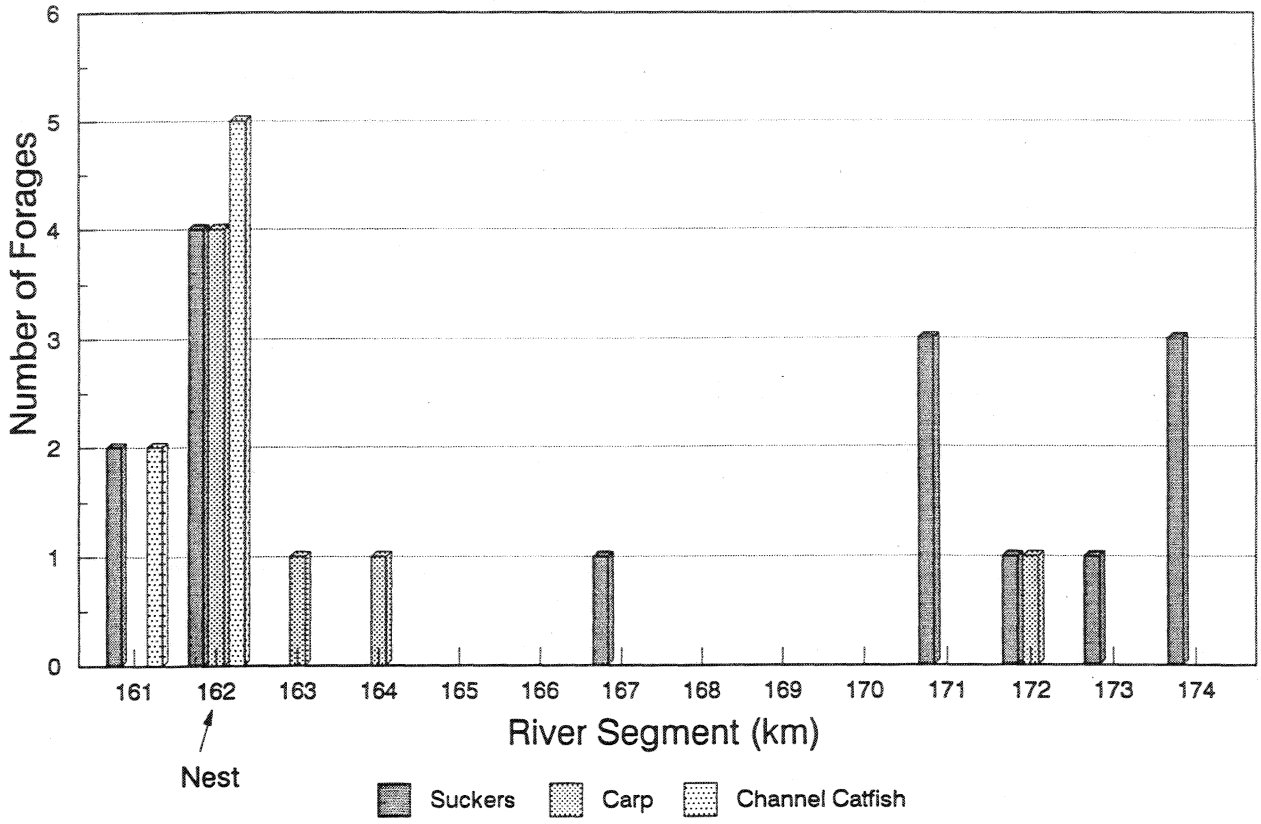


Figure B4.3-7. Distribution of observed forages for live fish of three species in the Ladders territory, by river segment in 1989. The three fish species shown—sucker spp., carp, and channel catfish—represent a total of 33 of 34 live fish prey identified to species. Data do not include piracies or prey retrievals.

15 March to 31 May), while carp are first noted on 15 April and channel catfish on 30 April. Carp and channel catfish continued to be taken until the end of the observation period (31 May and 30 May are respectively the last recorded dates).

Results in river segment 162, where the greatest number of forages were observed, show an even more distinct separation of prey over time (Figure B4.3-9). Suckers were taken from 16 March to 6 April, but not subsequently. Carp were first taken on 18 April, and the first channel catfish were noted on 30 April, with both species continuing to be taken until the end of observations at the end of May.

B4.3.2.4 Foraging Microhabitat. Since the number of observed forages for a given fish species is relatively low in this breeding area, we summarize our observations here rather than give a detailed breakdown of prey habitat measurements. Data are included in the discussion of overall foraging habitat (see Section A3.3).

Sucker species. We noted river habitat for 15 forages for live suckers: riffles were the most common (n = 11), followed by runs (n = 3), and pocket water (n = 1). Ten depth measurements at the strike points ranged from 10 to 53 cm; only two were of 40 cm or more (40 and 53 cm). Turbidity was clear to the bottom at nine strike points, with one measurement of 50 cm and one of 23 cm. Water

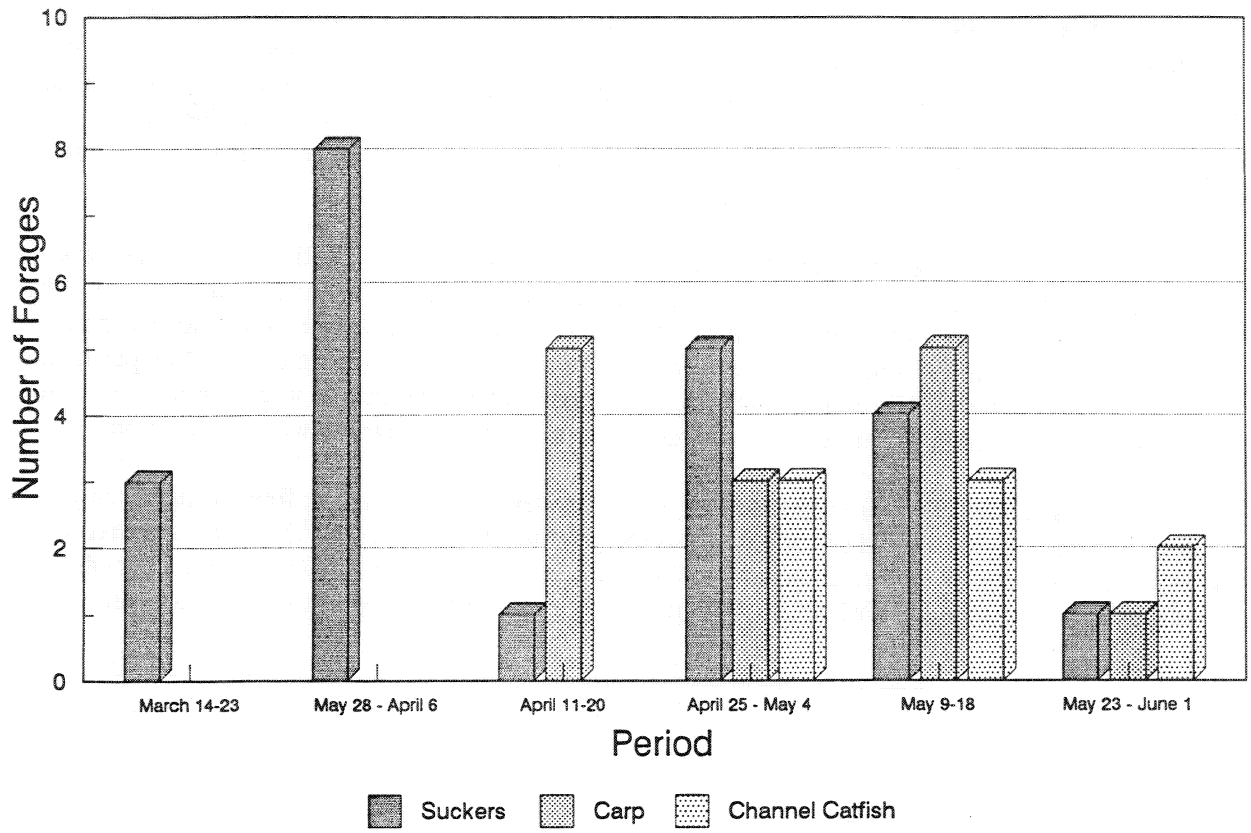


Figure B4.3-8. Observed forages for three fish species in different periods of 1989, Ladders territory ("Suckers" include the species identified as Sonora sucker). The three species shown account for 49 of 52 overall observed forages for fish in which the prey could be identified to species. Data do not include piracies or prey retrievals.

temperatures at strike points varied from 13–25°C with an average of 19° (n = 14). Water velocities ranged from no discernable current to 0.5 m/sec; of ten velocity measurements, four were 0.25 m/sec.

Carp. River habitat recorded for live carp included runs (n = 3), riffles (n = 2), and pocket water (n = 1). Two other carp were taken from riffles; however, we did not know whether they were taken alive or as carrion. Depths were shallow, ranging from 10–35 cm (n = 6). Turbidity was clear to the bottom in six cases, with one reading of 24 cm. Six temperature measurements ranged from 15–21°C, with an average of 19°C. Water velocities included one measurement of 1.0 m/sec, two of 0.5 m/sec, and three of no discernable current.

Channel Catfish. Of seven live channel catfish, two were taken in runs and five in pocket water. Five recorded depths ranged from 14–85 cm, with three of the measurements greater than 65 cm. Turbidity measurements show three in the range of 25–47 cm, and two clear to the bottom. Six measured water temperatures ranged from 20–22°C. Measured velocities included four records of 1.0 m/sec and one of 0.5 m/sec.

Flathead Catfish. We observed only two forages for this species, one in pocket water in segment 161 (status unknown) and one in a riffle in segment 163 (alive).

B4.3.2.5 Foraging Perches. We identified 82 forage perches in the Ladders breeding area. Fifty-three of these were on the ground: cliff ledges (n = 36), cliff tops (n = 11), boulders (n = 3), or unspecified cliffs (n = 3). Only 19 observed attack perches were in vegetation. Live junipers were most frequently used (n = 8), followed by snag junipers (n = 6), unidentifiable hillside vegetation (n = 2) or cliff vegetation (n = 1), and one perch each on a live mesquite and a conifer. Seven attacks originated directly from the nest, and three started from shore.

Distance from perch to attack point for attacks directly from the perch to the water varied from seven to 500 m. Of 53 direct attacks, 43 covered 75 m or less, six were from 76 to 150 m, and four were over 150 m from the perch to the attack point. Although the shorter distances were more common, they appeared to show a lower success rate: 20 successes (one a carrion forage) in the 43 attempts at less than 75 m, five successes of six attempts at 76-150 m (none of the successes were for carrion), and four successes of four attempts at over 150 m, although two of these successes were for carrion.

B4.3.2.6 Other Observed Forages. Piracies. We observed five piracies; four occurred on river near the nest in segments 161 to 163, and one originated from the nest itself. AF04 pirated three fish from great blue herons: one a channel catfish, one a live fish, and one identified only as a fish. AM08 flew from the nest and pirated a fish from an osprey high over the mesa toward Cottonwood Spring. AF04

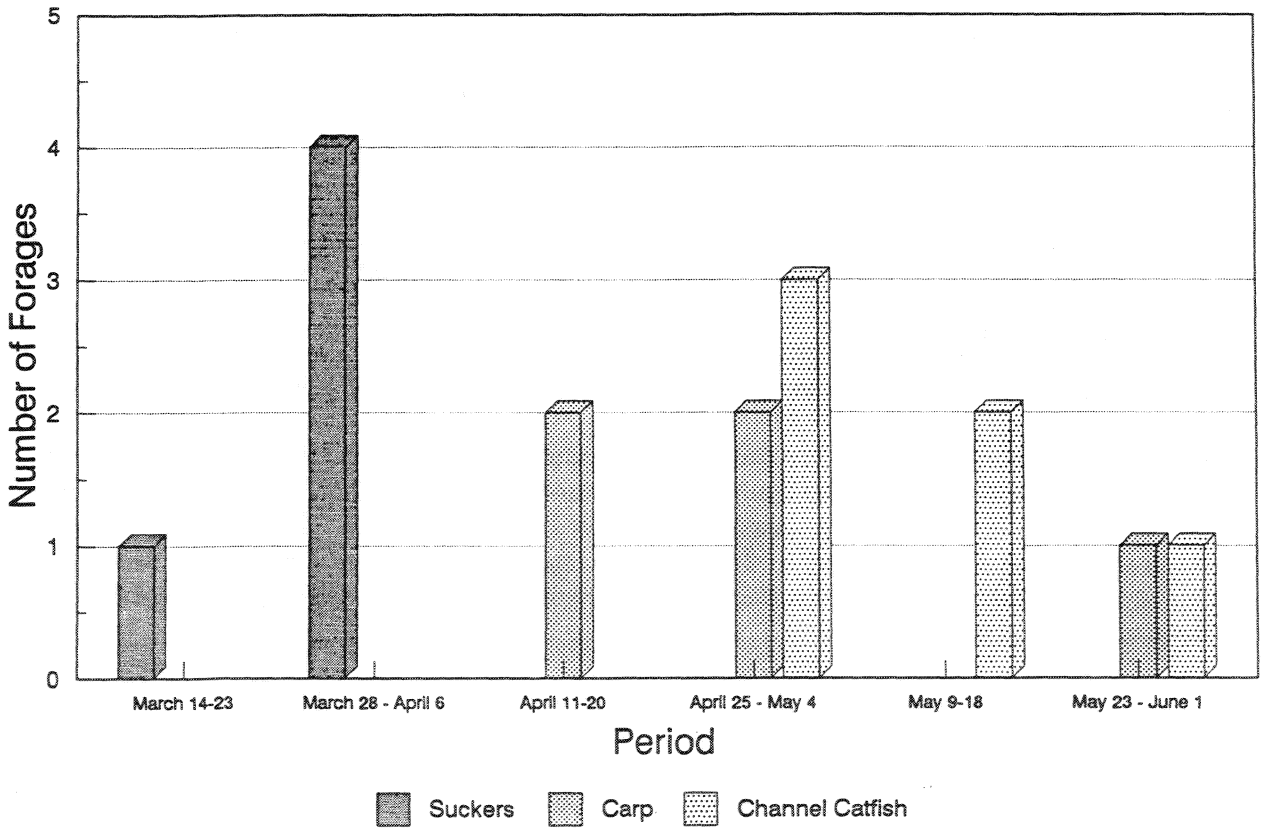


Figure B4.3-9. Observed forages for three fish species in different periods of 1989; location is river segment 162, Verde River, Ladders territory. As noted for B4.3-8, these three species account for almost all observed forages in the territory in which the fish prey could be identified to species. Data do not include piracies or prey retrievals.

attempted to pirate a dead great blue heron from a golden eagle. She attacked the golden eagle twice within 15 minutes, vocalizing and circling low over it with her feet down, but could not drive it from its prey.

Forages on Mammals. We observed only two forages for mammals, both by AF04. On 31 March 1989, she fed on a mule deer carcass, two to three days old, on Wingfield Mesa inland from Km 171.2. On 5 April, she took an unknown mammal from the river at Km 172.3 and delivered it to the nest. We could not determine if the prey was live or carrion.

B4.3.2.7 Macrohabitat Selection. We characterized river habitat during 27 June to 6 July 1989 when flows ranged from 20–22 cfs. The relative abundance of habitat types along the Verde River from Km 161.0–181.0 is depicted in Figure B4.3-10. The river in this territory was composed primarily of pool habitat (59% of total area) and run habitat (35%). Riffle habitat (normal riffles and super-riffle) only accounted for 4 percent and 1 percent, respectively, of the total area mapped. In general, most of the river (approximately 65%) was shallow (0.0–0.6 m deep). The average width of the Verde River in Ladders Breeding area during our surveys was 24 m.

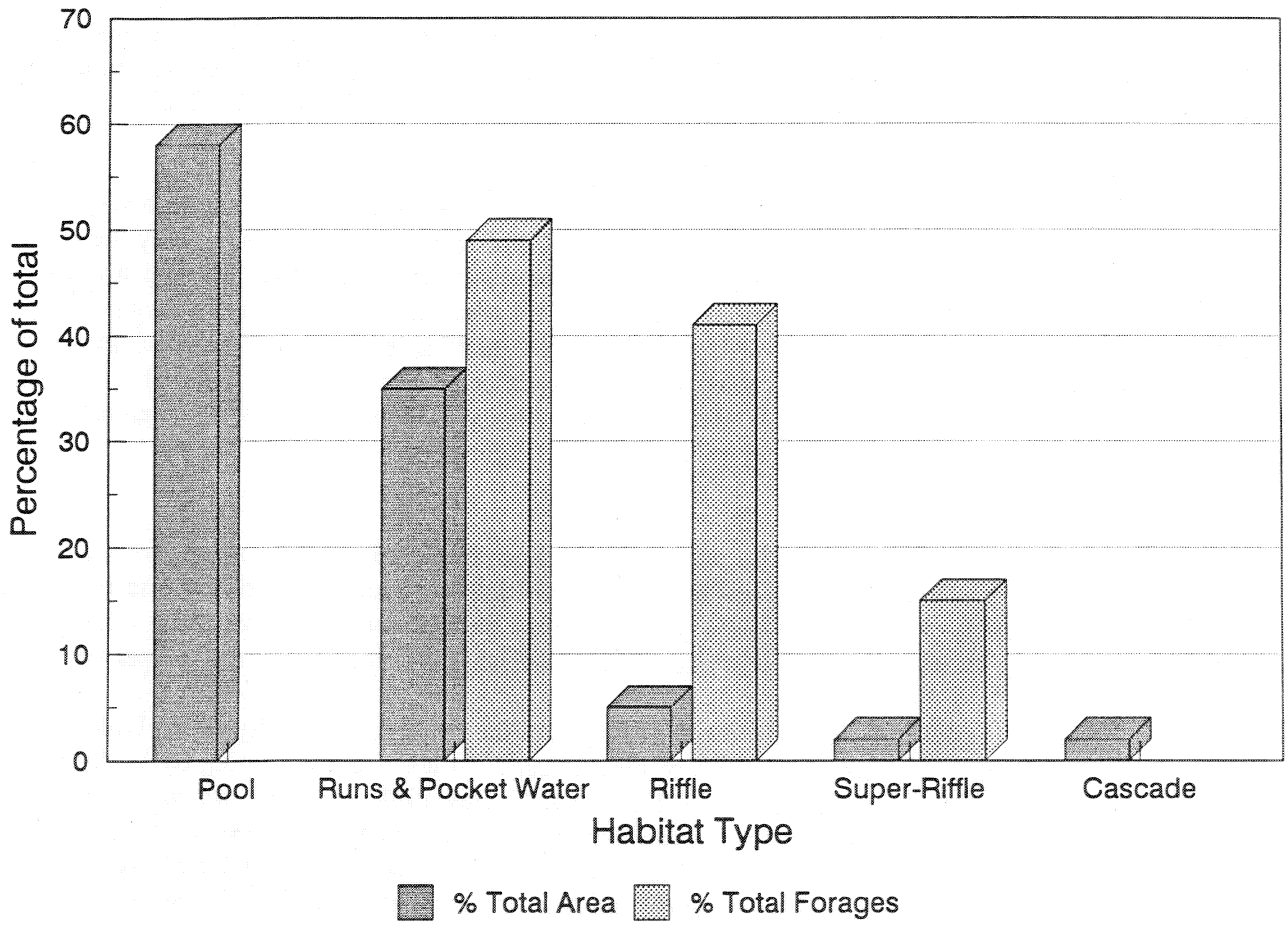


Figure B4.3-10. A comparison of habitat availability (by percent area) and total forages by habitat type in the Verde River (Ladders territory) in 1989.

Size parameters (width, length, and area) for each of the habitat types measured are summarized in Table B4.3-9. A statistical comparison of normal riffles and super-riffles revealed that super-riffles were significantly wider than normal riffles (t-test, $t = 2.82$, $df = 22$, $p < 0.02$), but were similar in terms of average length and area. Both of these habitat types were dominated by gravel and rubble substrate and were shallow (0.0–0.6 m).

The Ladders breeding area includes a 22-Km reach of the Verde River (Km 160.0–181.0) where eagles perched and foraged (Figure B4.3-3). We first tested the hypothesis that visitations were evenly distributed over the entire reach by Chi-Square analysis. We found that the observed pattern of visitations was not evenly distributed along the river ($\chi^2 = 771$, $df = 21$, $p < 0.001$). We next attempted to correlate visitations to specific habitat characteristics per Km segment (Table B4.3-10). Habitat characteristics included in this analysis were distance from nest and the abundance of different riverine habitats (i.e., pools, runs, riffles, super-riffles, and cascades). The Spearman rank correlation coefficient was calculated for each combination of visitation with habitat characteristics (Zar 1984). The results of this analysis indicate that visitations were significantly correlated with distance from nest (Spearman rank correlation, $n = 22$, $r_s = 0.646$, $P > 0.01$), but there was no significant correlation between eagle visitations and abundance of any particular habitat type.

It is important to remember that this analysis uses only data from the female bald eagle and therefore may be biases toward habitat use in the nest area. Of the total eagle visitations, 85 percent occurred within 3 km of the eagle's nest. Notably, however, that segment of the river within the 3 km radius also contained 87 percent of all super-riffle habitat.

B4.3.2.8 Observed Habitat Selection by Eagles on the Verde River. In 58 observed forages in the Verde River between Km 181.0–160.0 in Ladders Breeding area we were able to identify the specific location (habitat) of prey capture. A comparison of habitat availability in the river to the distribution of eagle foraging by habitat was revealing (Figure B4.3-10). Analysis of the observed versus expected visitations to each of the habitat types revealed that selection of foraging habitat was not random in this reach ($\chi^2 = 289$, $df = 4$, $p > 0.001$). Eagles preferentially selected riffles (54% of total forages) and runs (47%). No forages were observed in pool habitats, even though pools comprised 59 percent of total area we mapped the river in this territory at the time of our (Figure B4.3-10).

B4.3.3 Prey Studies

B4.3.3.1 Fisheries. We collected fisheries data in the Ladders breeding area to estimate the relative abundance, distribution, and spawning chronology of potential prey fishes occurring in the river, their habitat distributions, and spawning chronology. We also made incidental observations of behavior and other factors that might make species available to eagles at differing times of the nesting season.

Relative Abundance (Verde River). Little data is available on the fish community in the Ladders eagle breeding area. Existing information consists of results from gill net sets and seining by BioSystems in 1989 and Bureau of Reclamation field surveys during 18–20 May 1988. In 1989, we collected 182 fish in gill nets set overnight in pools and floated through riffle and run habitat between Kms 185 and 163. Desert and Sonora suckers composed 92 percent of the fish collected (12% and 80% respectively). Largemouth bass, carp, flathead catfish, bluegill, smallmouth bass and channel catfish accounted for the remaining 8 percent of the fish. However, our gill net data no doubt substantially underestimated carp abundance; we often observed carp either avoiding our nets or breaking free. During visual surveys, we frequently observed carp feeding in shallow water, but suckers were by far the most visible species in

Table B4.3-9. Comparison of habitat types in the Verde River in Ladders Territory. Standard deviations of mean values are given in parentheses.

Habitat	N	Total Length (m)	Mean Length (m)	Mean Width (m)	Total Area (m^2)	Mean Area (m^2)	% of area with substrate type						% of area with depth (m)			
							Mud	Sand	Gravel	Rubble	Boulder	Bedrock	0–0.6	0.6–1.2	1.2–1.8	>1.8
Run	100	11,208	120.7 (125.0)	20.5 (9.3)	246,561	2,631.1 (3,034.9)	3%	21%	37%	23%	9%	8%	90%	9%	1%	0%
Riffle	28	1,287	38.8 (32.2)	20.3 (8.4)	28,466	720.8 (434.4)	0%	7%	55%	37%	1%	0%	100%	0%	0%	0%
Super-riffle	9	311	34.6 (21.3)	34.7 (16.6)	9,613	1,068.2 (575.8)	0%	9%	57%	17%	16%	2%	100%	0%	0%	0%
Pool	50	13,197	264.0 (184.3)	28.7 (9.7)	424,470	8,489.4 (7,274.0)	10%	35%	31%	13%	3%	8%	48%	37%	14%	2%
Cascade	9	238	26.4 (12.4)	17.0 (6.8)	4,427	492.0 (395.9)	0%	1%	12%	22%	13%	52%	93%	7%	0%	0%
Total	196	26,242	143.4 (155.0	23.6 (10.6)	713,540	3,899.1 (5,242.4)	7%	28%	35%	18%	5%	7%	65%	25%	8%	1%

Table B4.3-10. Summary of visitations, distance from nest, and habitat abundance in twenty-two kilometer segments (Km 160–181) within the Ladders Territory.

Segment	Weighted Visitation Score	Distance from nest (km)	Habitat Area (m^2)				
			Pool	Run	Riffle	Super-Riffle	Cascade
160	4	1.62	16,443	10,115	0	4,585	0
161	55	1.14	28,233	5,032	0	0	107
162	91	0.43	6,696	22,971	0	1,626	0
163	40	0.60	18,414	7,472	482	0	0
164	34	1.40	16,862	4,974	0	862	265
165	0	1.62	16,607	9,925	0	0	1,285
166	4	2.36	15,346	16,029	0	0	669
167	9	2.19	14,290	14,954	0	650	0
168	38	2.48	6,952	9,042	0	651	0
169	3	3.40	18,445	2,719	0	0	0
170	0	4.12	20,651	16,104	0	0	0
171	8	4.05	4,992	19,403	1,043	0	0
172	10	4.83	16,287	8,022	686	0	0
173	7	5.57	20,567	5,493	1,787	0	0
174	7	6.43	12,371	14,238	0	0	0
175	3	7.19	16,221	7,900	1,082	0	0
176	1	8.02	15,472	5,905	582	0	0
177	9	8.71	2,318	11,853	401	0	0
178	0	9.43	24,393	1,754	0	1,240	1,468
179	0	10.07	14,542	6,676	161	0	0
180	0	10.71	21,203	5,259	0	0	0
181	1	11.33	22,160	9,051	0	0	147

the territory. Gill netting by the Bureau of Reclamation in 1988 in the Ladders breeding area collected 14 Sonora suckers, eight desert suckers, 11 roundtail chubs, one smallmouth bass, and two green sunfish.

More comprehensive fisheries data (from 1975, 1986, 1987, and 1988) are available for the Verde River both upstream and downstream of the Ladders eagle breeding area (see Table E2-4) which can be used to predict species abundance in this area. The fish community from the Highway 17 Bridge to Perkinsville was primarily composed of native fishes, with suckers (37%), roundtail chub (17%), and squawfish (26%) being most abundant. Carp (2%), catfish (1%), smallmouth bass (6%) and green sunfish (12%) were the most common exotic species. The presence of squawfish above the Highway 17 Bridge is probably a result of stocking by AGF, and it is unknown if any are present in the Ladders breeding area.

The fish community in the East Verde breeding area (Kms 123–140), downstream of the Ladders nest, is considerably different from that above the Highway 17 Bridge (see Table E2-4). The fisheries data

used in the following summary were from collections in 1986 by O. Hendrikson (AGF) and by M. Jakle (Reclamation) in 1988. In the East Verde breeding area, carp were the most abundant prey fish, comprising over 44 percent of the fish collected. Suckers and catfish were equally abundant, each making up 17 percent of the fish community. The remainder of the community consisted of smallmouth bass (14%), largemouth bass (3%), green sunfish (3%) and bluegills (3%).

Giving the major differences in the fish community above and below the Ladders territory, we speculate that suckers and carp are the most common prey fish in the territory, followed by catfish and smallmouth bass. Our netting and visual surveys suggest that suckers are far more abundant than carp, despite the sampling biases. Therefore, the fish community in the Ladders breeding area would appear to be in transition from being dominated (upstream) by native fishes, primarily suckers, to being dominated (downstream) by exotics, namely carp, catfish, and smallmouth bass.

Fish Vulnerability. We divided the Verde River within the Ladders Breeding area into three reaches, based on general habitat conditions and fish vulnerability: (1) Camp Verde Reach from Km 185–179; (2) West Clear Creek Reach from Km 178–166; and, (3) Nest Area Reach from Km 165–160. We estimated fish vulnerability during gill netting surveys and roving- and fixed-point surveys in each reach. In these surveys we concentrated on estimating fish abundance in shallow water less than 0.6 m deep. The reader should not assume that the results of these surveys describe the relative abundance of species in all habitats; for example, large numbers of fish may have been present in deep runs or pools. The following discussion characterizes fish availability in shallow areas of the three reaches.

Camp Verde Reach (Km 185–179). The Camp Verde Reach consisted of relatively high velocity, deep riffles and runs separated by pools. The river channel was relatively narrow in this reach, and gradient was moderate, resulting in deeper habitat than in the West Clear Creek reach. Surface turbulence limited visibility in many riffles and runs. No super-riffles and only 4 classical riffles were found in this reach. Our floating gill net surveys collected a total of 37 fish in 713 m of river (35 suckers and 2 carp). Although this data suggests that suckers were abundant in shallow water, many habitats in this reach were passed over during our survey because they were too either too swift or too deep to sample. In our roving visual surveys, we also noted that fish were relatively scarce in shallow water in the Camp Verde Reach. The majority of habitats in this reach were either too deep or contained surface turbulence which limited our ability to observe fish. Even in shallow habitats, fish were seldom observed.

West Clear Creek Reach (Km 178–166). The West Clear Creek reach is located in Verde Valley where river gradient is low and the river channel widens compared to other areas upstream and downstream reaches. Due to gradual sloping banks along most habitats in this reach, as flows increase the habitats tend to get wider rather than deeper due to spreading of water onto the floodplain, conditions that result in the formation of many shallow riffles and runs. Four super-riffles and eight normal riffles also occur in this stretch of river.

We conducted both roving visual and gill netting surveys in this river reach. We collected a total of 112 fish in 2800 m of river sampled using floating gill nets. Suckers comprised over 94 percent of species collected, with Sonora suckers (n = 91) considerably more abundant than desert suckers (n = 15). Low numbers of carp, smallmouth bass, channel catfish, and flathead catfish were also collected. During visual surveys, suckers were by far the most common species observed. We frequently observed groups of several hundred suckers in shallow runs in this reach during April and May. Carp were also observed on a regular basis in this reach although we rarely saw more than 2 carp in an area at one time.

Nest Area Reach (Km 160–165). The Nest Area reach is located in a deep canyon where river gradient increases and channel width decreases resulting in an increase in average deep and velocity. Several steep cascades (waterfalls) can be found in this reach near Km 165.1. Although, the majority of habitat area in this reach appears either too deep or too swift for eagles to forage effectively, prime foraging habitat may be found in isolated regions. Based on our foraging data (see Section B4.3.2), riffles and super-riffles were used preferential by the Ladders' eagles. In the nest area reach, a total of five super-riffles were identified; these were located at Kms 164.1, 162.6, 160.6, 160.3, and 160.1. Only one normal riffle was mapped in this reach. Shallow pocket water habitat was also present from Km 162.5 to 161.9. Interestingly, despite the presence of apparently suitable nesting habitat (cliffs) from Km 166.5–Km 159.0, the eagle nest in 1989 was located at Km 162.8 within 200 m of a super-riffle, while in 1988 the eagle nest was located at Km 163.8 within 300 m of a super-riffle.

We used floating gill nets in April and May 1989 to sample over 4423 ft of river but collected only 7 fish (3 smallmouth bass and 4 suckers). However, we did observe both channel catfish and carp in this reach, although they were able to avoid our nets. During our roving visual surveys in April and May 1990 from Km 166–158, we rarely observed suckers in the nest reach, even in riffle habitat, and it appeared to us that suckers were considerably less available to eagles in this reach than in the West Clear Creek reach upstream. However, we did not conduct surveys in the nest reach in February and March, when suckers were presumably spawning in the river. Based on observations of sucker spawning behavior in other bald eagle territories (see Bartlett and Blue Point), it is likely that suckers were found in shallow water in this reach in the early spring.

We conducted fixed point visual surveys of two gravel bars, which form a super-riffle, just downstream of the 1989 Ladders nest (Km 162.6) on 3 April and 1 and 13 May 1989 to record diel and temporal changes in fish abundance. Observations during these surveys were from the top of a cliff approximately 25 m above the river. We used binoculars (10 × 50) to examine the riffle and a spotting scope (20–60×) for species identification, abundance estimates, and fish behavior classification (Figure B4.3-11). During our surveys, the female eagle spent long periods of time looking at the gravel bars while shading the chicks in the nest. Significantly lower numbers of fish were observed in the area in April compared to May at all times during the day (ANOVA, $p < 0.01$). It appears that foraging opportunities in riffles in the nest area in the late spring was limited to carp.

However, during May the female eagle caught several live catfish from pocket water habitat located just downstream of the 1989 nest (Km 162.5–161.9). We walked through the pocket water habitat on two different days in May to determine if catfish might be available to eagles on a regular basis. During these surveys, we observed two catfish (approximately 35 cm TL) in shallow water (less than 0.06 m deep), with their heads under a boulder but their bodies exposed. Both fish remained in this position for over 30 minutes. We do not know what the catfish were doing but we were able to approach within 0.3 m of the fish before spooking them. Although this information is anecdotal and may not represent a common circumstance, these fish were clearly vulnerable to eagles. No suckers or carp were observed in the pocket water habitat during these surveys.

Based on overall fish availability, the West Clear Creek reach appeared to contain greater numbers of fish in shallow water in April and May than the Camp Verde or Nest Area reaches. However, all the reaches did contain fish in shallow water habitat. The eagles' preference for the nest area, particularly late in the nesting season, may be a reflection of the distribution of super-riffles in the river and activity of prey fish. However, the death of the male probably resulted in the female's greater use of the nest area. Had

the male eagle survived, both eagles might have foraged more commonly in other areas. In any case, we found five super-riffles within 2 Km from of the nest but only four additional super-riffles in the reminding 21 Km of this breeding area. Our visual surveys showed an increase in carp availability in shallow water in the nest area in late spring.

Size and Sex Distribution of Suckers. Only Sonora suckers were collected in sufficient numbers in gill nets in the Ladders Breeding area to characterize size and sex distribution. We noted three distinct size classes in Sonora suckers in this territory; they ranged from 190–220 mm, 390–490 mm and 510–540 mm TL (Figure B4.3-12). Fish smaller than 200 mm TL were under-represented due to gear selectivity. However, since we never recorded eagles foraging on suckers smaller than 200 mm TL, our data is probably representative of prey availability. Interestingly, we did not collect any suckers between 250–380 mm TL, suggesting that their reproductive success was poor in past years (Total year-class failures are quite common in many sucker species). The size class distribution of Sonora suckers observed in the Ladders breeding area was quite similar to their distribution at Bartlett and Blue Point, suggesting that these size classes tend to dominate the fishery in central Arizona rivers. Of the 118 fish collected in floating gill nets that we sexed, 58 percent were females and 42 were males.

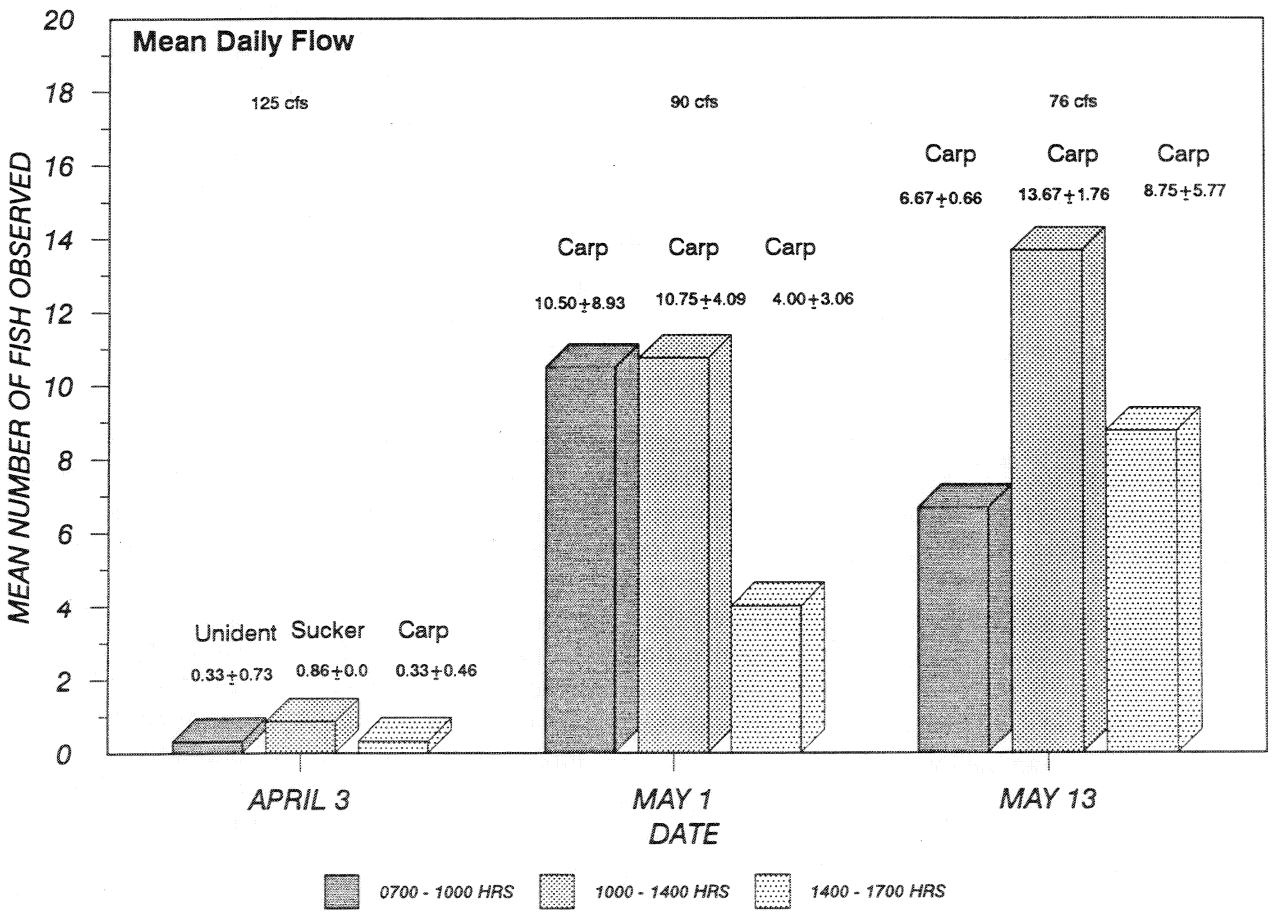


Figure B4.3-11. Mean number (and associated 95% confidence interval) of fish observed in shallow water at Km 162.6 in the Verde River in April and May 1989.

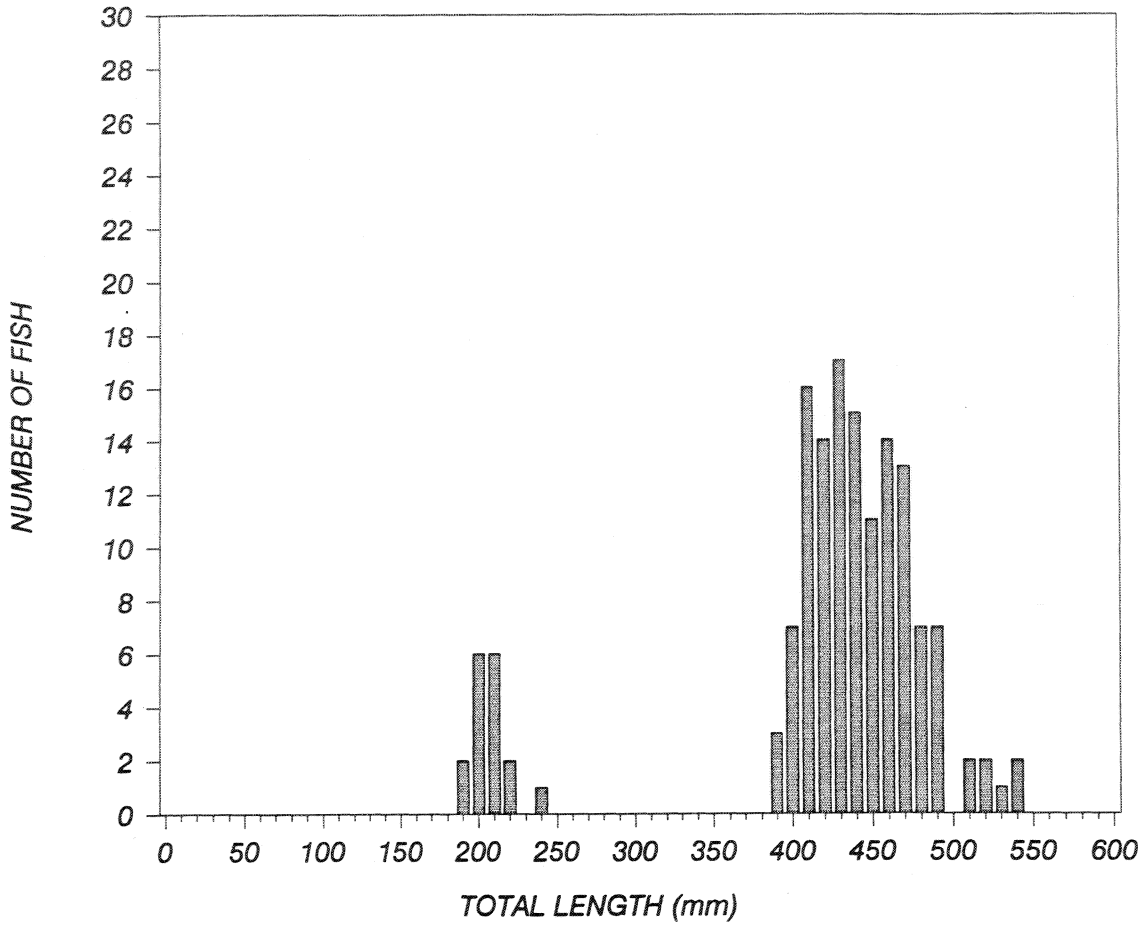


Figure B4.3-12. Size distribution of Sonora suckers in the Verde River, Ladders territory (1989).

Spawning Chronology of Prey Fish. We conducted roving visual surveys in the Ladders Breeding area on 4–6 April and 2–14 May 1989 over Kms 185 to 160. During these surveys a biologist walked along the river bank noting the abundance, location, habitat, and behavior of potential prey species. We used polarized sunglasses and binoculars (10 × 50) to assist in species identification during these surveys.

Only suckers were observed in sufficient numbers to form any conclusions. We did not observe any courtship or spawning activity by suckers in either of the surveys, suggesting spawning had already occurred. To verify our visual observations, we captured 19 desert suckers and 142 Sonora suckers in floating gill nets in April and May 1989 and assessed their reproductive status. In April, the majority of 52 suckers examined were spawned out; however, three desert suckers and 9 Sonora suckers released milt when squeezed. By early he May, all the desert suckers (n = 12) and Sonora suckers (n = 79) examined were spawned out. Based on this data, we speculate that peak spawning by suckers in the Ladders Breeding area occurred prior to April, probably in February and March.

The peak spawning periods of suckers, carp and catfish in the river may be determined by comparing water temperatures in the river to the preferred spawning temperatures of each species. Water temperatures in the Verde River within the Ladders Breeding area in February–May 1989 are illustrated

in Figure B4.3-13. Based on our literature review and data collected during this study (see Section E2 and E3), we anticipate peak spawning by suckers when river temperature are between 14–18°C, by carp when temperatures reach 18–24°C, and by channel and flathead catfish when temperature are between 22–27°C. At Ladders in 1989, we estimate that peak spawning for suckers occurred between late February and late March, carp spawning between late March and June, and catfish spawning from mid April to June.

B4.3.3.2 Waterbird Surveys. The results of four waterbird surveys conducted in April and May are given in Table B4.3-11. Although species were present that are known to be occasionally taken by bald eagles (e.g., mallards), no birds of any kind were recorded as prey of the Ladders pair, except for a great-blue heron that AF04 attempted to steal from a golden eagle.

B4.3.4 Human Impacts

Our records show that the Ladders pair did not experience high numbers of interactions with public users, Non-motorized boaters, including rafters, kayakers, and canoeists, entered the nest area mainly in March when the river level was elevated from spring run-off. Shooting incidents, though not common, were of special concern.

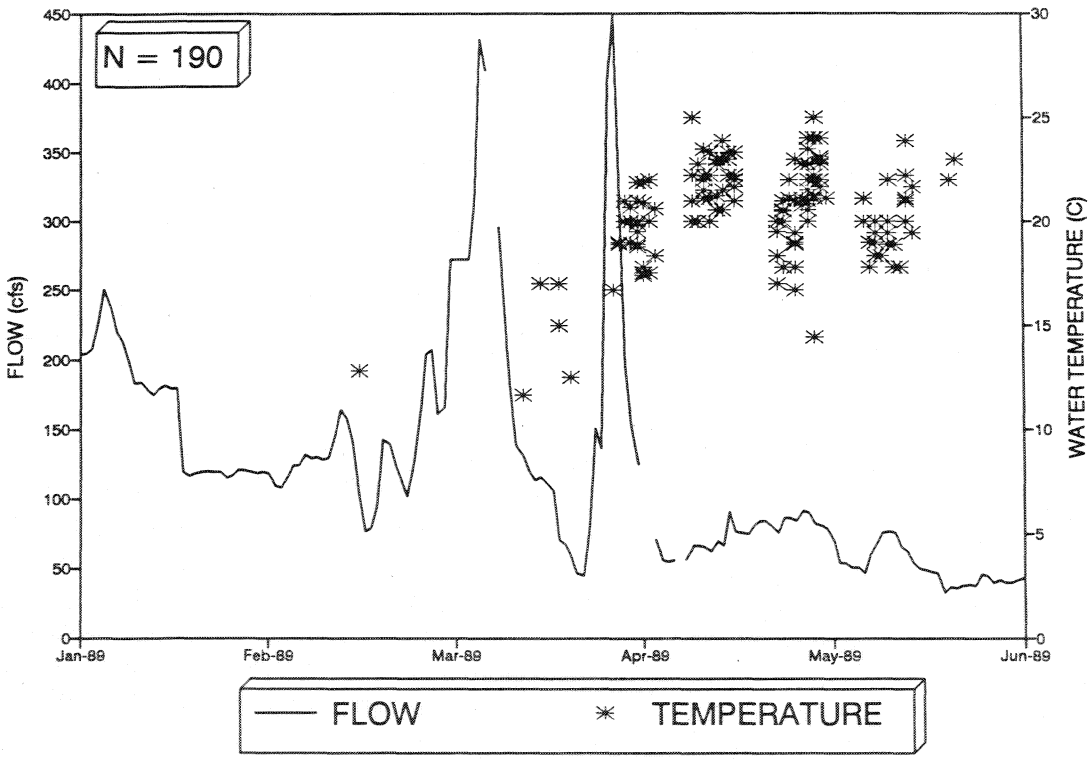


Figure B4.3-13. Mean daily flow and temperature measurements on the Verde River (Km 160–181) from January–June 1989. Temperature measurements taken between 0930–1730 hr.

Table B4.3-11. Water birds observed in surveys at Ladders breeding area (1987–1989).

Species	Avg. No. Individuals per Survey	% Species/Month April	May
Mallard	1.8 (n=7)	8.1	—
Green-winged Teal	2.0 (n=8)	2.3	11.1
Ring-necked Duck	1.8 (n=7)	—	13.0
Common Merganser	8.8 (n=35)	27.9	20.4
Snowy Egret	1.0 (n=4)	—	7.4
Great Blue Heron	7.3 (n=29)	23.3	16.7
Green-backed Heron	2.0 (n=8)	4.7	7.4
Other Waterbirds	10.5 (n=42)	33.7	24.0
		n = 86 (three surveys)	n = 54 (one survey)

On 23 October 1984, the Forest Service enacted a closure around the most recently-used nest areas, limiting entry from 1 December to 15 June. A revision in 1987 extended the closure date to 30 June. The closure boundary extends from river Km 162.2 to Km 165.2 and up Chasm Creek and Sycamore Canyon. The closure is posted twice along the river with a small sign marking the upstream boundary and a larger one directly below the Chasm Creek nest. Roads entering the closure have gates with locks and signs stating the reason for the closure (for protection of wildlife and watershed), dates of effect, and a map. Rafting, kayaking, and canoeing do not require a permit, although, the Forest Service is going to suggest a free permit system as part of their Scenic Management Program (part of the Wild and Scenic River Act) for the purpose of monitoring river use.

The public use events in Table B4.3-12 were recorded on an incidental basis during the 1987, 1988, and 1989 breeding seasons; incidents were noted throughout the territory wherever they occurred within 100 m of an eagle. The data are not representative of the actual distribution of public users but rather depended on the location of the observer and the eagles. We recorded 28 events (56% of the total) within the closure consisting of the following public use types: 14 low-level flights, seven rafts, two helicopters,

Table B4.3-12. Summary of public use events and eagle responses at Ladders territory in 1989.

Type Public Use	No. Public Use Incidents	Percent of Total Incidents	Duration (min)	Percent Duration	Response to Public User			
					N	W	I	F
Hiking	3	6.0	3	0.5	—	1	—	2
Boating (non-motorized)	25	50.0	*472	72.5	1	20	1	3
Agency Worker (wading)	1	2.0	135	20.7	—	1	—	—
Shooting	2	4.0	2	0.3	—	—	—	2
Helicopter	2	4.0	7	1.1	—	2	—	—
Low-level Flight	14	28.0	14	2.2	13	1	—	—
Four-wheel Drive (off-road)	1	2.0	1	0.2	—	1	—	—
Horseback Riding	2	4.0	16	2.5	—	2	—	—
TOTAL	50		650		14	28	1	7

N = No response; W = Watching; I = Activity Interrupted; F = Flush.
* Nine records not totaled.

two horseback riders, one off-road four-wheel drive, one hiker, and one agency worker. Of these, only the hiking incident caused an eagle to flush. In all events (inside and outside the closure), only three of 25 (12%) non-motorized boating incidents caused an eagle to flush, yet two of three (68 percent) hiking events and all shooting events ($n = 2$) caused an eagle to flush. Only one flush was recorded near the nest area (within 100–200 m).

Floating the Verde River through the Ladders territory may effect the eagles in two ways: (1) boaters may cause adults to flush, potentially leaving nestlings susceptible to exposure, and (2) boats floating through preferred foraging areas may prevent eagles from hunting. Table B4.3-12 shows that in 25 circumstances in which boaters passed within 100 m of an eagle in the Ladders territory, three caused flushing.

An area where the eagles may be affected by public users is that of Beasley Flats (Km 168.5–171.6) and Beasley Cliffs (Km 165.4–168.4). The pair frequently visited the area. In April and May, AF04 spent 18 percent of the total time away from the nest cliff in the Beasley Flat\Cliffs area ($n = 5{,}560$ minutes). The Beasley area has been easily accessible to the public, and public use is expected to increase there with the completion of upgraded facilities, including: (1) surfacing the road to Beasley Flat; (2) establishing an area for launching rafts; and, (3) providing picnic tables, ramadas, and restrooms. The raft launch point is located at Km 169, about 1 Km upstream from Beasley Cliffs, a popular hunting perch for the pair.

We recorded four shooting incidents in or near the Beasley Flat\Cliffs area during 14–15 April 1989. Two were recorded as public use events involving eagles, one of which involved a public user firing a shot at the breeding adult male (AM08) perched at Beasley Cliffs (Km 168.1) on 15 April at 0855 hr, hitting the cliff below his perch and causing him to flush to the nest area. The other two shooting incidents were incidental observations, one of which involved the use of an automatic weapon.

B4.3.5 Discussion

The primary prey species taken in this river territory were suckers, carp, and channel catfish. Suckers were taken in riffles and runs, carp in runs, and channel catfish in runs and pocket water. All suckers taken were live, as were most channel catfish.

Observed forages for the three prey categories showed differences in location. Suckers were taken downstream from the nest area at river segments 161 and 162, as well as upstream in segments 171 to 174. Carp were taken close to the nest in segments 162 to 164, and channel catfish were taken only in segments 161 and 162.

The timing of observed forages for these species also varied. Suckers were taken throughout the breeding season, while we first noted forages for carp and channel catfish in mid-April and the end of April, respectively. Forages for suckers in the nest vicinity ended in early April, but were followed by forages for carp in mid-April and channel catfish late in that month.

The data from direct forage observations are supported by data from fisheries studies and prey deliveries in that suckers were predominant in the eagles' diet (fish surveys showed suckers most common), and carp and catfish were of increasing importance as the nesting season progressed. Figure B4.3-9 shows that suckers were not taken in the river segment containing the nest after the period beginning 26 March, 1989. Subsequent forages there were for carp and catfish. Fisheries studies in the nest area showed a

distinct increase in the number of carp in the area after the beginning of April, and, in incidental observations in May, biologists walking the river observed catfish in vulnerable positions in shallow water just downstream of the nest. These fish were near boulders, which is consistent with forage observations in which eagles took channel catfish in pocket water.

An interesting aspect of the home range distribution of the radio tagged female is that it was strongly skewed toward upstream locations. Figure B4.3-3 shows that AF04 perched from Km 160, about 2 Km downstream of the nest area, to Km 181 near Camp Verde, about 17 Km upstream of the nest area (the nests were at Kms 162 and 163). The distribution of observed forages showed a similar pattern; we observed the adults foraging from Kms 161–177.

Three possible explanations come to mind regarding the unequal home range distribution: (1) the eagles were responding to upstream/downstream differences in disturbance factors; (2) the pair was avoiding territorial confrontation with another pair of eagles downstream; and, (3) there were habitat differences in the upstream and downstream reaches. The first explanation, disturbance differences, is easily disposed of since the downstream reach is virtual wilderness, except for a ranch at Km 156; disturbance potential increases dramatically in the upstream reach, approaching Camp Verde. Of the second possibility, a downstream pair of eagles, the nearest known bald eagle pair downstream is at East Verde, almost 30 river Km away. Golden eagles nest somewhere nearby and may discourage the pair from visiting downstream areas. We occasionally observed the Ladders bald eagles interacting aggressively with golden eagles.

The third possibility, that of habitat differences explaining the unequal distribution of visitation and foraging, is suggested by the distribution of super-riffles. There were only two super-riffles (none first class) in 15 Kms downstream of Km 160, the downstream limit of AM04's visitations. In contrast, there were 10 super-riffles in the 15 Kms upstream of Km 160. Two of the four first-class super-riffles in the territory are in the immediate nest area.

Eliminating the "nest effect" by weighting the visitation scores (with foraging data) of the nest Km and the two adjacent Kms (Kms 161 and 163), the three Kms in the nest vicinity nevertheless show high visitation scores, collectively accounting for 50 percent of total visitations (Figure B4.3-3). One of the reasons for this might be that the nest (Km 162) is located directly over a super-riffle. To test the significance of super-riffles in influencing the distribution of the eagles, we note that in the 18 Kms from Km 160 to Km 177, there were 6 Kms containing super-riffles (33%) and 12 Kms without super-riffles (67%). Weighted visitations scores totaled 195 points for Kms with super-riffles (52.3%) and 178 points for those without super-riffles (47.7%). This comparison of super-riffle occurrence with eagle visitation strongly suggests non-random selection of super-riffle habitat ($\chi^2 = 26.6$, df = 1, $p < 0.001$).

B4.3.6 Impacts of the Diversion Projects

The water diversion projects may affect eagles temporarily, from the activity of construction itself, or permanently, from habitat modification resulting from the new structure. Direct impacts to eagles from construction disturbance would depend on the exact placement of the diversion projects. Diversion points for the City of Prescott/Yavapai–Prescott and Cottonwood Water Company are far upstream from the Ladders territory (U.S. Fish and Wildlife Service 1989a), and should have no direct affect on eagles in this territory. At this time, no specific location is proposed for the Camp Verde diversion. Depending on placement, construction could result in direct disturbance to eagles, either at foraging sites or nesting areas.

Plate B17. Ladders eaglets (7 weeks old) with large channel catfish and sucker in nest, April 1992 (photo by D. Driscoll).

Construction of infiltration galleries results in short-term increases in turbidity (U.S. Bureau of Reclamation 1988). This increased turbidity could temporarily impact eagles by reducing prey visibility.

The Fish and Wildlife Coordinating Act Report (U.S. Fish and Wildlife Service 1989a) on water diversions in the Verde and East Verde rivers recommends no diversion of water from the Verde River, holding that maintenance of flows is necessary to protect bald eagle foraging habitat. Whether or not bald eagles would be affected depends on the impact of the diversions on sucker, carp, and catfish populations in the nesting area, and the use of shallow habitat by these species. These fisheries considerations are beyond our scope of work. We can speculate that reduced flows resulting from diversions might raise instream temperatures, favoring carp and catfish over suckers (see Section E3), but whether a reduction in suckers would affect the eagles is unknown.

B4.3.7 Management Recommendations

Although human disturbance is uncommon at the Ladders nest, the potential for adverse affects is substantial. The nesting cliffs are relatively small, and there is easy access to the areas directly above and below them. Thus, adults on the nest are easily flushed and their eggs or young exposed. We therefore recommend the closure be enforced during periods when eggs or young are present, or courtship is underway.

People have reported beached rivercraft below the nest cliffs each year. Since all watercraft must portage around "The Falls" at Km 165.0, signs there stating "No Stopping until Past Chasm Creek, Bald Eagle Nesting Area" would be easily seen. Another sign stating "OK To Stop After This Point" could be placed downstream of Chasm Creek. If the eagles utilize nests 1 and 2 in the future, the "No Stopping" signs should be extended past the confluence of Bull Run Creek.

Mexican chicken bugs were implicated in the deaths of both eaglets in 1987, and we again found a high density of these bugs in the nest in 1989. In our opinion, dusting the nest with pyrethrins during nest climbs for banding would be warranted if (1) problems with chicken bugs persist; and, (2) further research affirms that using pyrethrins is both directly and indirectly harmless to the eagles.

B4.4 EAST VERDE BREEDING AREA

The East Verde breeding area, located 100 km north of Phoenix on the Verde River near the confluence of the East Verde River (Figure B4.4-1), was chosen by the agencies for study mainly because, like the Ladders breeding area, it was representative of habitat on an unregulated river and could be compared with the ecologies of bald eagles using regulated habitat. The territory is near a major tributary, the East Verde River, providing an opportunity to explore the significance of this type of ecological feature to nesting bald eagles. The East Verde River is artificially supplemented with flows from the Phelps Dodge Corporation, but because the imports occur near the headwaters, the flows of the East Verde are typical of a natural free-flowing creek. Also to consider were the possible effects of reduced flows from water diversions proposed for the upper Verde River, as might have also affected the Ladders bald eagles (see Section B4.3 for description). An additional reason to study the East Verde pair came to light shortly after the study was underway when BioSystems was instructed to address the impacts of water diversions planned for the East Verde River, an area whose importance to the eagles was unknown. The timetable of decisions regarding the East Verde diversions was such that our findings regarding possible effects on bald eagles were needed by Fall 1987.

East Verde is within the Upper Sonoran Life Zone (C. H. Merriam 1890, 1898; in Lowe 1964), and surrounding habitat is of the Great Basin Conifer Woodland, Interior Chaparral, and Semidesert Grassland Biomes (Brown and Lowe 1980, Brown 1982). The riparian habitat is a mixture of the Sonoran Riparian Deciduous Forest and Woodlands Biome, the Sonoran Riparian Scrubland Biome, and the Sonoran Interior Strands Biome (see Section D2).

The East Verde breeding area is bounded by steep slopes and large cliffs. The river bottom is somewhat open around Childs, but the canyon closes in downstream. Fossil Creek and the East Verde River, which drains the Mogollon Rim, enter the mainstem within a few kilometers of the nest area, a reach which is characterized by steep and rugged terrain, although the land becomes more open downstream near Houston Creek. Isolated cottonwoods, sycamores, and willows are thinly scattered along the river from Fossil Creek to the nest area, just upstream of which there is a mesquite bosque on the east bank. A line of large cottonwoods once grew downstream of Houston Creek; however, the trees burned in a wildfire in 1986.

History of Reproduction

The East Verde breeding area, discovered in 1973, currently contains one cliff nest on the free-flowing Verde River between the mouths of Fossil Creek and the East Verde River. Over the years, the pair has built at least seven nests, four on cliffs and three in trees. Adults fledged 10 young from 1973–1977 and 16 during 1980–1989, for a total of 26 known fledglings. The East Verde nesting territory remained unoccupied at known nest sites in 1979, following abandonment of two eggs in 1978. One young hatched in 1983, but died as a nestling. The pair laid at least one egg in 1990, however it is not known if young hatched. Overall, reproductive performance has been among the highest of Arizona bald eagle breeding areas (See Section D4.12 for details on annual productivity and mortality at East Verde).

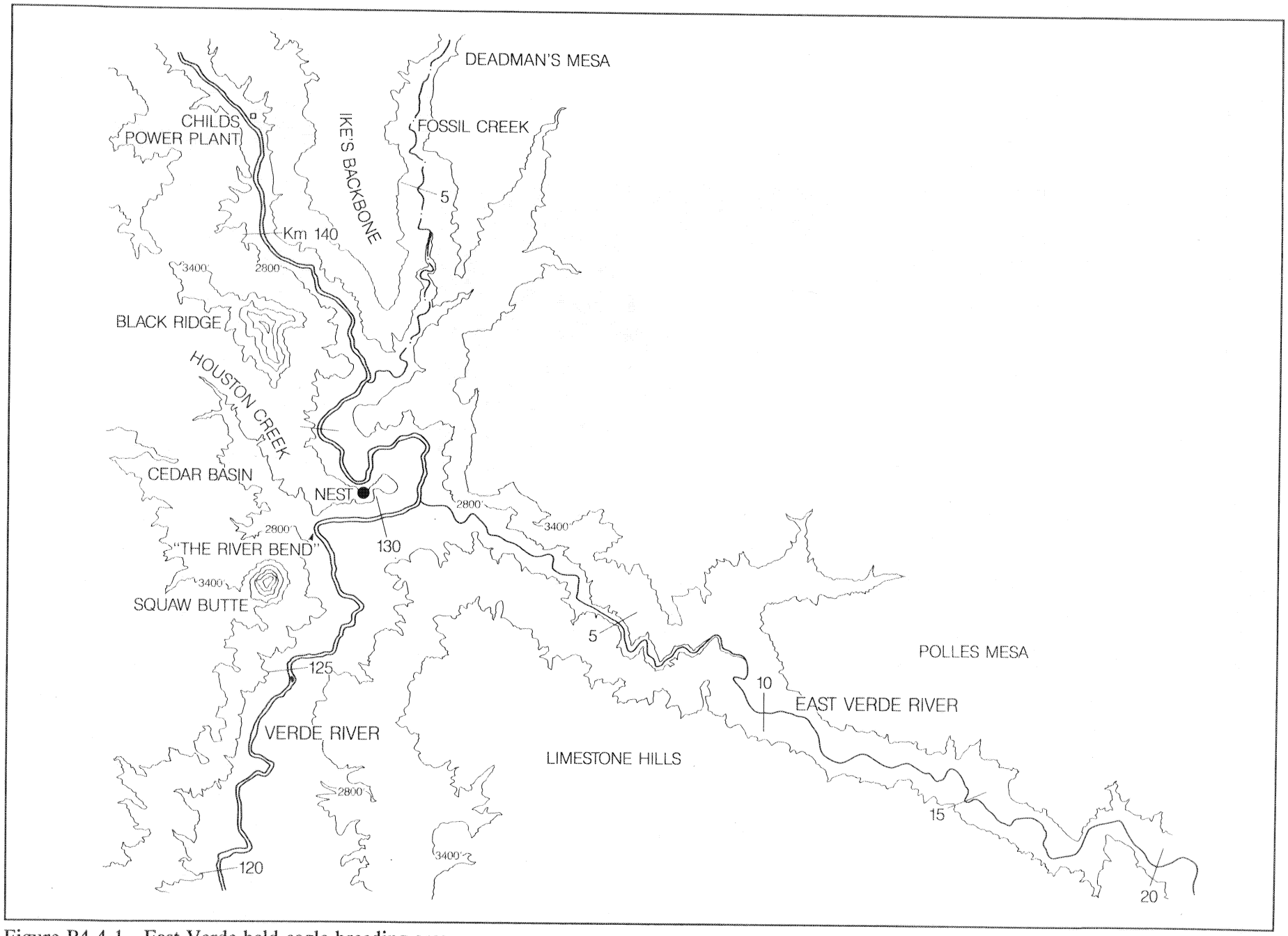


Figure B4.4-1. East Verde bald eagle breeding area.

Plate B18. East Verde nest containing two 7-8-week-old eaglets on the free-flowing Verde River, April 1989 (photo by D. Driscoll).

Flows in the Verde and East Verde Rivers

Characterization of flow in the Verde River within the East Verde eagle territory (Km 123–140) is hampered by the lack of a stream gage in the area. Only two USGS gaging stations are located on the free-flowing Verde River upstream of Horseshoe Reservoir; one in Km 88 (Tangle Creek) and one in Km 180 (Camp Verde). The nest is located about halfway between these two stations. We chose to characterize flows in the Verde River within the East Verde eagle territory using data from the Tangle Creek gaging station because the majority of tributaries (including West Clear Creek, Fossil Creek and the East Verde River) and diversion (Childs powerhouse) enter the mainstem between the Camp Verde gaging station Km 180 and the downstream boundary of the East Verde eagle territory (Km 123). Therefore, flow patterns at the Tangle Creek gaging station are more representative of those found on the river within the eagle territory (see Section B4.3 for flows at Camp Verde).

Mean monthly flows in the Verde River at Tangle Creek from November 1986 to May 1989 are graphed in Figure B4.4-2. In general, highest monthly mean flows occurred in late winter (February and March) and early spring (April), although high monthly flows also occurred in November 1987 and August 1988. In 1987, daily mean flows ranged from 107 cfs on 25 July to 9,620 cfs on 2 November. Mean monthly flow in 1987 was highest in March (Figure B4.4-2). In 1988, the range of daily flow was from 133 cfs on 17 June to 9,460 cfs on 3 February, with the highest mean monthly flows observed in February and April. The highest mean daily flow observed during the first 6 months of 1989 was 1,300 cfs on 6 February.

Overall, flows were higher in winter and early spring 1988 compared to the same time period in 1987 and 1989. In February 1988, mean monthly flow was 1,489 cfs, compared to 783 cfs and 428 cfs in 1987 and 1989, respectively.

Characterization of flows in the East Verde River within the East Verde eagle territory (Km 0.0–20.0) is simplified by the presence of a gaging station near the mouth (Km 3.1). As in the Verde River, highest monthly mean flows in the East Verde River generally occurred in late winter (February and March) and early spring (April), although high monthly flows also occurred in November 1987 and August 1988 (Figure B4.4-3). Daily mean flows in 1987 ranged from 8 cfs on 29 August to 767 cfs on 1 November. Mean monthly flows were overall highest in the East Verde River in March, averaging 175 cfs. In 1988, daily mean flows ranged from 8 cfs on 6 July to 1,840 cfs on 3 February. Mean

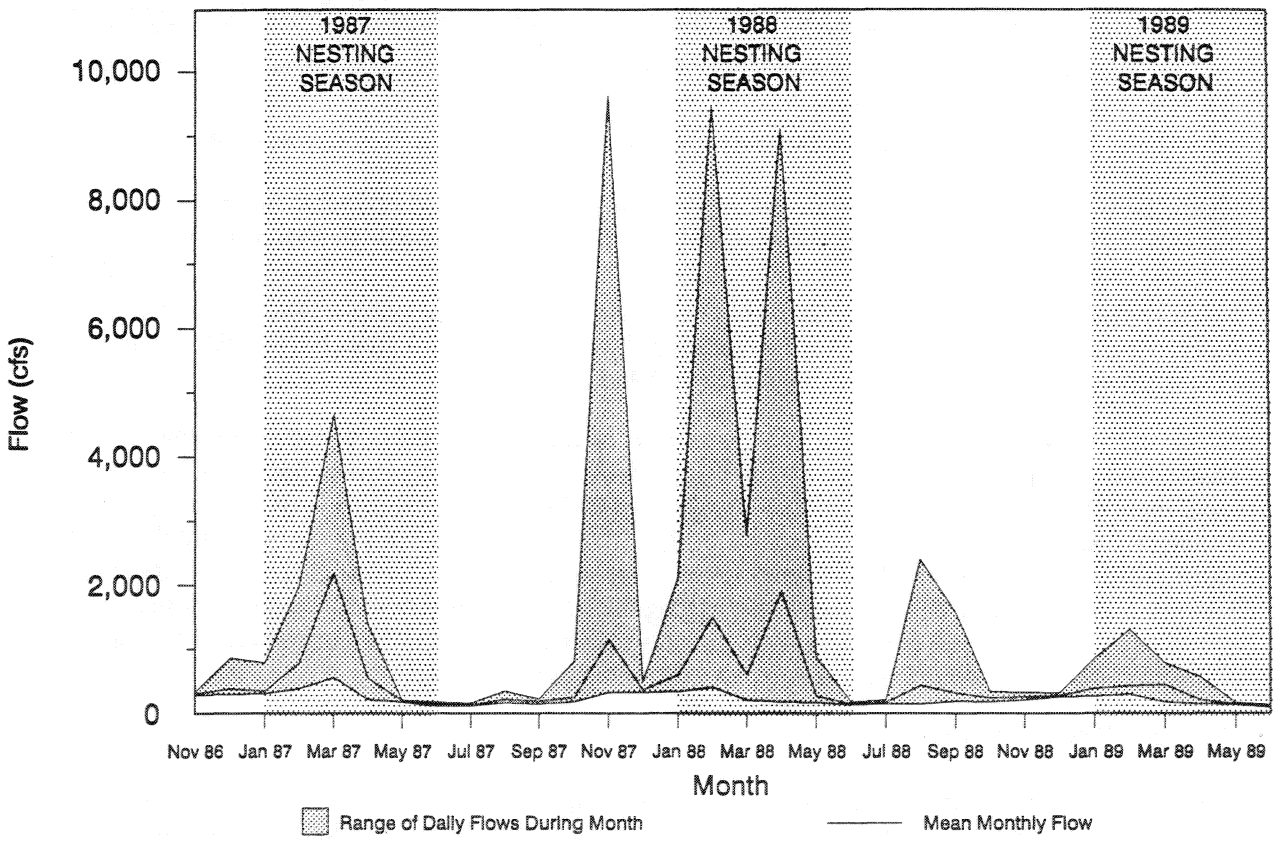


Figure B4.4-2. Mean monthly flows and range of daily flow in the Verde River at Tangle Creek from November 1986–May 1989. Flows measured at USGS Gaging Station located at river kilometer 90.

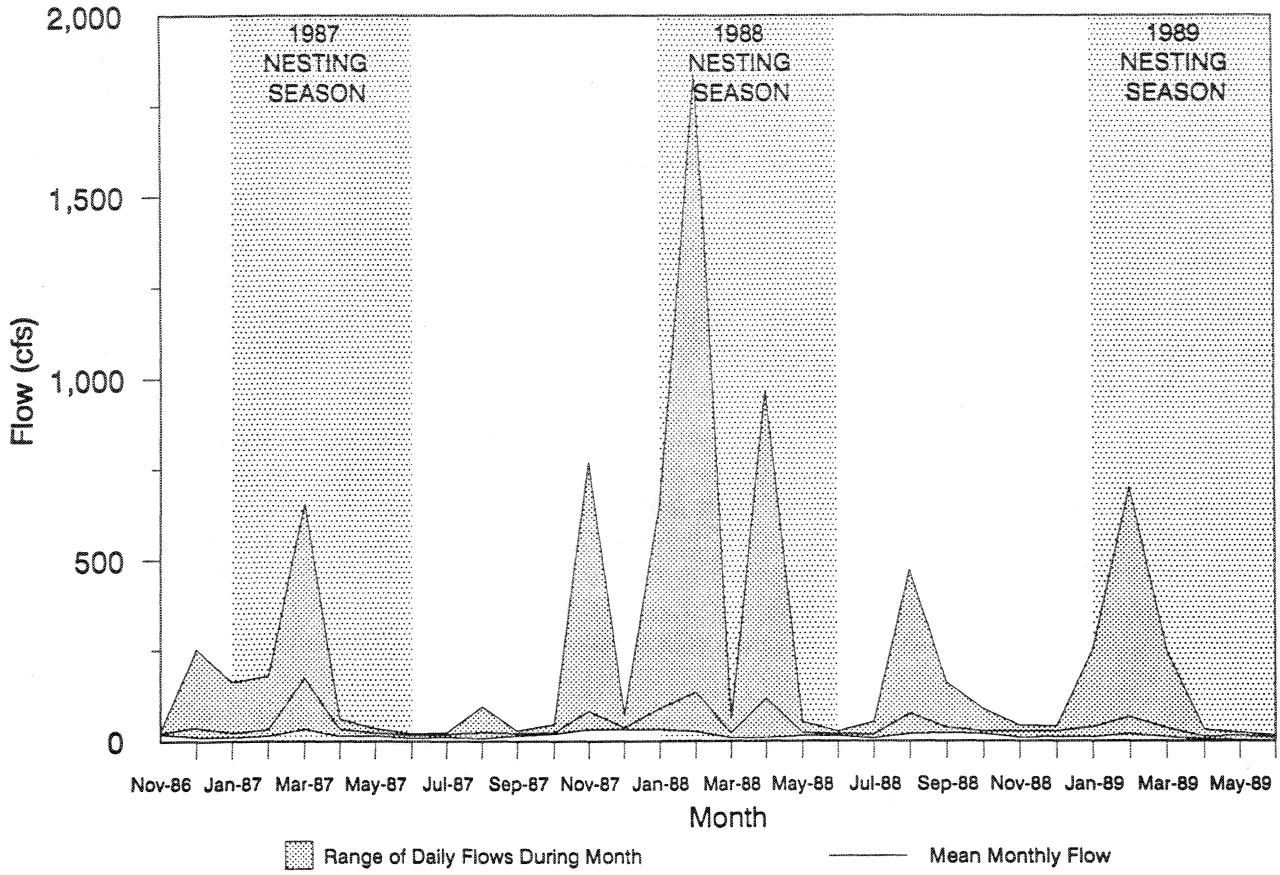


Figure B4.4-3. Mean monthly flows and range of daily flow in the East Verde River near its mouth from November 1986–May 1989. Flows measured at USGS Gaging Station located at river kilometer 3.1.

monthly flows were highest in 1988 during February and April averaging 134 and 116 cfs, respectively. In 1989 (through June only), the highest monthly flows occurred in February (69 cfs). Among the three years, flows in the East Verde were highest in 1988.

Flows in the East Verde River are largely a result of imports. The importing of various amounts from East Clear Creek to the East Verde River by Phelps Dodge Corporation began in October 1965, as repayment for SRP water diverted to a Phelps Dodge Copper mining operation in the upper Gila River drainage. All 30 cfs imported to the head of the East Verde River are said to be available at the mouth; reported evapotranspiration losses in summer were less than 1 cfs. According to Carson (1986) the imports may eventually be terminated, depending on "... circumstances in the copper mining industry..." and if so, "... flow characteristics will be dramatically changed." Presumably, fish abundance and species composition would also change, should the imports terminate.

Planned Water Diversions

Plan 6 water projects, involving water diversions on the Verde and East Verde rivers, would potentially affect the East Verde breeding area (U.S. Fish and Wildlife Service 1989a). Five diversions would supply water to eight destinations, resulting in a reduction of up to 43 cfs (June) in the mainstem below the mouth of the East Verde River (Table B4.4-1). This flow reduction could be increased to 73 cfs were existing water imports to the East Verde River terminated. The diversions on the upper Verde River are

Table B4.4-1. Proposed water diversions (cfs) from the Verde and East Verde rivers (data from U.S. Fish and Wildlife Service 1989a) compared with measured flows in 1987–1989 at Camp Verde (Km 180), Tangle Creek (Km 90) and the East Verde River (near the mouth).

	March		April		May		June	
	Normal	(Peak)	Normal	(Peak)	Normal	(Peak)	Normal	(Peak)
Verde River								
Planned Diversions from the Verde River	11.7	(15.2)	17.0	(23.2)	20.4	(28.7)	26.5	(37.8)
Measured Flows at Camp Verde Mean (Min.–Max.)	441.6	(45–2089)	476.2	(31–5756)	55.5	(28–246)	27.0	(17–47)
Mean Resulting Flow[1]	429.9		459.2		35.1		0.5	
Minimum Resulting Flow[2]	29.8		7.8		−0.7		−20.8	
Measured Flows at Tangle Creek Mean (Min.–Max.)	1072.6	(177–4650)	878.2	(139–9110)	201.7	(126–866)	132.5	(100–170)
Mean Resulting Flow	1060.9		861.2		181.3		106.0	
Minimum Resulting Flow	161.8		115.8		97.3		62.2	
East Verde River								
Planned Diversions from the East Verde River	3.8	(4.0)	4.1	(4.4)	4.2	(4.7)	4.5	(5.2)
Measured Flows at E. Verde R. Mean (Min.–Max.)	78.1	(10–657)	55.5	(5–964)	21.3	(3–53)	16.1	(1–27)
Mean Resulting Flow	74.3		51.4		17.1		11.6	
Minimum Resulting Flow	6.0		0.6		−1.7		−4.2	

[1] *Mean resulting flow* was calculated by subtracting normal diversion from mean monthly flow.
[2] *Minimum resulting flow* was calculated by subtracting peak diversion from measured minimum flow.

described in Section B4.3, Ladders Breeding Area). According to Carson (1986), diversions on the East Verde River would remove about 4–5 cfs for three allottees which would account for reductions of about 7 percent of median March flow to about 30 percent of median December flow.

The City of Payson and the Tonto Apache Reservation would use an infiltration gallery at the intersection of Huston Mesa Road. The E&R Water Company allocation has been transferred to the Pine/ Strawberry Improvement Association, which could use a diversion dam currently in place on Pine Creek, 3.2 km above Pine (U.S. Fish and Wildlife Service 1989a).

Schedule of Study

ABENWP personnel began observing the East Verde eagles on 6 February 1987. BioSystems captured the adult male eagle (AM02) on 25 March and attached a Telonics 18-month backpack transmitter. We began telemetry tracking on 30 March and continued on a schedule of "10-days on and four days off" until June. Three to six biologists tracked the eagles from dawn to dusk, coordinating efforts with an observer stationed at the nest to record prey deliveries. Observers attempted to anticipate the eagle's movement patterns and take positions at strategic points. We tried to maximize the amount of visual observation to obtain foraging data.

Between 7 March and 3 June 1987, we observed 100 prey deliveries from a blind on a promontory overlooking the nest about 200 m away. Topographical features usually allowed us to enter and exit the blind without coming into the eagle's field of vision. We used a Questar telescope to obtain a detailed view of the nest and its contents. We also collected data on 90 observed forage attempts by eagles from 6 February to 3 June; AM02 made 59 of these forages, the female made 29, and two involved an unidentified subadult eagle.

B4.4.1 Home Range

Telemetry during the 1987 nesting season revealed a home range spanning Kms 123 to 140 on the Verde River, Kms 0–20 on the East Verde River, and Kms 0–4 on Fossil Creek, a total of 41 river kilometers (Figure B4.4-4). Besides the nest area (weighted in the visitation graph according its role as a foraging site), the most frequently visited mainstem Kms over the season were Kms 135 and 136 near the mouth of Fossil Creek and Kms 128 near Houston Creek.

AM02's farthest observable use of the Verde River upstream from the nest extended to the Childs powerlines at Km 140.0. He soared over high landmarks such as Ike's Backbone, Black Ridge, and the Hardscrabble drainage near Deadman's Mesa on some flights, catching updrafts. The downstream extent of AM02's range on the Verde River reached an open valley at Km 123.1–124.5. On 2 May, the male soared downstream nearly to Muleshoe Bend (Km 113) then returned to the nest area; this appeared to be a patrolling or exploratory flight.

AM02 changed his home range distribution over the course of the nesting season. These changes were reflected both in terms of the number of days AM02 visited different portions of his range (Table B4.4-2) and the number of perching and/or foraging visitations (Table B4.4-3 and Figure B4.4-5). In early April, AM02 flew up the East Verde River and occasionally ranged (and foraged) as far as 20 river Km upstream from the mouth. He also visited Fossil Creek a number of times early in April. However, by early May, he had virtually abandoned the East Verde foraging areas in favor of the mainstem Verde River. His use of river sections downstream of the nest (Kms 133.3–133.9) increased during the mid-

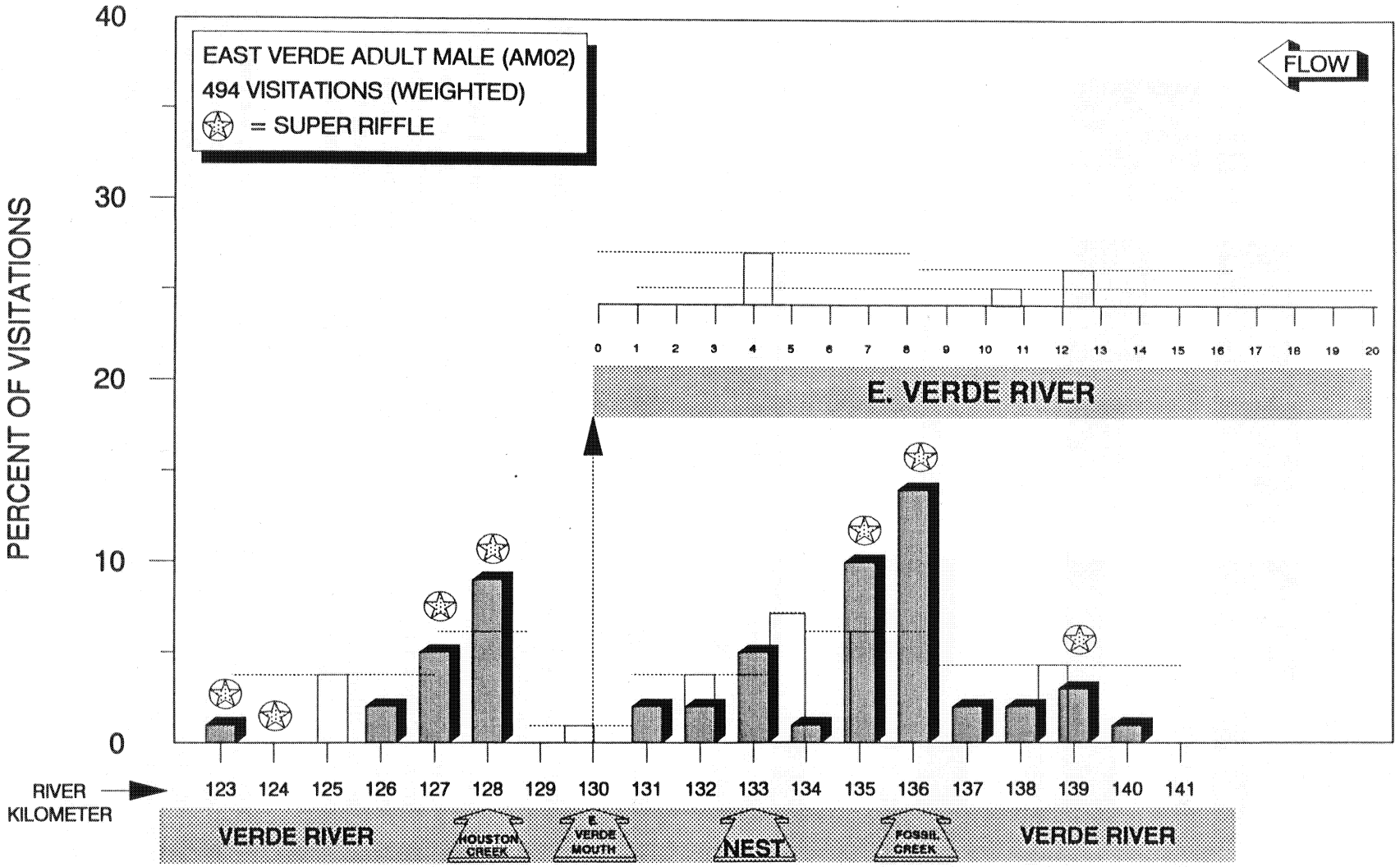


Figure B4.4-4. The home range of the telemetered East Verde adult male (AM02) in the 1987 breeding season. Visitation percentages in the nest vicinity were weighted according to the proportion of total prey deliveries from the nest area by the male. Open bars indicate cases when trackers could not locate the eagle, the dotted lines extending laterally from those bars indicate zones of eagle occupancy for the imprecise locations.

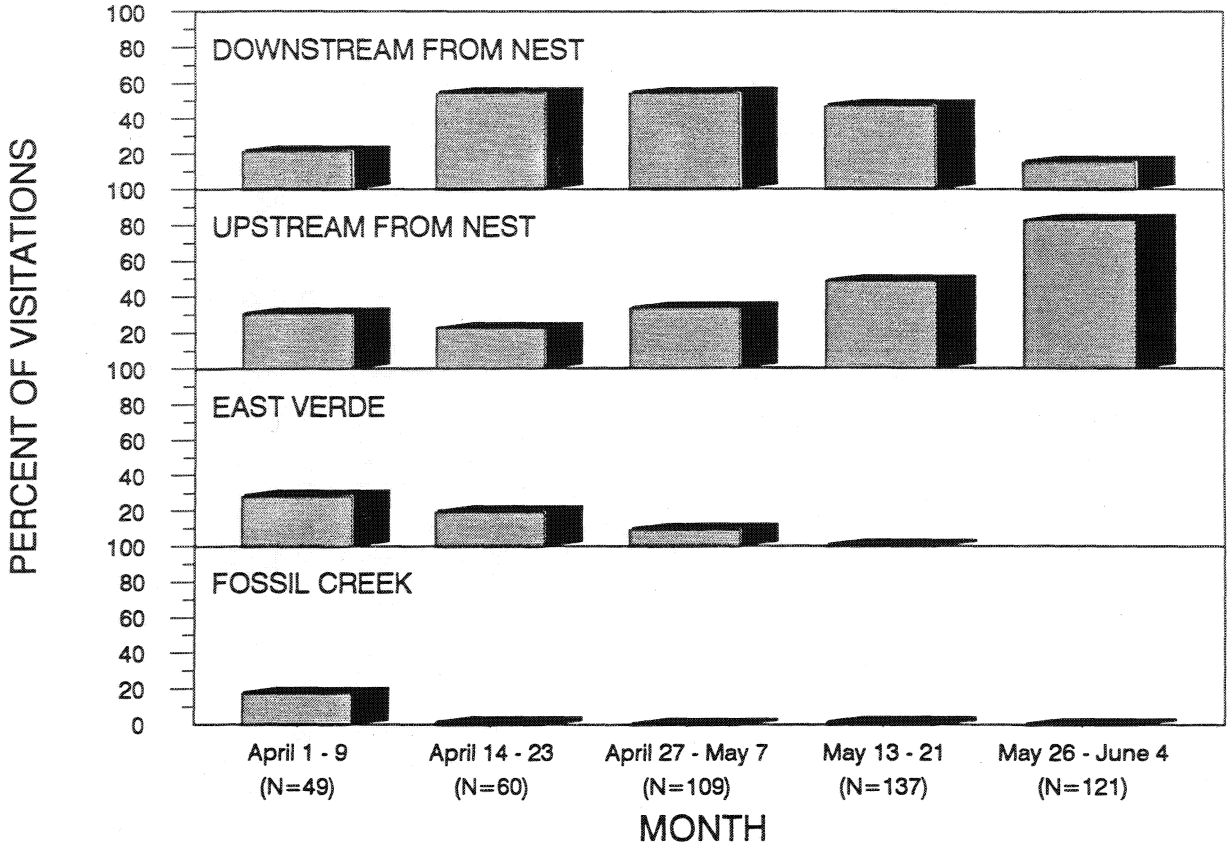


Figure B4.4-5. Chronological changes in visitations to locations outside the nest area (Kms 133.3–133.9)(1987 data).

point of the chick cycle, but by mid-May his main focus was on the area upstream of the nest, especially around the mouth of Fossil Creek (see Figure B4.4-4).

To visit the East Verde River in early April, AM02 consistently soared high (we estimated 1500–2000 ft AGL) above the nest area, then glided to Limestone Hills or Cedar Basin Ridge. AM02 used these two high east–west ridges to travel up the East Verde river on currents of rising air. He would continue east, crossing over to Polles Mesa or following Limestone Hills to Km 10 of the East Verde River, from which he would move upstream, particularly in early April. Later in April, AM02 also utilized the lower section of the East Verde River. After the first week in May, AM02 did not often visit the East Verde River.

The following year (1988), although we did not again study foraging ecology of the pair, we obtained additional data on the use of the East Verde River by the adult male in February, March, and April. During a 2-day monitoring session on 20 February, AM02 perched along the East Verde River at about Km 14, at which time we also observed an immature bald eagle and an unidentified adult bald eagle perched along the East Verde river. We returned during 4-10 March and again observed AM02 and other eagles using the tributary. Typically, AM02 would visit the East Verde River twice per day, once in late morning or early afternoon and again in late afternoon.

Table B4.4-2. Days of visitation by the East Verde adult male eagle (AM02) to nine zones within the home range (1987).

Zone	PERIOD				
	April 1–9	April 14–23	April 28–May 7	May 13–21	May 26–June 4
701	1	3	8	4	3
702	7	7	9	9	5
703	1	0	1	5	1
704	3	7	6	9	5
705	9	10	10	9	9
706	6	9	7	9	9
707	2	2	5	6	7
710, 711, 712	6	7	6	2	0
720	2	1	1	2	1

Key to Location Zones

Km 123.0–126.8	701 Downstream of Bend Cliffs, Verde River.
Km 126.9–128.7	702 Houston Creek to Bend Cliffs, Verde River.
Km 128.8–130.7	703 East Verde River to Houston Creek, Verde River.
Km 130.8–133.2	704 Nest area to East Verde, Verde River.
Km 133.3–133.9	705 Nest area, Verde River.
Km 134.0–136.2	706 Fossil Creek to nest area, Verde River.
Km 136.3–141.3	707 Upstream of Fossil Creek, Verde River.
Km 0.0–20.0	710, 711, 712 East Verde River.
Km 0.0–4.0	720 Fossil Creek.

During the March observations, AM02 perched along the lower section of the East Verde River between Km 0 and Km 10; he visited the upper section of the river (Kms 11–20) only once to soar. We also observed at least one near-adult, another unknown adult, and an immature bald eagle. We found the young eagle several times between Km 17 and Km 19.2, and we saw the near-adult six times between Km 14–Km 20. On 6 March, we saw AM02 soaring with an immature eagle at 1450 hr. and an adult female bald eagle (not his mate, LF01) at 1525 hours near the mouth of the East Verde River.

Other observations of eagles along the East Verde River were related to us by Charles Swaboda, caretaker at the LF Ranch (Km 20). In January and early February, he observed AM02 (or at least an adult bald eagle with a radio antenna) flying near LF Ranch; the eagle then headed downriver. In early March, Swaboda again observed an adult bald eagle near LF Ranch.

Table B4.4-3. Number and percent of visitations within zones by AM02, 1987 (unweighted). *See* Figure B4.4-3 for explanation of scores.

Location	April 1–9		April 14–23		April 28–May 7		May 13–21		May 26–June 4		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Downriver of nest (Km 123.0–133.2)	11	11.3	33	30.3	60	33.0	66	33.8	20	10.2	190	25.2
Nest area (unweighted) (Km 133.3–133.9)	48	49.5	49	45.0	49	31.0	58	29.7	75	38.3	279	37.0
Upriver of nest (Km 134.0–146.3)	15	15.5	14	12.8	37	23.4	67	34.4	100	51.0	233	30.9
East Verde (Km 0.0–20.0)	14	14.4	12	11.0	11	7.0	1	0.5	0	0.0	38	5.0
Fossil Creek	9	9.3	1	0.9	1	0.6	3	1.5	1	0.5	15	2.0
Total	97	100.0	109	100.0	158	100.0	195	100.0	196	100.0	755	100.0

Airplane tracking in search of all telemetered eagles also revealed use of the East Verde River (see Sections A4 and C5). We found AM02 flying around Km 16 on 13 February, flying downstream of Km 10 on 4 March, perched in the same area on 2 April, and perched again up the East Verde River on 7 July. JZ02, the 1987 juvenile from Orme nest, perched on the East Verde River on 3 April and 4 May, and NM01, the Salome near-adult male, was found on 19 April and 7 May, both times perched on the lower part of the East Verde River, several miles upstream of the confluence with the Verde mainstem. On 7 May, we also found the 1987 Fort McDowell juvenile, JM03, perched near Doll Baby Ranch, upstream of Km 20. Lastly, we found NF01, the Salome near-adult female near the LF Ranch on the East Verde River at Km 20 on 2 April. In summary, of the five telemetered bald eagles not attached to territories during the 1988 breeding season, four visited the East Verde River on at least one occasion. This suggests that this water course is important bald eagle habitat in spring.

B4.4.2 Foraging Studies

Our knowledge of prey and habitat selection by the East Verde bald eagles was facilitated by our direct observations of prey deliveries and by telemetry and visual tracking of the adults. In many cases we were able to observe forages directly, but when we were unable to do so, we determined forage locations through radio communication (and time records) between the nest observer and the trackers who recorded the location of the eagle in the minutes immediately preceding the delivery. Sometimes these locations were precise, and at other times, an eagle's occurrence within a zone was the best data that could be obtained (see Section B2).

B4.4.2.1 Prey Selection. The number and estimated biomass of each prey species brought into the East Verde nest by the adult male bald eagle (AM02) in 1987 is presented in Table B4.4-4. Carp was the most important prey species, both in numbers (n = 25) and biomass delivered (48%). Large carp were

Table B4.4-4. Prey taken and prey delivered to nest by the male bald eagle (AM02) from East Verde breeding area in 1987. Column A indicates number of prey from observed forages plus prey deliveries to the nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals					B. Whole Biomass (grams)				
	28-Day Period:					28-Day Period:				
Species	3/01/87–3/28/87	3/29/87–4/25/87	4/26/87–5/23/87	5/24/87–6/20/87	Total	3/01/87–3/28/87	3/29/87–4/25/87	4/26/87–5/23/87	5/24/87–6/20/87	Total
Fish Species										
Sucker	1 10%	4 14%	5 14%	1 8%	11 13%	273 5%	3,923 13%	5,277 15%	273 2%	9,746 11%
Carp		10 36%	10 28%	5 38%	25 29%		15,597 53%	14,154 41%	9,168 58%	38,919 46%
Flathead Catfish	1 10%	3 11%	6 17%	1 8%	11 13%	2,610 46%	4,122 14%	10,051 29%	2,302 15%	19,085 22%
Channel Catfish			1 3%	2 15%	3 3%			94 0%	1,138 7%	1,232 1%
Unknown Catfish		2 7%			2 2%		838 3%			838 1%
Smallmouth Bass		1 4%	6 17%	1 8%	8 9%		538 2%	1,433 4%	163 1%	2,134 2%
Largemouth Bass			2 6%		2 2%			2,019 6%		2,019 2%
Black Bass				1 8%	1 1%				409 3%	409 0%
Lepomis sp.		1 4%			1 1%		46 0%			46 0%
Unknown Centrarchid		1 4%			1 1%		212 1%			212 0%
Unknown Fish		5 18%	3 8%	2 15%	10 11%		3,796 13%	1,211 3%	2.324 15%	7,331 9%
Subtotal	2 20%	27 96%	33 92%	13 100%	75 86%	2,883 51%	29,072 99%	34,239 99%	15,777 100%	81,971 96%
Other Species										
Soft-shelled Turtle		1 4%	1 3%		2 2%		150 1%	150 0%		300 0%
Neotoma sp.	1 10%				1 1%	281 5%				281 0%
Domestic Cow (Calf)	7 70%				7 8%	2,520 44%				2,520 3%
Unknown Mammal			2 6%		2 2%			370 1%		370 0%
Subtotal	8 80%	1 4%	3 8%	0 0%	12 14%	2,801 49%	150 1%	520 1%	0 0%	3,471 4%
TOTAL	**10 100%**	**28 100%**	**36 100%**	**13 100%**	**87 100%**	**5,684 100%**	**29,222 100%**	**34,759 100%**	**15,777 100%**	**85,442 100%**

Table B4.4-4. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 3/01/87–3/28/87	3/29/87–4/25/87	4/26/87–5/23/87	5/24/87–6/20/87	Total
Fish Species					
Sucker	273 *(1) 11%	3,127 (4) 21%	3,911 (4) 19%	273 (1) 3%	7,584 (10) 16%
Carp		8,130 (10) 55%	9,068 (9) 43%	5,801 (4) 63%	22,999 (23) 48%
Flathead Catfish	1,566 (1) 63%	1,873 (3) 13%	3,848 (6) 18%	1,151 (1) 12%	8,438 (11) 18%
Channel Catfish			94 (1) 0%	990 (2) 11%	1,084 (3) 2%
Unknown Catfish		754 (2) 5%			754 (2) 2%
Smallmouth Bass		355 (1) 2%	1,130 (5) 5%	163 (1) 2%	1,648 (7) 3%
Largemouth Bass			1,579 (2) 8%		1,579 (2) 3%
Black Bass					
Lepomis sp.		46 (1) 0%			46 (1) 0%
Unknown Centrarchid		212 (1) 1%			212 (1) 0%
Unknown Fish		94 (1) 1%	894 (2) 4%	860 (1) 9%	1,848 (4) 4%
Subtotal	1,839 (2) 74%	14,591 (23) 99%	20,524 (29) 98%	9,238 (10) 100%	46,192 (64) 97%
Other Species					
Soft-shelled Turtle		150 (1) 1%	150 (1) 1%		300 (2) 1%
Neotoma sp.	281 (1) 11%				281 (1) 1%
Domestic Cow (Calf)	360 (1) 15%				360 (1) 1%
Unknown Mammal			370 (2) 2%		370 (2) 1%
Subtotal	641 (2) 26%	150 (1) 1%	520 (3) 2%	0 0%	1,311 (6) 3%
TOTAL	**2,480 (4) 100%**	**14,741 (24) 100%**	**21,044 (32) 100%**	**9,238 (10) 100%**	**47,503 (70) 100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

sometimes delivered to the nest in pieces, so, in viewing the table, the reader should understand that we differentiated between the estimated weight of the prey item when it arrived in the nest (biomass delivered) and the estimated weight of the entire fish before it was altered by the adult prior to flight back to the nest (total biomass). Other important fish prey were flathead catfish and suckers, comprising 18 percent and 16 percent, respectively, of the biomass delivered by AM02. Some of the flathead catfish were probably obtained as carrion left behind by anglers (minus the fillets). Smallmouth and largemouth bass both contributed approximately 3 percent to the biomass of the male's nest deliveries. AM02 delivered one *Lepomis* sp., probably a green sunfish; we found this species common in all streams in the territory. Together, fish species totaled 97 percent of the biomass delivered. Non-fish prey included small numbers of soft-shelled turtles, a wood rat, and portions of a Hereford calf.

Prey taken and prey delivered to the nest by the East Verde female (LF01) in 1987 appears in Table B4.4-5. Of the 103 total prey items that we observed brought to the nest, the male bald eagle was responsible for 70 items (68%) and the female for 33 items (32%). AM02 delivered 47.5 kg of estimated biomass; LF01 brought in less than one-half that of the male (20.1 kg). Both the male and female brought back about one-third carp, 23 and 12 of their respective deliveries of prey items. Percentages of carp biomass delivered were also similar for the pair, 48 percent and 50 percent for the male and female eagles, respectively. The male eagle delivered more suckers and catfish; LF01 captured more non-fish prey. Fish composed 81 percent of the female's total biomass contribution. She also brought in turtles, a wood rat, and calf carrion along with a Gambel's quail and a rock squirrel. LF01 captured the rock squirrel as it attempted to swim across the Verde River below the nest. Prey items identified from remains collected in the East Verde nest area are discussed in Section B5.1.6.

Table B4.4-6 shows the timing of prey utilization during the 1987 nesting season by the East Verde adults. Although intensive observations at the nest did not begin until 31 March, incidental observations by ABENWP personnel from 3-12 March and 17-26 March indicated that calf carrion and sucker species were important then. During this period, the mainstem was high and muddy and we observed spawning suckers in tributary streams (i.e., Houston Creek, Fossil Creek, East Verde River) during March and April. At least two Hereford calves were stillborn within one mile of the nest in the early spring (Red Creek Ranch staff, pers. comm.). Eagles took a significant amount of carrion prey, but much of it was acquired from the same dead cow and calf during March, a single food item which accounted for a large percentage of the mammalian biomass in the diet. Remember that we recorded increased use of mammals during periods of high, turbid mainstem flows at the Ladders territory (see Section B4.3).

Another peak in sucker use occurred during late April and early May. Carp use was fairly consistent throughout the breeding season, although numbers peaked in mid-April and again in mid- to late May. Catfish use was relatively consistent throughout. As at the Ladders site (Section B4.3), carp and catfish use generally increased when sucker predation declined. Smallmouth and largemouth bass began to appear in the nest around early May which coincided with bass spawning activity observed on the Verde River. Bass may have become available while protecting their nests in shallow water. The single smallmouth bass taken earlier was carrion. At least one channel catfish was also taken as carrion; we observed Sonoran mud turtles feeding on the carcass before the eagles found it.

B4.4.2.2 Geography of Foraging. In previous studies, bald eagles at the East Verde breeding area were observed foraging on the Verde River in the vicinity of nests 1, 6, and 7 (shown in Part F-Nest Map Atlas)(Haywood and Ohmart 1980, Haywood and Ohmart 1981, Haywood and Ohmart 1983, Canestorp 1984, Grubb 1984, Frazer and Tischendorf 1985, Grubb 1986a, Berger and Von Gonten 1986). Although ABENWP nestwatchers reported the eagles delivering prey to the nest from the direction of the

Table B4.4-5. Prey taken and prey delivered to nest by the female bald eagle (LF01) from East Verde breeding area in 1987. Column A indicates number of prey from observed forages plus prey deliveries to the nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals					B. Whole Biomass (grams)				
	28-Day Period:					28-Day Period:				
Species	3/01/87–3/28/87	3/29/87–4/25/87	4/26/87–5/23/87	5/24/87–6/20/87	Total	3/01/87–3/28/87	3/29/87–4/25/87	4/26/87–5/23/87	5/24/87–6/20/87	Total
Fish Species										
Sucker	2 14%	1 8%			3 6%	1,457 15%	1,184 7%			2,641 6%
Carp	2 14%	6 46%	4 31%	5 50%	17 34%	4,235 43%	11,244 71%	3,289 29%	7,278 76%	26,046 56%
Flathead Catfish			1 8%		1 2%			4,589 41%		4,589 10%
Channel Catfish			1 8%		1 2%			218 2%		218 0%
Smallmouth Bass				3 30%	3 6%				1,160 12%	1,160 2%
Largemouth Bass			2 15%	1 10%	3 6%			930 8%	890 9%	1,820 4%
Unknown Fish		2 15%	2 15%		4 8%		1,246 8%	1,196 11%		2,442 5%
Subtotal	4 29%	9 69%	10 77%	9 90%	32 64%	5,692 57%	13,674 86%	10,222 91%	9,328 98%	38,916 83%
Other Species										
Soft-shelled Turtle		1 8%		1 10%	2 4%		240 2%		200 2%	440 1%
Turtle sp.			1 8%		1 2%			350 3%		350 1%
Gambel's Quail		1 8%			1 2%		166 1%			166 0%
Neotoma sp.			1 8%		1 2%			281 3%		281 1%
Rock Squirrel		1 8%			1 2%		817 5%			817 2%
Domestic Cow (Calf)	10 71%				10 20%	4,240 43%				4,240 9%
Unidentified Carrion		1 8%	1 8%		2 4%		1,049 7%	360 3%		1,409 3%
Subtotal	10 71%	4 31%	3 23%	1 10%	18 36%	4,240 43%	2,272 14%	991 9%	200 2%	7,703 17%
TOTAL	**14 100%**	**13 100%**	**13 100%**	10 100%	50 100%	9,932 100%	15,946 100%	11,213 100%	9,528 100%	46,619 100%

Table B4.4-5. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 3/01/87–3/28/87			3/29/87–4/25/87			4/26/87–5/23/87			5/24/87–6/20/87			Total		
Fish Species															
Sucker	1,457	*(2)	25%	710	(1)	11%							2,167	(3)	11%
Carp	2,961	(2)	51%	3,431	(5)	55%	1,401	(2)	30%	2,338	(3)	69%	10,131	(12)	50%
Flathead Catfish							918	(1)	20%				918	(1)	5%
Channel Catfish							218	(1)	5%				218	(1)	1%
Smallmouth Bass										622	(2)	18%	622	(2)	3%
Largemouth Bass							930	(2)	20%	445	(1)	13%	1,375	(3)	7%
Unknown Fish				860	(1)	14%	34	(1)	1%				894	(2)	4%
Subtotal	4,418	(4)	76%	5,001	(7)	80%	3,501	(7)	75%	3,405	(6)	100%	16,325	(24)	81%
Other Species															
Soft-shelled Turtle				240	(1)	4%	200	(1)	4%				440	(2)	2%
Turtle sp.							350	(1)	7%				350	(1)	2%
Gambel's Quail				166	(1)	3%							166	(1)	1%
Neotoma sp.							281	(1)	6%				281	(1)	1%
Rock Squirrel				817	(1)	13%							817	(1)	4%
Domestic Cow (Calf)	1,360	(2)	24%										1,360	(2)	7%
Unidentified Carrion							360	(1)	8%				360	(1)	2%
Subtotal	1,360	(2)	24%	1,223	(3)	20%	1,191	(4)	25%	0	(0)	0%	3,774	(9)	19%
TOTAL	**5,778**	**(6)**	**100%**	**6,224**	**(10)**	**100%**	**4,692**	**(11)**	**100%**	**3,405**	**(6)**	**100%**	**20,099**	**(33)**	**100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

Table B4.4-6. Summary of estimated biomass (grams) of prey delivered to the East Verde bald eagle nest in 1987 by both male and female adults. Numbers in parentheses refer to number of individuals delivered to nest. Some species are grouped for analysis. Percentages expressed as percent of column total rounded to nearest whole number.

	OBSERVATION PERIOD/DAYS OBSERVED							
Species	3/1-3/14/87 2 days*	3/15-3/28/87 3 days*	3/29-4/11/87 7 days	4/12-4/25/87 10 days	4/26-5/9/87 9 days	5/10-5/23/87 8 days	5/24-6/6/87 9 days	Total 48 days
Fish Species								
Sucker sp.		1,730 (3) 71%		3,837 (5) 27%	3,911 (4) 27%		273 (1) 2%	9,751 (13) 14%
Carp		712 (1) 29%	4,978 (5) 47%	8,832 (11) 62%	3,890 (3) 27%	6,579 (8) 61%	8,138 (7) 63%	33,130 (35) 49%
Catfish sp.			3,212 (3) 31%	981 (3) 7%	3,302 (5) 23%	1,776 (4) 16%	2,141 (3) 17%	11,412 (18) 17%
Black Bass sp.				355 (1) 2%	2,420 (6) 16%	1,219 (3) 11%	1,230 (4) 10%	5,224 (14) 8%
Other Centrarchids			212 (1) 2%	46 (1) 0%				258 (2) 0%
Unidentified Fish			860 (1) 8%	94 (1) 1%	894 (2) 6%	34 (1) 0%	860 (1) 7%	2,742 (6) 4%
Subtotal	0 (0) 0%	2,442 (4) 100%	9,262 (10) 88%	14,145 (22) 99%	14,417 (20) 98%	9,608 (16) 88%	12,643 (16) 98%	62,517 (88) 92%
Other Species								
Turtles			240 (1) 2%	150 (1) 1%	150 (1) 1%	350 (1) 3%	200 (1) 2%	1,090 (5) 2%
Gambel's Quail			166 (1) 2%					166 (1) 0%
Mammals	281 (1) 14%		817 (1) 8%		100 (1) 1%	551 (2) 5%		1,749 (5) 3%
Carrion (cow)	1,720 (3) 86%					360 (1) 3%		2,080 (4) 3%
Subtotal	2,001 (4) 100%	0 (0) 0%	1,223 (3) 12%	150 (1) 1%	250 (2) 2%	1,261 (4) 12%	200 (1) 2%	5,085 (15) 8%
TOTAL	**2,001 (4) 100%**	**2,442 (4) 100%**	**10,485 (13) 100%**	**14,295 (23) 100%**	**14,667 (22) 100%**	**10,869 (20) 100%**	**12,843 (17) 100%**	**67,602 (103) 100%**

* Intensive monitoring began on 31 March. Observations prior to that were opportunistic.

East Verde River, no foraging was documented on this drainage (Canestorp 1984, Grubb 1984, Frazer and Tischendorf 1985, Grubb 1986a).

In the present study, AM02 changed his primary foraging locations during the course of the nesting season (Table B4.4-7). As he was somewhat unpredictable in his use of foraging sites, it often took long periods to reach the areas where AM02 had disappeared in the rugged terrain. The female apparently also visited the same remote areas, but it was our impression that her movements were generally more focused around the nest vicinity. We assume that shifts in habitat use were related to changes in flow, turbidity, and prey behavior and/or distribution. For logistical reasons we could not obtain the same resolution in foraging data on the East Verde River as on the Verde.

Table B4.4-7. Number and percent of forages within zones by AM02, 1987.

	April 1–9		April 14–23		April 28–May 7		May 12–21		May 26–June 4		Total	
Location	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Downriver of nest (Km 123.0–133.2)	3	33.3	7	29.2	14	51.9	11	42.3	2	7.1	37	32.5
Nest area (Km 133.3–133.9)	2	22.2	1	4.2	2	7.4	0	0.0	2	7.1	7	6.1
Upriver of nest (Km 134.0–146.3)	0	0.0	8	33.3	6	22.2	15	57.7	24	85.7	53	46.5
East Verde	4	44.4	7	29.2	4	14.8	0	0.0	0	0.0	15	13.2
Fossil Creek	0	0.0	1	4.2	1	3.7	0	0.0	0	0.0	2	1.8
TOTAL	9	100.0	24	100.0	27	100.0	26	100.0	28	100.0	114	100.0

General capture locations for prey species delivered to the East Verde nest are shown in Table B4.4-8. It appears that eagles found carp and flathead catfish throughout their home range, while sucker species originated mainly from the East Verde River (10 of 13 deliveries of the male and female). The sucker captures may have been associated with spawning activity in the East Verde. In February and early March, before our intensive observations began, the mainstem Verde River contained high and turbid flows, while the East Verde contained lower flows and relatively clear water. In April, carp originated from the mainstem Verde River (n = 5), the East Verde River (n = 4), and from Fossil Creek (n = 1). By late April and May, AM02 took carp only from the mainstem Verde River (n = 10); five carp taken in late May/early April were also from the mainstem. Over one-half of all carp captured by the male (13 of 25) were from the Verde River upstream of the nest site. Most catfish originated from the Verde River; we observed only two bass taken in the East Verde River. Overall, trends in foraging geography included use of tributaries in early spring followed by increased use of the mainstem Verde River, with greater emphasis on the upstream section as the season progressed.

Table B4.4-8. Origin of prey taken by the radio-telemetered East Verde male adult bald eagle in 1987. Not all items delivered to the nest. Known forage locations by unradioed female shown in parenthesis are not included in totals.

	Verde River							Tributaries					
Observation Period / Species	Upstream of Fossil Cr. Km 136.3–141.3 707	Upstream of Nest to Fossil Cr. 134.0–136.2 706	Nest Area 133.3–133.9 705	Downstream of Nest to East Verde R. 130.8–133.2 704	East Verde River to Houston Cr. 128.8–130.7 703	Houston Creek to Bend Cliff 128.7–126.9 702	Downstream of Bend Cliffs 123.0–126.8 701	East Verde River Unspeciifed 710	Lower East Verde River Km 0–8 711	Upper East Verde River 8–20 712	Fossil Creek 720	Unknown	Total
3/1/87–3/28/87													
Sucker sp.	—	—	(1)	—	—	—	—	1 (1)	—	—	—	—	1 25%
Flathead Catfish	—	—	—	—	—	—	—	1	—	—	—	—	1 25%
Woodrat sp.	—	—	—	—	—	—	—	—	—	—	—	1	1 25%
Domestic Cow (carrion)	—	—	1 (9)	—	—	—	—	—	—	—	—	—	1 25%
Total %	0 0%	0 0%	1 25%	0 0%	0 0%	0 0%	0 0%	2 50%	0 0%	0 0%	0 0%	1 25%	4 100%
3/29/87–4/25/87													
Sucker sp.	—	—	—	—	—	—	—	1	—	3	—	—	4 14%
Carp	1	3	—	—	—	1 (2)	—	2 (2)	—	2	1	—	10 36%
Flathead Catfish	—	—	2	—	—	1	—	—	—	—	—	—	3 11%
Catfish sp.	—	—	—	—	—	1	—	—	—	1	—	—	2 7%
Smallmouth Bass	—	—	—	—	—	—	—	—	—	1	—	—	1 4%
Black Bass sp.	—	—	—	—	—	—	—	—	—	1	—	—	1 4%
Green Sunfish	—	1	—	—	—	—	—	—	—	—	—	—	1 4%
Unknown Fish	—	1	—	—	—	2	—	—	—	1	—	1	5 18%
Soft-shelled Turtle	—	—	—	—	—	1	—	—	—	—	—	—	1 4%
Rock Squirrel	—	—	(1)	—	—	—	—	—	—	—	—	—	0 0%
Total %	1 4%	5 18%	2 7%	0 0%	0 0%	6 21%	0 0%	3 11%	0 0%	9 32%	1 4%	1 4%	28 100%

Table B4.4-8. (Continued)

Observation Period	Species	Verde River: Upstream of Fossil Cr. Km 136.3–141.3 707	Upstream of Nest to Fossil Cr. 134.0–136.2 706	Nest Area 133.3–133.9 705	Downstream of Nest to East Verde R. 130.8–133.2 704	East Verde River to Houston Cr. 128.8–130.7 703	Houston Creek to Bend Cliff 128.7–126.9 702	Downstream of Bend Cliffs 123.0–126.8 701	Tributaries: East Verde River Unspeciifed 710	Lower East Verde River Km 0–8 711	Upper East Verde River 8–20 712	Fossil Creek 720	Unknown	Total
4/26/87–5/23/87														
	Sucker sp.	—	1	—	—	—	—	—	1	3	—	—	—	5 14%
	Carp	3	2 (3)	—	2	1	1	1 (1)	—	—	—	—	—	10 29%
	Channel Catfish	—	1	—	—	—	—	—	—	—	—	—	—	1 3%
	Flathead Catfish	—	1	2	2	—	1	—	—	—	—	—	—	6 17%
	Largemouth Bass	—	1	1	—	—	(1)	—	—	—	—	—	—	2 6%
	Smallmouth Bass	—	1	—	—	—	—	4	—	—	—	—	—	5 14%
	Black Bass sp.	—	1	—	—	—	—	—	—	—	—	—	—	1 3%
	Unknown Fish	—	—	—	—	—	1 (2)	2	—	—	—	—	—	3 9%
	Turtle sp.	—	—	—	(1)	—	—	1	—	—	—	—	—	1 3%
	Carrion	—	—	—	—	—	1	(1)	—	—	—	—	—	1 3%
Total %		3 9%	8 23%	3 9%	4 11%	1 3%	4 11%	8 23%	1 3%	3 9%	0 0%	0 0%	0 0%	35 100%
5/24/87–6/6/87														
	Sucker sp.	—	—	1	—	—	—	—	—	—	—	—	—	1 8%
	Carp	4	—	—	1	—	—	—	—	—	—	—	—	5 38%
	Channel Catfish	2	—	—	—	—	—	—	—	—	—	—	—	2 15%
	Flathead Catfish	1	—	—	—		—	—	—	—	—	—	—	1 8%
	Smallmouth Bass	—	1	—	1	—	—	—	—	—	—	—	—	2 15%
	Unknown Fish	1	1	—	—	—	—	—	—	—	—	—	—	2 15%
Total %		8 62%	2 15%	1 8%	2 15%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	13 100%

AM02's visits to the East Verde River appeared directed toward specific areas, although we were usually unable to determine his exact location. Km 20 of the East Verde, the east end of the eagles' observed home range (16 airline km from the nest), contains an abundance of cottonwoods and sycamores along shallow areas; the terrain is much more open than downstream (Km 5–15) where steep canyon walls predominate. We observed two piracies from an osprey in Kms 15-17, a stretch of river also shallow but with steep cliffs on one side. AM02 frequented Km 12-13, characterized by steep cliff walls, bends, and fast shallow riffles interspersed with deep pools. This appeared to be a favorite area along with Km 10, a long stretch of shallow fast water at a river bend surrounded by steep slopes. The increased occurrence of foraging eagles downstream of Km 10 on the East Verde River in late April may have been related to changes in fish distribution.

Eagles foraged along 17 Km of the mainstem Verde River, from Km 123, 11 Km downstream from the nest, to Km 140, 6 Km upstream of the nest. The eagles utilized the mainstem throughout the nesting season, and a significant proportion of forages were within 3 river Km of the nest. For example, 37 percent, 66 percent, and 84 percent of all mainstem forages for which we have sufficient locational data occurred within 1.0, 2.6 and 5.5 river Km of the nest, respectively. Excluding forages away from riverine habitats, these values are 21, 57, and 80 percent. Actual straight line distances between the nest and foraging sites were considerably shorter. Zones of the Verde River utilized by foraging eagles are discussed below.

Zone 707: Fossil Creek to Childs (Km 136.3–141.3). The eagles foraged on ten occasions at six different locations on the mainstem above its confluence with Fossil Creek. AM02 started using this area during the last week in May; he also occasionally used hunting perches 4 Km up Fossil Creek.

Zone 705 and 706: Nest Area Upstream to Fossil Creek (Km 133.6–136.5). AM02 apparently hunted this important area with greater regularity than the female, although both birds took bass, catfish and carp there. The female also pirated prey from a great blue heron and took carrion. She actively hunted Km 136.0–136.2 from several cliff perches on the east side of the river. After radio-tagging, we documented 26 foraging attempts by the male in this area near the mouth of Fossil Creek. A super-riffle was present at 136.2.

AM02 frequented many perches in the area, but appeared to have two favorite sites: one atop a low cliff adjacent the channel at the mouth of Fossil Creek where the super-riffle was located, and the other a more extensive broken cliff, roughly 100 m from shore, at Km 135.6. The bird spent a large amount of time at both sites; he regularly hunted from the cliff near the edge of Fossil Creek.

The bald eagles also obtained food in the immediate vicinity of the nest. During 7–24 March, the birds fed a minimum of 17 times on carrion resulting from the death of a cow and calf just across the river from the nest. They foraged on seven other occasions within about 400 m of the nest, taking mammals and live fish.

Zone 702, 703, and 704: Nest Area Downstream to "The Bend" (Km 126.8–133.6). Both eagles utilized the 1986 nest area, from Houston Creek (Km 128.8) to "The Bend" (Km 126.8), although the female appeared to use it more consistently. We saw the birds foraging in this 2 Km section on 17 occasions. The eagles hunted from cliff perches on both sides of the river and from a mesquite bosque. The river at this location was characterized by super-riffles at Kms 127.5 and 128.0–128.1. Several sections in this reach support a considerable amount of emergent and riparian vegetation. At "The River Bend" a large

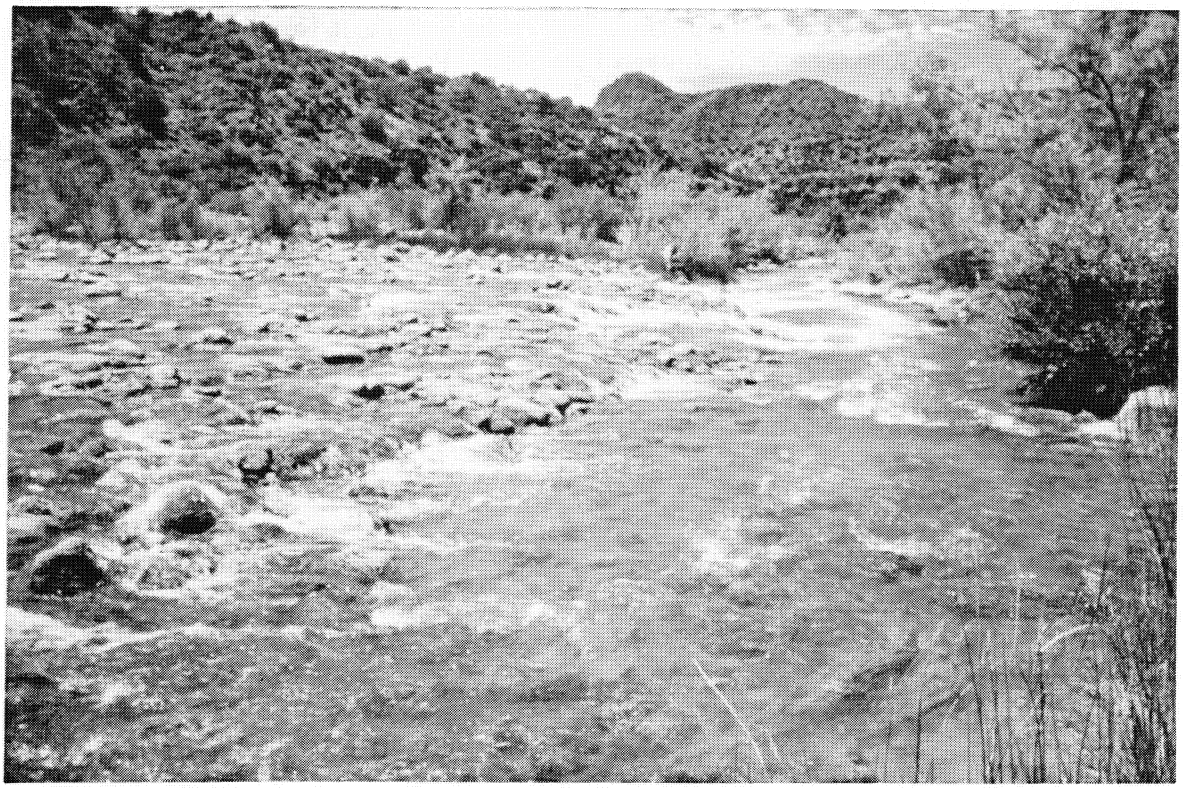


Plate B19. Verde River at the confluence of Fossil Creek, May 1987 (photo by R. Hunter-Long).

snag-top cottonwood at Km 126.9 was frequently used as a hunting perch. The East Verde pair used Km 128 from the beginning of April into June.

The eagles were not observed foraging in the area downstream from the 1987 nest to Houston Creek. They occasionally perched along the string of cliffs along the river at Km 132. An extensive braided area of river was present from Km 130.0–131.0 which may have been used by the eagles. We know they successfully hunted in the vicinity and subsequently delivered food to the nest, but we made no direct observations of forages.

Zone 701: "The Bend" Downstream (Km 123.0–126.8). We observed two foraging events on fish at a somewhat isolated forage location in the downstream end of the home range (Km 123.1). Hunting perches included small rock outcrops and a mesquite bosque interspersed with cottonwoods on the west side of the river. In contrast to most of the foraging areas, AM02 appeared to be utilizing a deep riverine pool, the only observed foraging site within the entire 3.8 Km zone. A super-riffle occurred at approximately Km 123.3; we did not see the eagles forage there, but they may have done so.

B4.4.2.3 Foraging Perches. The East Verde eagles usually detected, then attacked prey from perches. This mode of attack accounted for about 78 percent of the observed forage attempts where we could reasonably determine behavior. The adults hunted from perches of various types including cliff faces, live medium-sized deciduous trees, mesquite snags and other snags (Table B4.4-9).

Table B4.4-9. Frequency of use of perch types by AM02 in the East Verde Nesting Territory (excluding the nest area) during April through June 1987. For this table, only one perching event per perch type was tabulated per day.

Perch Type	Outside Nest Area	Nest Area Only
Conifer	4	40
Snag-top Conifer	0	1
Snag	24	0
Deciduous, large	9	0
Deciduous, medium	15	0
Deciduous sapling	3	5
Snag-top Deciduous	3	1
Juniper	35	1
Juniper Snag	19	5
Other (comments)	4	0
Mesquite (live)	15	1
Mesquite Snag (dead or bare)	6	2
Shrub, unidentified (live)	3	0
Cottonwood, large	2	36
Cut Bank	1	6
Cliff Ledge	23	3
Cliff Top	25	2
Cliff Face Vegetation	13	4
Boulders	9	2
Shore	3	2
Sand Bar	5	0
Cactus	0	0
Palo Verde	0	1
Stump or Stick	14	0

In general, the eagles appeared to be tolerant in their choice of perch types, and the relative use of these for hunting may simply reflect their availability in habitat preferred for other reasons. The distance between an eagle's perch and its intended prey varied considerably, depending on whether it was hunting live prey or obtaining carrion. The maximum distance for any forage, including those where the bird had prior knowledge of the carrion source, was 900 m, and averaged 210 $\pm$ 73 m (2 SE). In contrast, when birds hunted live prey, which they detected from a perch, the maximum distance to the prey was only 150 m and averaged 37 $\pm$ 8 m (2 SE). The mean distances to prey for successful (n = 24) versus unsuccessful (n = 31) hunts did not differ significantly ($t = 0.093$, $p > 0.926$).

Adults often perched for extended periods at sites many meters from the river and watched the water. Instead of attacking directly from these positions, they typically perched closer to the river channel before

actively pursuing prey. We speculate that from the high perches the birds scanned large areas of river for fish moving into very shallow water.

B4.4.2.4 Habitat at Observed Forages. Eagles foraged in a variety of riverine habitats. Of 27 successful and 34 unsuccessful observed foraging events, 45.9 percent of the total attempts were in riffles, 29.5 percent in runs, 13.1 percent in pools, 8.2 percent in backwaters, 1.6 percent pocket water, and 1.6 percent in cascades. Distance from strike point to the nearest point on shore ranged from 1-35 m and averaged about 7.6 $\pm$ 1.81 m (2 SE).

In 27 observed successful forages for fish judged to have been alive when taken by the eagle, depths at strike points ranged from 8 cm (3 measurements) to over 200 cm (2 measurements). Mean depth at strike points (of the 25 forages of less than 200 cm) was 38 cm; however, 19 (76%) were less than 38 cm, and 12 (48%) were less than 18 cm deep. Of the eight remaining forages, six were in water between 68 and 155 cm deep. Of 33 observed unsuccessful forages, the average depth at strike points was only 27 cm (SD +/− 14 cm).

Water velocity at foraging sites on the Verde River averaged just less than one-third meter per second. Water surface condition at strike points was variable; forages were uniformly divided among sites with conditions classified as glassy, or with 1-2-cm swirls, or 3-5-cm peaks. Bald eagles usually foraged in clear, shallow water, with Secchi disk reading "clear to the bottom." Turbidity would have restricted visibility at only three forage locations, with water depths of 155 cm, 109 cm and 100 cm, and corresponding Secchi readings of 84 cm, 90 cm and 65 cm. Average Secchi disk readings were roughly 75 cm in spring and 110 cm in early summer.

We classified aquatic vegetation at 60 eagle strike points. When vegetation was present (70%) it usually consisted of thick tufts of algae growing on the rocky substrate (58%). These conditions typically occurred in riffles and fast shallow runs. To a large extent, the riverine substrate reflected flow characteristics of the river and soils of the drainage. Forty forage sites (62%) had a rocky substrate and nine (14%) had a sandy bottom. The rocky substrates were usually found in riffles or other fast flowing areas. Sandy substrates were common along many riverine habitats, but especially at both ends and along the shallow shores of runs.

B4.4.3 Prey Studies

During our investigations of fish and other prey in the East Verde territory we attempted to determine: (1) if bald eagles forage selectively in specific areas or habitats in the river; (2) if areas used by foraging eagles are significantly different from areas where they did not forage; and, (3) changes in fish distribution and availability in the Verde River and the East Verde River during the nesting season. To accomplish these tasks, we first needed to characterize habitat conditions and fish communities in the rivers to compare with foraging data on the eagles.

Because the East Verde breeding area contained a major tributary (the East Verde River) which the eagles exploited during a portion of the chick cycle, we surveyed the fisheries of the tributary with particular interest. We did this not only to investigate the possible impacts of the proposed water diversions from the tributary, but because there is so little information on the role of tributaries in the ecologies of Arizona bald eagles.

B4.4.3.1 River Habitat Surveys. We assessed and measured habitat on the Verde and East Verde rivers in June 1987 in order to: (1) determine relative and absolute habitat abundance; (2) ascertain whether or not bald eagle foraging areas differed significantly from non-foraging areas; (3) determine if bald eagles foraged in habitats in proportion to their abundance or actively selected specific habitat types; and, (4) select representative fish sampling locations.

Habitat Characterization. Based on our knowledge of bald eagle foraging distribution, we mapped the mainstem Verde River from Km 142.0 downstream to Km 122.0 on 10–16 June 1987. Mean daily flow in the river was approximately 139 cfs during the survey. Similarly, we characterized habitat on the East Verde River from the Verde River confluence (Km 0.0) upstream to LF Ranch (Km 20.0). During mapping on 14–17 June 1987, mean flow in the East Verde River was 17 cfs.

During the surveys, we identified major habitat types (E8-9) and measured habitats to determine habitat width, dominant and subdominant substrate, dominant cover type, and depth profiles. In addition, we estimated percentage of braided habitat, percentage of surface turbulence, and average slopes for the right and left banks. We also noted the presence of tributaries and potential barriers to fish migration (there were no fish barriers on the mainstem).

Markers placed every 100 m along the entire study area ensured that exact habitat locations could be identified. Habitat lengths were measured using the 100 m markers as reference points. We measured habitat widths in the Verde River with a fiberglass tape; however, in the East Verde River exact measurements were not taken. Instead, habitat widths were estimated and recorded as 10-foot intervals using a 20-foot cord for reference. We determined dominant and subdominant substrate type, habitat depth, and dominant cover type by walking transects. We calculated various summary data for each reach, including: (1) average length, width, area, and substrate; (2) dominant cover type; (3) percent of habitats of various depths; (4) percent surface turbulence; and, (5) percent of braided habitat type.

In the Verde River, we examined two reaches in detail, including: (1) "Foraging Reach" (includes Km 127.0–128.9, Km 133.0–137.9, Km 139.0–139.9), and (2) "Non-foraging Reach" (includes Km 140.0–141.9, Km 129.0–130.9, Km 124.0–125.9, Km 122.0–122.9). Inclusion in the foraging reach required at least three documented forage attempts, while the non-foraging reach was composed of Kms with no known forage attempts. This system excluded segments that contained one or two forages; however, this represented only 9 percent of the total attempts. We compared foraging and non-foraging reaches to determine the presence of significant habitat differences. Analysis of average length, width, area, substrate, and depth of specific habitat types, and overall abundance of habitats, allowed us to explore whether physical habitat was crucial to the eagles' selection of forage areas.

On the East Verde River, we examined two study reaches: the lower East Verde (Km 0.0–7.9) and the upper East Verde (Km 8.0–19.9). We did this because in early April 1987 the male visited the upper reach more frequently than the lower reach, despite the greater distance of the upper reach from the nest. In late April, the male increased his use of the lower reach.

Verde River Habitat. The relative abundance of habitat types in the Verde River from Km 142.0–123.0 is summarized in Table B4.4-10. The river in this territory is comprised primarily of run habitat (56.8% of total area), pocket water habitat (14.5%), and riffle (normal riffles and super-riffles) habitat (15.2%). Interestingly, the majority of habitats contain relatively few shallow water areas (< 0.6 m deep); only pocket water, riffles and super-riffle habitat contain substantial areas of shallow water habitat.

Table B4.4-10. Summary of habitat characteristics for the Verde River (East Verde Territory) between Km 142.0–123.0.

Habitat Type	Total Length (m)	Percent of Total Length (%)	Total Area m^2	Percent of Total Area (%)	Habitat Area <0.6 m Deep	Percent of Total Area <0.6 m Deep
Pool	1,277	6.9	40,488	8.6	1,015.5	2.5
Pocket Water	2,255	12.2	68,211	14.5	17,102.9	25.1
Super Riffle	928	5.0	28,424	6.0	25,856.0	91.0
Riffle	2,035	11.0	43,251	9.2	31,285.0	72.3
Backwater	14	0.1	264	0.1	2.6	1.0
Cascade	1,307	7.1	22,748	4.8	1,610.0	7.1
Run	10,692	57.8	266,957	56.8	6,414.0	2.4
TOTAL	18,508	100.0	470,343	100.0	83,286	

Comparisons of habitat abundance (by area) in foraging and non-foraging reaches of the Verde River are given in Figure B4.4-6. To test whether foraging and non-foraging reaches of the river contained similar habitat types, we used Chi-Square statistics on habitat data arranged in a contingency table. Because of the large numbers (m^2), we used the square root of the area of each main habitat type (pool, riffle, super-riffle, run, pocket water, and cascade). The results strongly suggest that a difference exists in the abundance of habitat types in the foraging and non-foraging segments ($\chi^2 = 166.6$, df = 5, $p < 0.001$). Note in the table that super-riffles occur only in the foraging reach.

We then tested whether differences within habitat types existed between foraging and non-foraging reaches. Information on lengths, widths, areas, substrate type, and depth ranges for each habitat type in the foraging and non-foraging reaches of the Verde River is summarized in Table B4.4-11. Mean length, width, and area of habitat types found in the two reaches were not significantly different by t-test. Substrate and depth differences between the two reaches appear minor. We also compared data on perch quality between the two reaches (perch evaluations every 100 m throughout); no difference was found (Table B4.4-12).

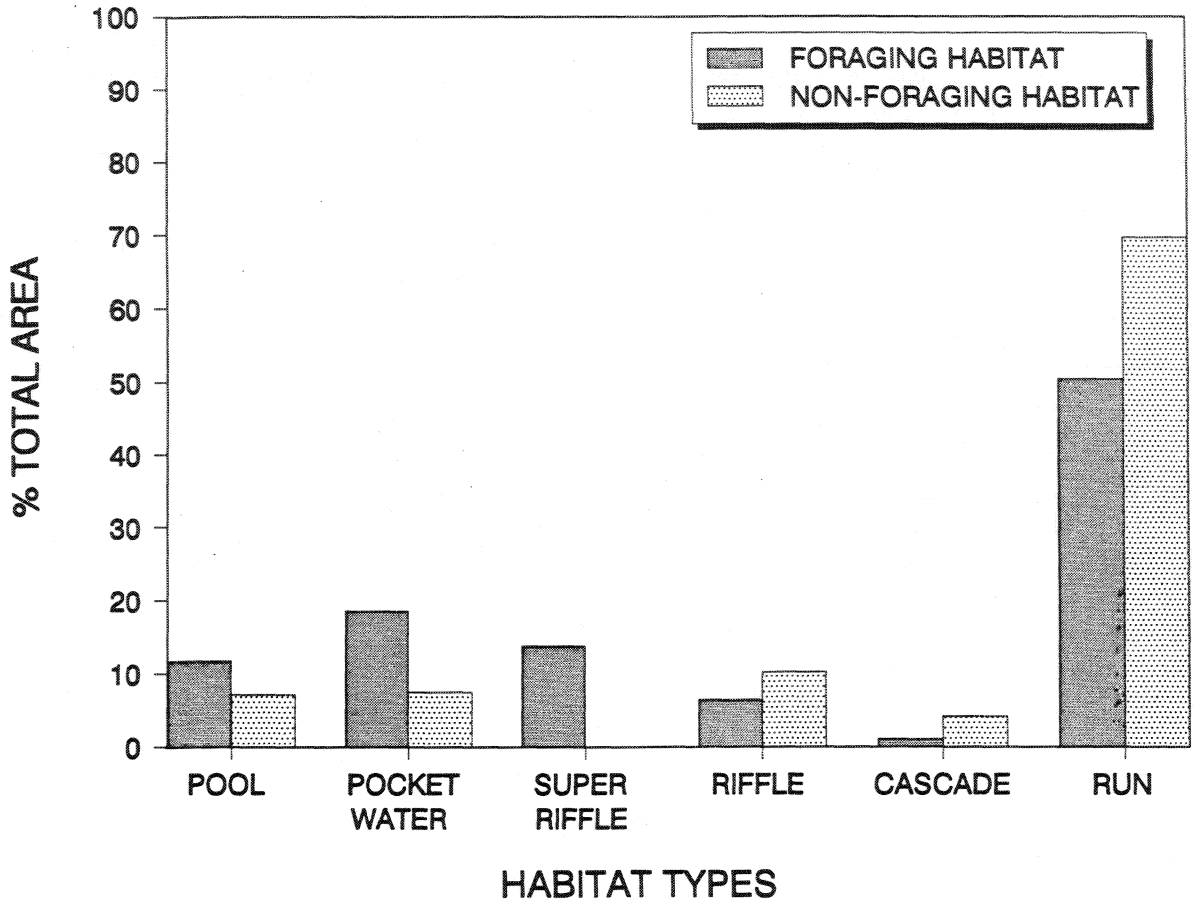


Figure B4.4-6. Relative abundance (by area) of habitat types in eagle foraging and nonforaging areas of the Verde River in June 1987. Mean flow during the habitat surveys was approximately 139 cfs.

We then compared super-riffles and classical riffles in foraging areas to determine if differences existed between these habitats. We found that super-riffles were significantly wider than classical riffles (t-test, $p < 0.02$) and were larger in area (t-test, $p < 0.05$). Substrate type was similar in both types of riffles and was dominated by rubble and boulder (Table B4.4-11). Super-riffles measured shallower than classical riffles: 99 percent of the total area of super-riffles was less than 0.6 m deep whereas 90 percent of the total area of riffles was less than 0.6 m deep.

B4.4.3.2 Habitat Selection. We attempted to correlate visitations to specific habitat characteristics in each kilometer segment (Table B4.4-13) in AM04's home range along 19 Kms of the mainstem (Km 141–123)(see Figure B4.4-4). Habitat characteristics included in this analysis were distance from nest and the abundance of various riverine habitats (i.e., pools, runs, riffles, super-riffles, pocket waters, back waters, and cascades). The Spearman rank correlation coefficient was calculated for each combination of visitation with habitat characteristics (Zar 1984). The results of this analysis indicated that visitations were not significantly correlated with distance from nest or the abundance of pools, pocket waters, runs, classical riffles, backwaters or cascades (Spearman rank correlation; $p = 0.01$). However, we found

Table B4.4-11. Comparison of habitat types in foraging and non-foraging segments of the Verde River. Standard deviations of mean values are given in parentheses.

Habitat	N	Total Length (m)	Mean Length (m)		Mean Width (m)		Total Area (m^2)	Mean Area (m^2)		Dominant Substrate	% of Area With Depth (m) 0–0.6	0.6–1.2	1.2–1.8	>1.8
Run														
Foraging	26	4,166.8	160.3	(126.1)	26.0	(11.2)	109,055.3	4,194.4	(4,191.6)	Rubble,Gravel	36%	35%	26%	3%
Non-Foraging	37	5,156.3	139.4	(97.0)	23.7	(10.6)	126,763.7	3,426.0	(3,238.2)	Rubble,Gravel	39%	34%	24%	3%
Riffle														
Foraging	9	872.4	96.9	(73.8)	18.1	(6.1)	14,200.4	1,577.8	(1,196.3)	Rubble,Boulder	90%	10%	0%	0%
Non-Foraging	7	698.4	99.8	(50.3)	26.0	(10.4)	17,053.1	2,436.2	(1,409.5)	Boulder,Rubble	76%	24%	0%	0%
Super-Riffle														
Foraging	6	804.6	134.1	(94.2)	34.1	(14.7)	25,294.6	4,215.8	(3,275.7)	Rubble,Boulder	99%	1%	0%	0%
Non-Foraging	0													
Pool														
Foraging	5	714.1	142.8	(149.3)	33.6	(8.5)	24,637.1	4,927.4	(5,472.8)	Gravel,Sand	16%	47%	25%	12%
Non-Foraging	3	385.2	128.4	(46.7)	33.4	(5.8)	12,070.8	4,023.6	(683.1)	Mud,Rubble	0%	4%	33%	63%
Cascade														
Foraging	4	265.9	66.5	(41.9)	11.4	(6.8)	2,186.9	546.7	(364.0)	Boulder,Rubble	95%	5%	0%	0%
Non-Foraging	9	530.5	58.9	(26.8)	12.4	(4.1)	6,951.4	772.4	(478.4)	Rubble,Boulder	77%	22%	0%	0%
Pocket Water														
Foraging	8	1,426.0	178.2	(68.5)	26.8	(14.2)	39,041.2	4,880.1	(4,257.9)	Rubble,Boulder	83%	17%	0%	0%
Non-Foraging	3	290.3	96.8	(59.0)	28.2	(9.1)	9,539.7	3,179.9	(2,832.9)	Rubble,Gravel	98%	2%	0%	0%
Backwater														
Foraging	0													
Non-Foraging	1	13.7	—	—	19.2		263.6	—	—	—	1%	1%	68%	30%

Table B4.4-12. Comparison of perch suitability in foraging and non-foraging sections of the Verde River, Arizona.

Perch	Frequency	Percent	Approximate	95% CI
Forage				
Unsuitable	1	1.30	8.53	0.00
Low Suitability	6	7.79	18.25	1.82
Moderate Suitability	34	44.16	58.41	29.51
High Suitability	36	46.75	60.91	31.87
Total	77			
Non-forage				
Unsuitable	0	0.00	n/a	n/a
Low Suitability	1	1.67	10.42	0.00
Moderate Suitability	26	43.33	69.81	38.19
High Suitability	33	55.00	69.81	36.19
Total	60			

a significant correlation between eagle visitations and super-riffle abundance (Spearman rank correlation; $0.05 < p > 0.01$).

It is notable that 72 percent of all visitations to the Verde River were to seven segments (Kms 123, 127, 128, 134, 135, 136, and 139). These segments contained 100 percent of super-riffle habitat in the territory but only 21 percent of classical riffle habitat by area)(see Figure B4.4-4).

We observed 61 forages on the Verde River between Km 123–141 in 1987 in which we were able to identify the specific habitat at the strike points. A graphic comparison of habitat availability in this reach to the distribution of eagle foraging by habitat is shown in Figure B4.4-7. Chi-square analysis of the observed versus expected visitations to each habitat type strongly suggested that the eagles preferentially foraged in riffle habitats ($\chi^2 = 21.0$, df = 5, $p < 0.001$). Twenty-eight of the 61 observed strike points were at riffles but less than ten were expected on the basis of total length of this habitat along the river. In this analysis, we did not separate eagle foraging data into classical and super-riffle habitats because the concept of the super-riffle was developed after studies in this territory were completed; the observers did not distinguish among these habitats in their foraging records.

Table B4.4-13. Summary of visitation, distance from nest and habitat abundance in 19 km segments (Km 123–141) in the Verde River (East Verde Territory)(1987 data).

Segment	Visitation Score	Distance from Nest (km)	Pool	Pocket Water	Run	Riffle	Super-Riffle	Cascade	Backwater
123	4	5.4		1,661	11,415		3,129	2,250	
124	1	4.0			15,674	5,050			
125	0	3.2	3,204		18,318	1,515			264
126	11	2.5	1,829	2,691	27,821			623	
127	26	1.9		5,511	3,497		11,032	294	
128	44	1.2	4,224	19,005	6,057		3,177		
129	0	0.6		7,174	17,023	3,727		797	
130	0	0.9		1,453	22,179	5,215		505	
131	10	1.2	1,952		17,760	6,747			
132	12	1.0		6,557	15,891	1,068		730	
133	26	0.2	1,751	1,549	16,855	2,186		881	
134	6	0.9	2,833		4,461	3,515	2,718	1,012	
135	48	1.5	15,829	10,585	3,743		2,530		
136	70	2.1			25,535		3,630		
137	10	3.0			18,169	1,838			
138	10	3.9			14,197	810		6,376	
139	16	4.7		1,531	22,799	4,784	2,208		
140	4	5.6		3,140	15,745	1,661		1,241	
141	1	6.4	8,867		11,549	812		3,110	

B4.4.3.3 East Verde River Habitat. The relative abundance of habitat types in upper and lower reaches of the East Verde River (Km 0.0 8.0 and Km 8.0–20.0 respectively) is summarized in Figure B4.4-8. The upper reach of the river is comprised primarily of pocket water habitat (49% of total area), run habitat (33.5%), and pool habitat (15.9%). The lower reach of the river had a similar habitat distribution with run habitat comprising 42.2 percent of total river area followed by pocket water habitat (42.2%) and pool habitat (15.3). In both reaches, riffle habitat and cascade comprised less than 4 percent of total habitat by area.

To test whether the upper and lower reaches of the river contained similar habitat types, we used Chi-square statistics on habitat data arranged in a contingency table (square root of habitat area). The assumption of no difference in habitat distribution between the two reaches was rejected by Chi-square ($\chi^2 = 23.8$, df = 4, $p < 0.001$).

We then tested whether differences within a habitat type exist between the two reaches. Information on lengths, widths, areas, substrate type, and depth ranges for each habitat type in the upper and lower reaches of the East Verde River is summarized in Table B4.4-14. Mean length, width, and area of

habitat types for all habitats found in the two reaches are not significantly different (t-test, $p < 0.05$) with the exception of mean length and area of course pocket water and mean width of moderately deep pools (t-test, $p = 0.05$). When different, mean values were greater in habitats in the upper reach.

Over 64 percent of the total area of each habitat type (excluding pools) in both the upper and lower reaches of the river was <0.6 m in depth. Depth profiles of non-pool habitats were quite similar in both reaches. Shallow pools were different between reaches: over 50 percent of their area was less than 0.6 m deep in the upper reach versus only 5 percent in the lower reach. The only potential fish barrier in the East Verde River was a cascade at Km 16.0. In April 1987, suckers were observed successfully negotiating the barrier; however, they appeared physically exhausted. At lower flows, the cascade may prevent fish from moving upstream.

B4.4.3.4 Fish Distribution and Abundance on the Mainstem. We attempted to determine fish distribution and relative abundance on the Verde River in June 1987 using four sampling procedures: electrofishing in shallow water habitats, gill netting in pools, visual surveys in representative habitats in each reach, and seining in shallow pools and runs. Of these we found that gill netting was the most useful in comparing foraging with non-foraging reaches.

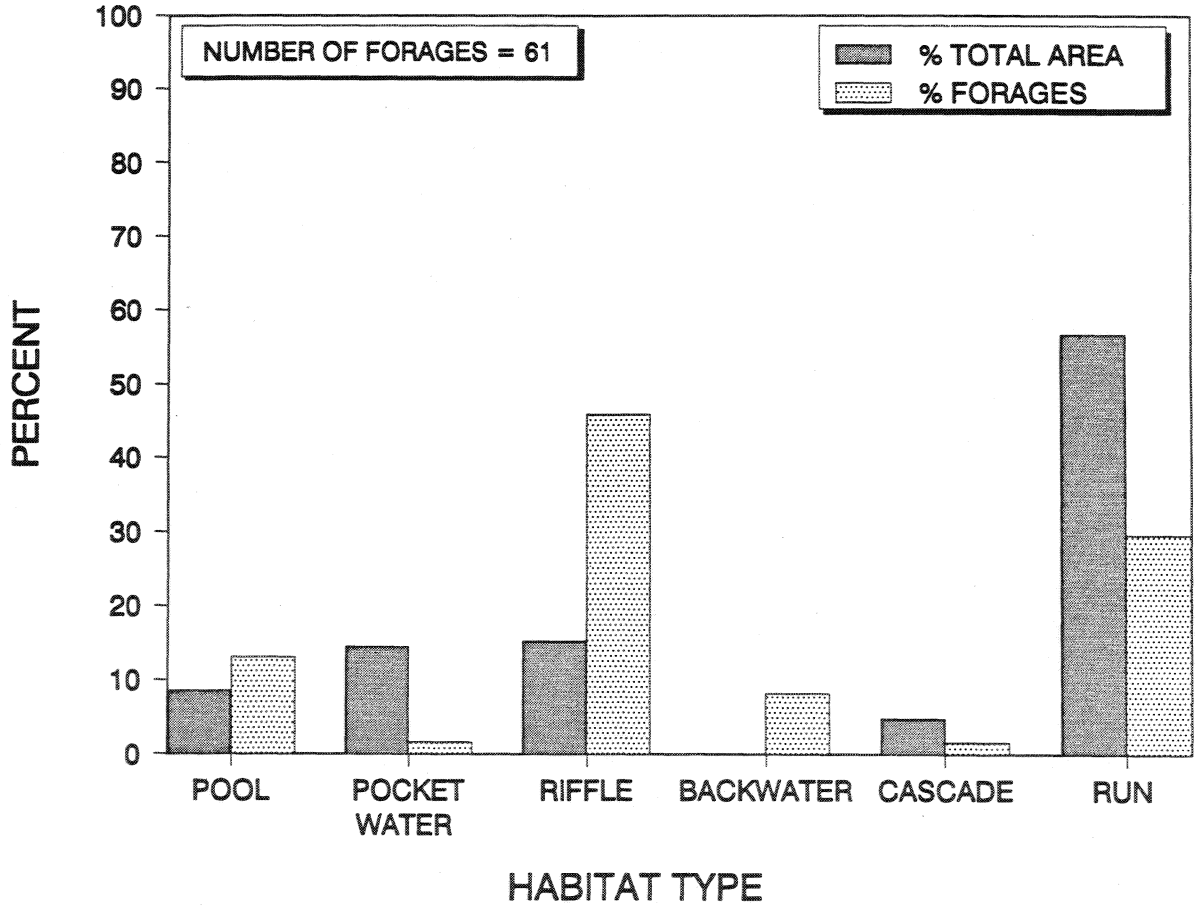


Figure B4.4-7. A comparison of habitat availability (by percent area) and percent of total forages by habitat type in the Verde River (Km 121.6–142.0)(1987 data).

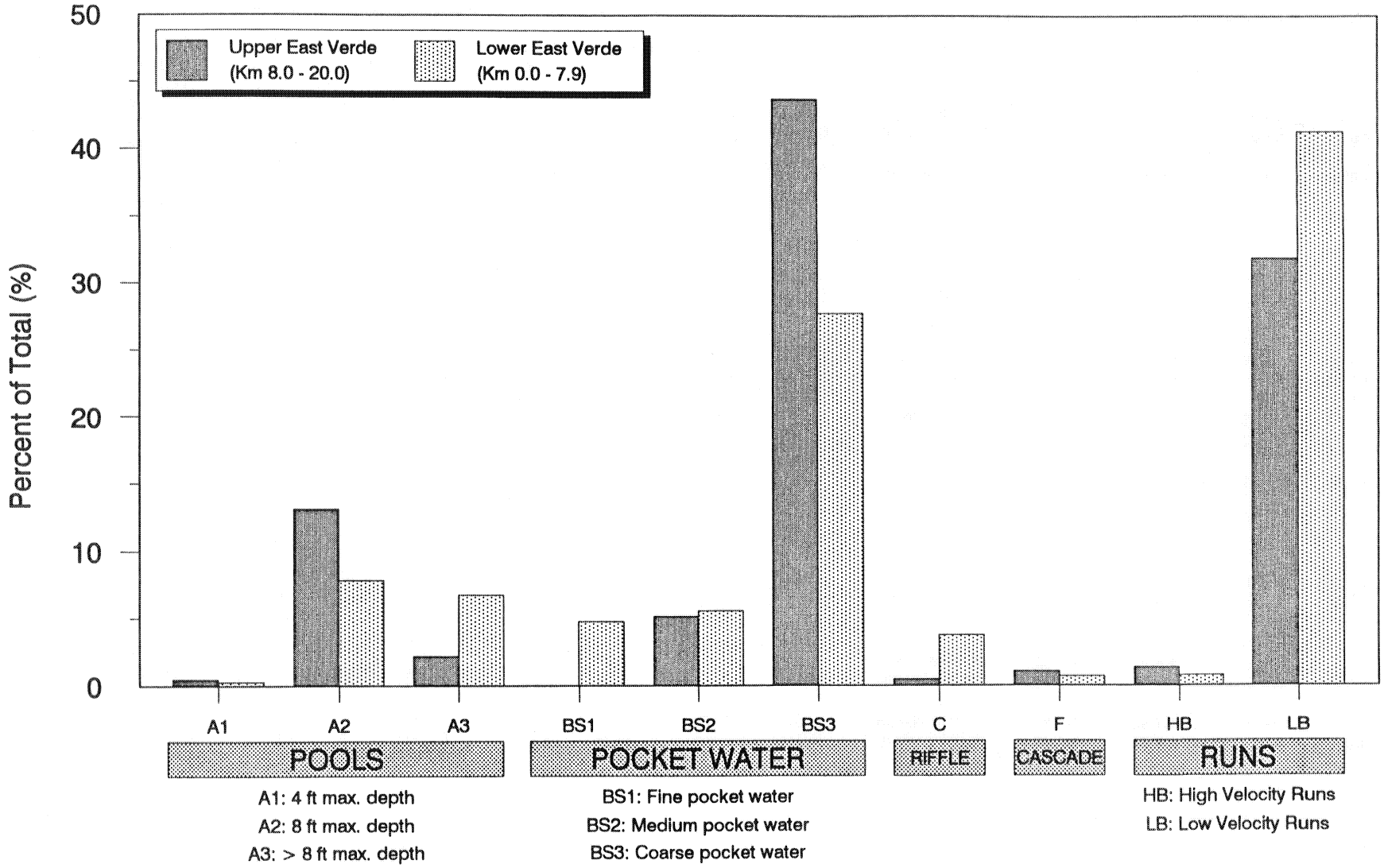


Figure B4.4-8. Relative abundance (by area) of habitat types in the lower and upper reaches of the East Verde River in June 1987.

Table B4.4-14. Comparison of habitat types in the upper and lower reaches of the East Verde River. Standard deviations of mean values are given in parentheses.

Habitat	N	Mean Length (m)		Mean Width (m)		Mean Area (m^2)		Dominant Substrate	% of Area With Depth (m) 0–0.6	0.6–1.2	1.2–1.8	>1.8
Runs												
High Velocity												
Upper Reach	5	51.7	(42.7)	8.2	(2.0)	446.9	(411.8)	Bedrock,Rubble	86.5%	13.5%	0%	0%
Lower Reach	5	20.4	(5.2)	7.3	(2.5)	139.3	(19.5	Rubble,Boulder	64.7%	35.3%	0.0%	0.0%
Low Velocity												
Upper Reach	39	82.4	(64.4)	13.4	(6.4)	1,320.0	(1,885.5)	Gravel,Rubble	75.4%	20.7%	3.4%	0.6%
Lower Reach	43	72.7	(52.0)	11.9	(3.8)	863.0	(776.7)	Gravel,Rubble	73.9%	19.8%	4.3%	2.0%
Riffle												
Upper Reach	6	23.0	(16.3)	6.1	(3.0)	140.2	(133.0)	Rubble,Gravel	100.0%	0.0%	0.0%	0.0%
Lower Reach	16	23.6	(15.9)	8.8	(3.2)	211.9	(163.5)	Rubble,Gravel	99.3%	0.7%	0.0%	0.0%
Pool												
Shallow (Max. depth 4 ft.)												
Upper Reach	1	96.0	(0.0)	9.1	(0.0)	878.2	(0.0)	Gravel,Sand	50.0%	50.0%	0.0%	0.0%
Lower Reach	1	33.7	(0.0)	9.1	(0.0)	308.4	(0.0)	Rubble,Gravel	5.0%	50.0%	45.0%	0.0%
Medium (Max. depth 8 ft.)												
Upper Reach	12	98.3	(73.0)	17.3	(4.0)	1,698.0	1,499.0	Sand,Gravel	9.2%	47.9%	21.2%	21.7%
Lower Reach	8	67.8	(27.0)	12.4	(5.3)	839.7	(564.8)	Sand,Gravel	18.8%	28.6%	23.7%	28.9%
Deep (Max depth >8 ft.)												
Upper Reach	3	74.9	(43.2)	14.2	(4.7)	1,152.0	(972.7)	Rubble,Sand	0.0%	3.0%	4.5%	92.5%
Lower Reach	7	54.8	(25.9)	19.8	(15.0)	1,085.0	(343.8)	Sand,Gravel	22.7%	18.2%	37.6%	21.5%
Cascade												
Upper Reach	9	24.1	(31.2)	10.3	(5.8)	187.5	(139.1)	Bedrock,Boulder	97.0%	3.0%	0.0%	0.0%
Lower Reach	7	15.5	(6.2)	5.4	(2.8)	84.8	(44.4)	Boulder,Rubble	97.0%	3.0%	0.0%	0.0%
Pocket Water												
Fine Pocket Water												
Upper Reach												
Lower Reach	6	73.6	(63.0)	10.2	(2.5)	709.9	(556.2)	Rubble,Gravel	95.1%	4.9%	0.0%	0.0%
Medium Pocket Water												
Upper Reach	7	115.2	(80.7)	10.0	(2.3)	1,178.6	(853.8)	Rubble,Boulder	99.6%	0.4%	0.0%	0.0%
Lower Reach	7	66.7	(35.5)	10.0	(2.3)	716.1	(557.1)	Rubble,Boulder	97.6%	2.4%	0.0%	0.0%
Coarse Pocket Water												
Upper Reach	37	158.5	(113.1)	11.7	(4.1)	1,895.7	(1529.1)	Boulder,Rubble	96.6%	3.4%	0.0%	0.0%
Lower Reach	24	100.7	(75.0)	10.8	(5.0)	1,041.6	(762.6)	Boulder,Rubble	93.9%	6.1%	0.0%	0.0%

We sampled pools with gill nets measuring 80 ft long by 6 ft deep containing four 20-foot sections of mesh size 3.5, 2.5, 1.5, and 0.5 inches. We placed gill nets overnight at seven sites in the non-foraging reach of the Verde River and five sites in the foraging reach; sites were randomly selected. Seines used in the river measured 50 ft × 4 ft and 50 ft × 6 ft, each with 3/16 inch mesh. Results from gill netting in pools in foraging and non-foraging areas of the Verde River are shown in Table B4.4-15. A t-test comparison was not significant in indicating a difference in the total number of fish in the foraging versus non-foraging area (t-test, $0.10 < p > 0.05$; however, it did show a significant difference between the areas in the total numbers of forage fish ($p < 0.05$). Gill nets in foraging areas caught over three times as many fish (regardless of size) and over four times more forage fish than gill nets in non-foraging areas. In foraging areas, we collected five different fish species (carp, channel catfish, flathead catfish, smallmouth bass, and sucker sp.) and two Sonoran mud turtles. In non-foraging areas, only three fish species were collected (carp, smallmouth bass and flathead catfish). In both areas, carp was the most abundant species collected.

We conducted electrofishing surveys only within the foraging reach of the Verde River; one pass was made during the surveys using a Smith-Root Model 7 backpack shocker. In four habitats (slow runs, medium and course pocket water habitats, and riffles) we collected a total of 81 fish, consisting of four species: red shiner (76.5% of catch), smallmouth bass and flathead catfish (11.1% each), and desert sucker (1.2%). None of the fish collected during electroshocking were large enough to provide eagle forage. However, prior to placing block nets in the habitats shocked, we surveyed each habitat visually and typically saw large carp leaving the habitats, especially riffles and low-velocity runs rather than pocket water habitats.

We sampled 13 sites by seining (2–5 hauls per site) in mainstem foraging areas, collecting 260 fish. Red shiners comprised 85.8 percent, smallmouth bass 13.8 percent, and mosquito fish 0.4 percent. All fish collected were <55 mm standard length except for two smallmouth bass which ranged from 137–143 mm. No seine hauls were taken in non-foraging areas.

Visual surveys employed a fisheries biologist walking along the river margin or making observations from an elevated position (i.e., cliff) to document the number of fish present by species and their approximate length in a habitat. During habitat mapping on the Verde River, we also obtained visual data. In both foraging and non-foraging areas, carp were the most abundant species observed in all habitat types. We commonly observed them in shallow water (<0.6 m deep) or cruising slowly along the surface in deeper water. We observed the highest densities of carp in low-gradient runs and pocket water. Carp abundance varied in riffles. In some riffles, we saw groups of two to five carp, while in other riffles we saw no carp. Carp were probably transient in riffles, moving into these habitats to briefly forage on the greater abundance of invertebrates there.

B4.4.3.5 Fish Distribution and Abundance on the East Verde River. We attempted to determine fish distribution and relative abundance in the East Verde River in June and July 1987 using three sampling procedures: electroshocking in shallow water habitats, gill netting in pools, and visual surveying of fish in representative habitats in each reach. Electroshocking was more effective on this tributary than the mainstem because in the smaller environment block nests could be set before the fish escaped. Electrofishing was thus our main source of data on species composition, distribution, and biomass. Visual survey data helped to verify how well the shocking data represented fish communities in the reaches.

Table B4.4-15. Fish collected by gill netting pools in nonforaging and foraging sites of the Verde River.

VERDE RIVER—NONFORAGING SITES

Net No.[1]	Location	Date Sampled	Species	Total # All Fish	Total # Forage Fish	Biomass (gm) All Fish	Biomass(gm) Forage Fish
2	Km 141.5	6/9/87	Carp	1	1	472	472
			Smallmouth Bass	1	1	164	164
3	Km 141.3	6/10/87	Smallmouth Bass	1	0	-	-
			Flathead Catfish	1	0	Carrion	-
7	Km 130.7	6/14/87	Carp	2	2	1480	1480
	Totals for 7 gill nets:			6	4		

VERDE RIVER—FORAGING SITES

Net (gm) No.[2]	Location	Date Sampled	Species	Total # All Fish	Total # Forage Fish	Biomass (gm) All Fish	Biomass Forage Fish
2	Km 137.0	6/11/87	Carp	2	2	1505	1505
			Mud Turtle	1	1	-	-
3	Km 136.8	6/12/87	Carp	2	2	1210	1210
			Smallmouth Bass	1	1	123	123
4	Km 136.0	6/12/87	Carp	1	1	-	- [3]
			Channel Catfish	2	2	1640	1640 [4]
			Flathead Catfish	1	1	581	581
			Sucker spp.	1	1	-	- [3]
			Mud Turtle	1	1	-	-
5	Km 136.0	6/12/87	Carp	2	2	1780	1780
	Totals for 5 gill nets:			14	14		
	Adjusted totals for 7 gill nets:			20	20		

[1] Nets Nos. 1, 4, 5, and 6 were unsuccessful.
[2] Net No. 1 was unsuccessful.
[3] No weight; fish partially eaten by otter.

We sorted the data and used only fish of the minimum size suitable for eagle forage (BioSystems Analysis, Inc. 1985) to calculate the relative abundance and densities of key forage fish in each habitat type. Minimum total lengths for forage fish in this study were: carp (258 mm), green sunfish (150 mm), catfish (150 mm), smallmouth bass (181 mm) and suckers (236 mm). We determined habitat utilization of forage species by dividing the density of forage fish in each specific habitat type by the sum of fish density in all habitat types.

Electrofishing. We conducted electrofishing surveys in both the lower and upper reaches of the East Verde River. Two replicates of each habitat type were randomly selected for sampling in each study reach with one exception: only one shallow pool was sampled in the upper reach (100% of that habitat type) of the East Verde. We shocked at 23 sites in the East Verde River. Only habitats located between Km 12.0 and 20.0 in the upper reach of the East Verde River were randomized, due to the inaccessibility of habitat in Km 8.0–12.0. Habitats located between Km 0.0–5.4 in the lower reach of East Verde were also randomized. No sampling occurred in habitats located in Km 5.5–7.9 due to difficulty of access.

We measured the surface area of each habitat sampled for later estimations of fish density. The number of fish collected in one pass was used as an index of relative fish abundance and distribution. The validity of this index in accurately reflecting the fish present in the East Verde River was checked by using a multiple-pass removal method (Moran 1951, Zippin 1956) in one replicate of each habitat sampled. We calculated population estimates based on two-pass removal sampling. The regression calculated for the number of fish caught in the first pass versus the population estimates was:

$$\text{Log Population Estimate} = -0.06 + 1.25 \text{ Log Pass 1}; R^2 = 0.996$$

Over 81 percent of fish in the size category eagles forage upon were collected in the first pass. In all cases the population estimate ranged within five fish of the number collected in the first pass. Ninety-five percent confidence intervals for all the individual habitats sampled were also smaller (range: 0–5 fish). Therefore, the number of fish caught in pass one appeared to be a good indicator of the fish present in a habitat, so we considered only fish caught in the first pass in our analysis.

Total numbers and biomass of fish collected by electroshocking in the lower and upper reaches of the East Verde River are listed in Tables B4.4-16 and B4.4-17. In the upper reach (Km 8.0–20.0), native fish accounted for over 78 percent of the fish captured, and 68 percent of the biomass. Native speckled dace (50.2%) and Sonora suckers (21.1%) dominated numerically, followed by smallmouth bass (an introduced species). Sonora suckers (66.1%) and smallmouth bass (24.2%) accounted for the most biomass of all species collected in the upper reach.

Gill Netting. In each study reach of the East Verde River, two gill nets were placed overnight (approximately 12 hours) into one deep pool. Gill nets measured 80 ft long by 6 ft deep and contained four 20-foot sections of mesh size 3.5, 2.5, 1.5, and 0.5 inches. Fish collected while electroshocking, gill-netting, and seining were weighed and measured (standard and total lengths).

Results from gill netting on pools in the upper and lower reaches of the East Verde River are shown in Table B4.4-18. We found no significant difference between the total number of fish and the total number of forage fish between the two reaches (t-test, $p < 0.05$). However, species differences were observed in the gill netting data from the two reaches. In the upper reach, only Sonora suckers were collected, while on the lower reach only green sunfish, carp, largemouth bass, and smallmouth bass were collected from pools.

Table B4.4-16. Total number of fish collected during electroshocking in the lower section of the East Verde River between Km 0.1–5.3 (June 1987).

Species	Total Number Collected	Percent of Total	Total Biomass	Percent of Total
Carp	28	13.9	31,753.0	85.5
Channel Catfish	5	2.5	913.0	2.5
Flathead Catfish	5	2.5	285.0	0.8
Mosquitofish	1	0.5	0.0	0.0
Green Sunfish	2	1.0	92.0	0.2
Red Shiner	53	26.4	64.0	0.2
Smallmouth Bass	101	50.2	3,716.0	10.0
Yellow Bullhead	6	3.0	336.0	0.9
Total	201	100.0	37,159.0	100.0

Table B4.4-17. Total number of fish collected during electroshocking in the upper section of the East Verde River between Km 12.4–19.6 (June 1987).

Species	Total Number Collected	Percent of Total	Total Biomass	Percent of Total
Sonora Sucker	101	21.1	15,875.0	66.1
Roundtail Chub	1	0.2	250.0	1.0
Desert Sucker	1	0.2	119.0	0.5
Green Sunfish	3	0.6	94.0	0.4
Longfin Dace	33	6.9	61.0	0.3
Speckled Dace	240	50.2	132.0	0.6
Smallmouth Bass	64	13.4	5,819.0	24.2
Yellow Bullhead	35	7.3	1,671.0	7.0
Total	478	100.0	24,021.0	100.0

Table B4.4-18. Fish collected from gill netting pools in the lower and upper regions of the East Verde River.

LOWER EAST VERDE

Net No.	Location	Date Sampled	Species	Total No. All Fish	Total No. Forage Fish	Biomass (gm) All Fish	Biomass (gm) Forage Fish
1	Km 3.1	7/24/87	Green Sunfish	2	1	75	40
			Carp	4	4	2795	2795
			Largemouth Bass	1	1	106	106
2	Km 3.1	7/24/87	Smallmouth Bass	2	2	894	894
	Totals for 2 gill nets:			9	8	3870	3835

UPPER EAST VERDE

Net No.	Location	Date Sampled	Species	Total No. All Fish	Total No. Forage Fish	Biomass (gm) All Fish	Biomass (gm) Forage Fish
1	Km 14.1	6/27/87	Sonora Sucker	4	4	3090	3090
2	Km 14.1	6/27/87	Sonora Sucker	3	3	2640	2640
	Totals for 2 gill nets:			7	7	5730	5730

Visual Surveys. A visual survey of the lower reach of the East Verde from Km 0.2–3.2 in June 1987 agreed with the electroshocking data: carp was the most common fish, with smallmouth bass next. No suckers were observed. Several largemouth bass occurred in backwater areas of the river, and green sunfish was the only species actively spawning during the survey. We also visually surveyed the upper reach during June 1987 from Km 10.0–15.0. Smallmouth bass and suckers were abundant, followed by an occasional green sunfish. Only three carp were observed in this 5.0 Km section of the upper reach.

Bald Eagle Forage Fish in the East Verde River. The total number of forage fish collected in the habitats shocked and netted in the upper and lower reaches of the East Verde River were quite similar (72 to 62 individuals, respectively); however, the species available to eagles varied considerably. In the upper reach, electroshocking data showed that Sonora suckers (50.8%) and smallmouth bass (40.0%) were the most abundant fish in size categories appropriate for bald eagle foraging (Tables B4.4-19 and B4.4-20).

Only Sonora suckers were collected from gill netting of medium-depth pools. In the lower reach, carp (51.9%) and smallmouth bass (37.0%) were the most abundant forage fish available to bald eagles in habitats shocked. Gill-netted habitats had similar species composition.

Table B4.4-19. Total number of forage fish (for eagles) collected during electroshocking in the East Verde River between Km 12.4–19.6 (June 1987).

Species	Total Number Collected	Percent of Total	Total Biomass	Percent of Total
Sonora Sucker	33	50.8	14,328.0	70.1
Roundtail Chub	1	1.5	250.0	1.2
Desert Sucker	0	0.0	119.0	0.6
Green Sunfish	0	0.0	0.0	0.0
Longfin Dace	0	0.0	0.0	0.0
Speckled Dace	0	0.0	0.0	0.0
Smallmouth Bass	26	40.0	4,978.0	24.4
Yellow Bullhead	5	7.7	767.0	3.8
Total	65	100.0	20,442.0	100.0

A survey of sites upstream from our study area on the East Verde River was conducted in 1985 and 1987 in Km 23.0–26.0 (M. Jakle, pers. comm.). This fish community was also dominated by native fishes, namely Sonora and desert suckers (over 76% of the catch). The only introduced fish collected were green sunfish and yellow bullhead.

In contrast, our survey of the lower reach of the East Verde River (Kms 0.1–5.3) revealed a fish community composed entirely of introduced fishes. Smallmouth bass (50.2%) and red shiners (26.4%) were numerically most common in the catch, followed by carp (13.9%). In terms of biomass, carp (85.5%) and smallmouth bass (10.0%) were the major species collected in the lower reach. Gill netting of a medium-depth pool in the lower reach also yielded only introduced fish, with carp and smallmouth bass the dominant species (Table B4.4-18).

It is a common phenomenon in western streams and rivers to find different fish communities in upstream and downstream reaches, as we did in the East Verde River. Several investigators have reported introduced species replacing native fish in lower reaches (Deacon *et al.* 1964, Deacon and Bradley 1972, Holden and Irvine 1975, Cross 1978, McAda *et al.* 1980, Lanigan and Berry 1981, Cross 1985), a phenomenon frequently observed in Nevada (Deacon *et al.* 1964, Hubbs and Deacon 1964, Wilson *et al.*

Table B4.4-20. Total number of forage fish (for eagles) collected during electroshocking in the East Verde River between Km 0.1–5.3 (June 1987).

Species	Total Number Collected	Percent of Total	Total Biomass	Percent of Total
Carp	28	51.9	31,753.0	89.5
Channel Catfish	3	5.6	843.0	2.4
Flathead Catfish	1	1.9	153.0	0.4
Mosquitofish	0	0.0	0.0	0.0
Green Sunfish	1	1.9	88.0	0.2
Red Shiner	0	0.0	0.0	0.0
Smallmouth Bass	20	37.0	2,425.0	6.8
Yellow Bullhead	1	1.9	197.0	0.6
Total	54	100.0	35,459.0	100.0

1966). Lanigan and Berry (1981) found that within five years, introduced species became the dominant fish in the lower reaches of the White River in Utah where native fish had dominated. Changes in fish communities can occur rapidly once exotic fish are introduced.

Several factors may contribute to the absence of native fish in the lower reaches of the East Verde River. The absence of the native minnows there is probably the result of predation by smallmouth bass on the eggs, fry and adults. Survival of young-of-year suckers in the lower reach is also probably poor due to smallmouth bass predation. Adult suckers are possibly excluded from the lower reach through competition with carp for food and space. Moyle (1976) noted that Sacramento suckers in California are unable to maintain populations in waters dominated by introduced fishes, especially carp and goldfish.

High instream temperatures during the summer may also be a factor restricting roundtail chub and desert and Sonora suckers to the upper reach of the East Verde River. Temperatures in the lower reach during late afternoon in June and July 1987 have been recorded at over 28°C and 29°C, respectively. Temperatures in the upper reach during late afternoon in June were 23°C. Deacon and Minckley (1974) reported dying roundtail chub at 30.5°C. Siebert (1980) observed extensive seasonal movements of desert and Sonora suckers in Aravaipa Creek, Arizona in response to high water temperatures. Maximum water temperatures in the lower reaches of the Aravaipa Creek in June and July were 27.5° and 30.5°C, respectively.

Summer temperatures in the lower reach of the East Verde River are well within the preferred temperature range of both carp and smallmouth bass, which may give them a competitive advantage over

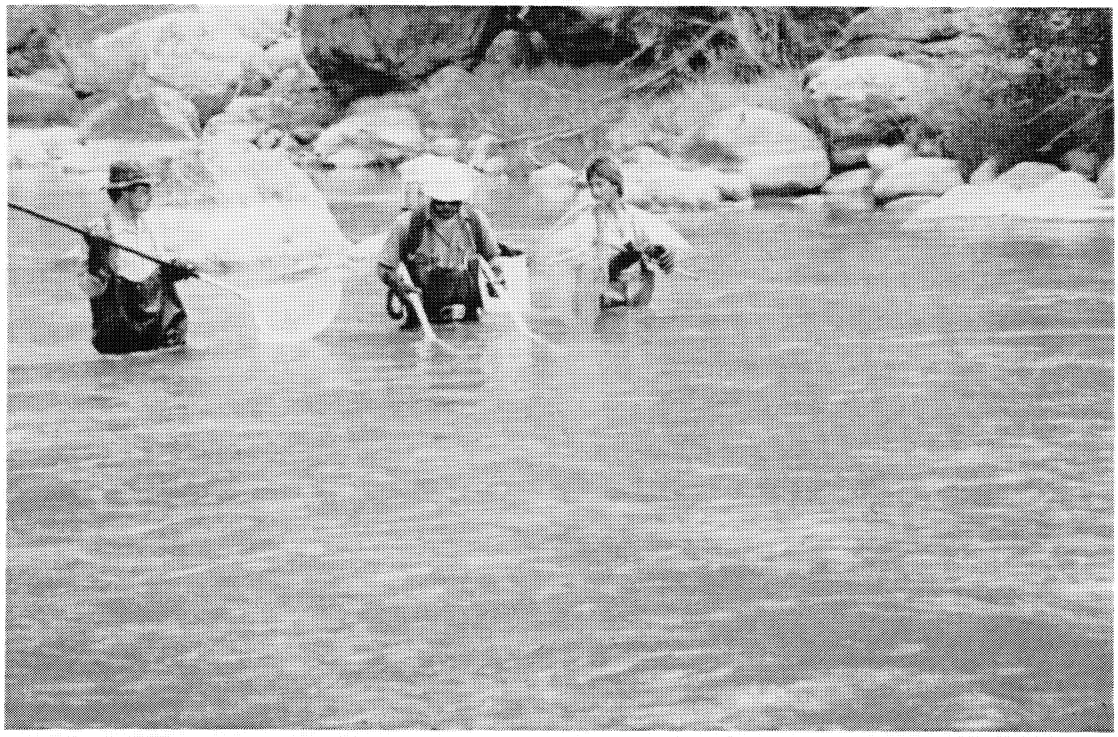


Plate B20. Ed Bianchi, Jeff Simms, and Mike Cross sampling fish at East Verde, July 1987 (photo by D. Driscoll).

the native species. Coutant (1977) reported temperature preferences of carp to range from 27.4–32.0°C. Adult smallmouth bass in the laboratory preferred temperatures of 28–31°C (Ferguson 1958, Bennet 1965, Barans and Tubbs 1973, Coutant 1975).

B4.4.3.6 Fish Distribution and Abundance in Fossil Creek. Like the East Verde River, native fishes dominated the upstream region of Fossil Creek while introduced fishes dominated its downstream reach. In July 1987, a visual survey of the lower reach of Fossil Creek from its confluence with the Verde River upstream 2.0 Km revealed only introduced fishes; smallmouth bass was the most abundant fish, followed by green sunfish. Numerous young-of-year smallmouth bass and spawning green sunfish were observed. Carp were rare, with only two individuals observed.

In the upper reach of Fossil Creek, about 12 Km upstream of the mouth, we seined and conducted a visual survey (0.5 Km in length), also in July 1987. Adult roundtail chub and Sonora and desert suckers were numerous in the survey, while smallmouth bass and green sunfish were absent. Afternoon water temperatures were approximately 3°C lower in upstream sites of Fossil Creek than in the lower reaches (25°C versus 28°C).

B4.4.3.7 Spawning Chronology in the Verde and East Verde Rivers. The spawning chronology of suckers, carp, catfish and smallmouth bass (primary eagle forage species) in the Verde and East Verde rivers during the nesting season can be estimated based on temperature conditions in the rivers and spawning requirements of each species. Based on literature reviews and data collected during this study

(see Sections E2 and E3) we anticipate that suckers spawn first as temperature warm to 14–18°C, followed by smallmouth bass (peak spawning 17–18°C), carp (peak spawning 18–24°C) and channel catfish and flathead catfish (peak spawning 22–27°C).

In the Verde River, water temperatures in April 1987 ranged from 15–17°C (n = 7) and fell within the preferred range for sucker and smallmouth bass spawning. Water temperature in May and June ranged from 18–24°C (n = 51), and conditions were thus more suitable for carp and catfish spawning.

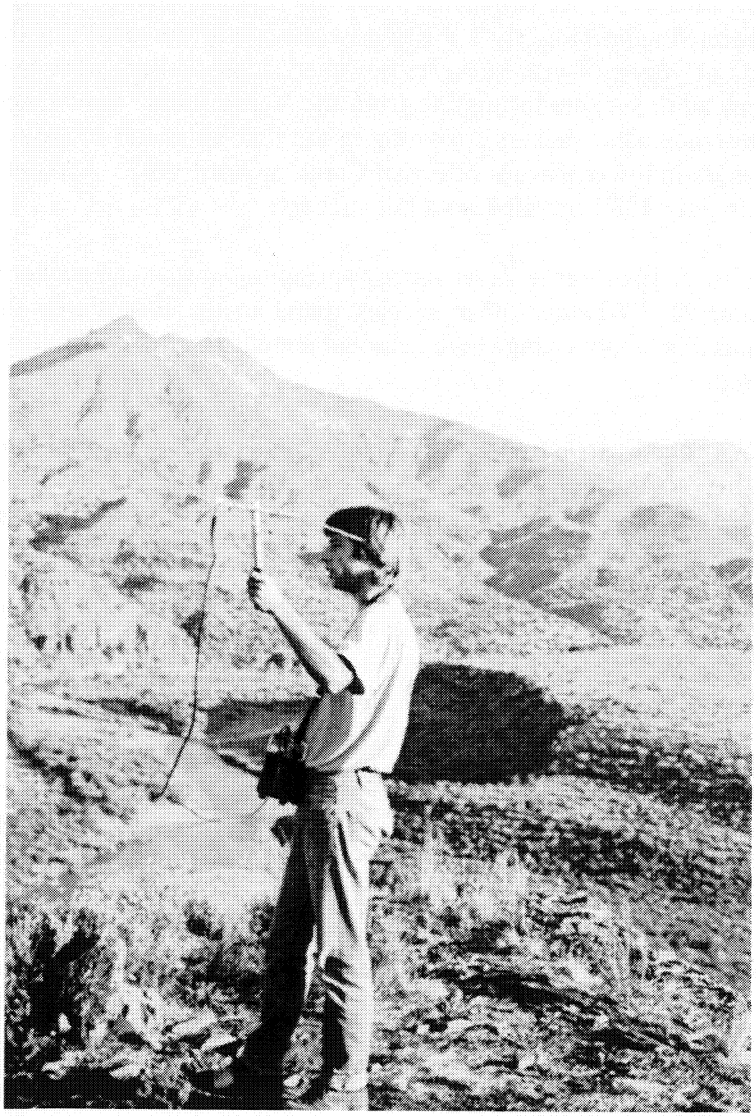


Plate B21. Mike Cross radio-tracking the East Verde male (AM02), April 1987 (photo by R. Mesta).

Range of water temperature in the East Verde River was 21–28°C in June (n = 7) and 23–28°C in July (n = 4) 1987. In 1988, water temperatures ranged from 6–12°C in February (n = 7), 15–18.5°C in April (n = 7) and 16–22°C in May (n = 3) 1988. Based on the available temperature data, we hypothesize that sucker spawning in the East Verde River probably occurred from late March to early May, while carp and catfish spawned in May–July.

B4.4.3.8 Sucker Spawning Runs from the Mainstem into Tributaries. Species composition in the tributaries in spring may differ from that measured during our summer surveys. Spring spawning runs of suckers (Sonora and desert) from the mainstem into tributaries may significantly enhance food availability for bald eagles. Actually, some evidence exists for sucker spawning runs from the Verde River its tributaries. In June 1987, we conducted visual surveys and seining in Houston Creek, a small intermittent tributary located approximately 1.9 Km downstream of the mouth of the East Verde River. We observed thousands of young-of-year suckers; however, adult suckers were absent. Higher spring flows in the creek allow adult suckers to migrate from the Verde River, spawn, then leave. In March 1987, we observed numerous adult suckers spawning in the first kilometer of Houston Creek. We also observed spawning suckers in lower reaches of Fossil Creek in April 1987. A visual survey of the lower reach of Fossil Creek in July 1987 revealed no adult suckers.

We did not survey the lower East Verde River during spring to substantiate sucker runs; however, it is plausible that they occurred. Whether other species found in the East Verde or Verde River have significant spawning runs that would change their seasonal abundance and availability in the river sections remains to be discovered.

B4.4.3.9 Carrion. We found carrion on three of eight carrion surveys on the Verde (4 surveys) and East Verde (4 surveys) rivers during spring 1987. On 19 April we found one dead and one moribund sucker on the East Verde river (ca. Km 15). On 20 April, we found one largemouth bass and one softshell turtle (mainstem), and on 31 May, one green sunfish (mainstem).

B4.4.3.10 Waterfowl. We conducted four waterfowl surveys in the nest area in April and May 1987. We saw no waterfowl on 18 April, two common mergansers on 2 May, and a family of one adult and 16 young common mergansers on 17 and 31 May.

B4.4.4 Human Impacts

The isolation of the East Verde breeding area protects the eagles from the high incidence of human disturbances characteristic of some of the less remote sites. This factor of seclusion has probably contributed to East Verde's history of being the second most productive bald eagle breeding areas in Arizona.

The most common form of public use we observed was non-motorized boating along the Verde River. Rafters, kayakers, and canoeists passed under the nest cliff. Most seemed unaware of the eagles' presence, and the eagles did not appear disturbed by the boaters. Ranching operations and light backpacker traffic also did not appear to adversely affect the eagles.

Eagles may benefit from the occasional anglers who leave large fish heads and filleted carcasses on shore; however, fish hooks left in the carcasses could potentially harm the birds. Fish hooks and monofilament have been observed in the mouths of eagles at other breeding territories in Arizona (Driscoll and Buckley 1986), and monofilament has caused mortality of at least one Arizona nestling bald eagle (see

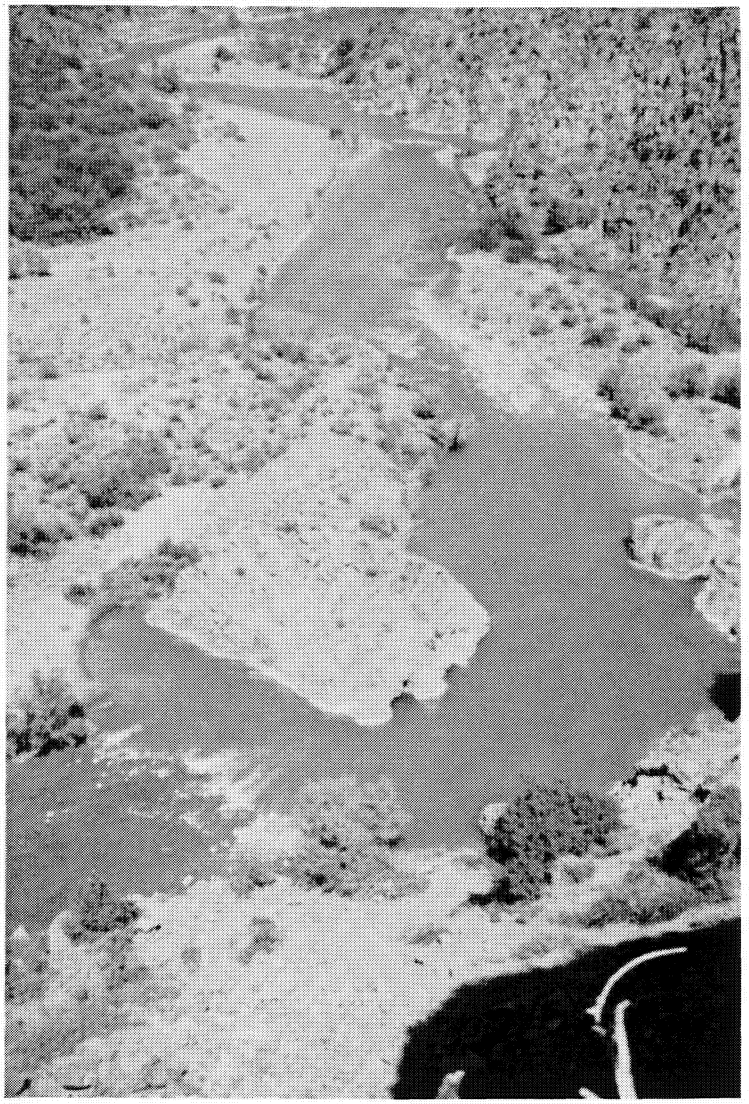


Plate B22. Verde River downstream of the East Verde nest, September 1987 (photo by D. Driscoll).

Section C3.3). Inspection of a dead common raven in the East Verde breeding area in July revealed approximately 20 cm of monofilament protruding from its bill.

We recorded fourteen public use incidents during the 1987 breeding season which involved the following: (1) Six non-motorized boats (kayaks, canoes, or rafts); (2) two anglers on foot; (3) four helicopters; and, (4) two fixed-wing airplanes. Both fishing events, two canoes, the one airplane, and the helicopter caused the eagle to flush. Six incidents took place within the nest area with two (a helicopter and an airplane) causing an eagle to flush. Two of the events in the nest area occurred on 7 and 8 March when the chick was less than two weeks old. The five aircraft incidents were noted as follows:

1. On 5 April, a small fixed-wing airplane flew over the nest area at about 1000 ft above ground level (AGL). This caused the female bald eagle to leave the nest and fly toward the plane while vocalizing.

2. On 30 April, a fixed-wing airplane passed through the nest area at nest elevation and made a second pass very near the observation blind. Both adults vocalized extensively during this disturbance.

3. On 13 May at 1643 hr, a law enforcement helicopter nearly collided with the soaring adult female who dove to evade the aircraft. The same helicopter made a second pass by the female two minutes later. Both passes occurred at less than 750 ft AGL.

4. On 14 May between 1702 and 1709 hr, this same helicopter made several low level passes by the nest. Both adults vocalized extensively. The male left his perch to circle the nest area with his feet down in a defensive posture.

5. On 15 and 16 May, helicopter N310AZ again approached the nest area. On the latter date, it landed within the wilderness boundary, 300 m from the nest.

B4.4.5 Discussion

During the 1987 nesting season the radio-tagged adult male AM02 foraged along 19 Km of the Verde River, 20 Km of the East Verde River, and on 4 Km of Fossil Creek. There were distinct seasonal shifts in AM02's use of habitat. The pair took suckers from the East Verde River during April, presumably when suckers were spawning there. The East Verde River may have been especially important during periods of high flow and turbidity on the Verde mainstem, when the East Verde ran clear. After the first week in May, the male no longer foraged on the East Verde River.

During the middle portion of the chick cycle, AM02 favored the area downstream of the nest. Both he and the female frequented the super-riffle areas in Kms 127.5–128.1 between the mouth of Houston Creek and the river bend around Km 126.8. During the latter part of the nesting season, AM02 increased his visits to the river section upstream of the nest, and by the end of May, 83 percent of his visitations and 85 percent of his observed forages occurred in the upstream reach, especially in the super-riffle area just downriver of the mouth of Fossil Creek.

Forty-five percent of AM02's 114 forages occurred on the East Verde River during the first monitoring session. Foraging declined there, and we have no records after 12 May. Only two forages were recorded on Fossil Creek during the entire season. Forages downriver of the nest made up 33 percent of all forages during the first session, increased to 50 percent of the forages between 28 April and 7 May, then decreased during the last session. Forages on the Verde River upriver of the nest began 14 April and increased to 85 percent of all forages during the final tracking period.

This movement from heavy visitation of tributaries, to use of downstream sections of the river, and then to high use of upriver portions of the Verde River likely reflects changes in occurrence, visibility, and susceptibility to capture of prey fish. Data on the distribution of AM02's foraging, shown in Table B4.4-8 and are reflective of the data on visitation given above (see Figure B4.4-5).

Also in support of the hypothesis that shifts in the geography of home range use were related to prey availability are data from observations of prey deliveries and foraging. These showed a diet mainly of

Plate B23. East Verde eaglet (JL20) at 9 weeks of age, April 1987 (photo by R. Mesta).

live fish: carp were the principal prey, both numerically and in terms of biomass, followed by suckers and flathead catfish. Several other taxa, all exotics, were identified, including channel catfish, largemouth bass, smallmouth bass, and green sunfish, but the contributions of each of these to biomass were relatively small compared to carp, suckers, and flathead catfish. The eagles used carp and flathead catfish significantly in both the early and late periods of the nesting cycle, but 11 of 12 suckers delivered to the nest appeared before 8 May, suggesting that the availability of suckers peaked during spawning as we have found to be the case in other territories.

B4.4.5.1 Significance of the East Verde River. Our telemetry and food habits data suggest that during April, and possibly earlier, the East Verde River is an important foraging area for bald eagles. Nine of

12 suckers brought to the nest by the eagles originated in the East Verde River; one was taken on the mainstem, and two from unknown locations. Six carp, one flathead catfish, one smallmouth bass, and two unidentified fish were also taken on the East Verde River. These prey items represent 27 percent (12,826 grams) of the total observed biomass of prey brought to the nest by AM02 (47,503 grams). Such a figure is significant in view of the fact that the adult male and possibly also his mate did not appear to visit the East Verde after the first week in May. The fisheries resources of the East Verde River thus appear seasonally important to the success of the pair. We suspect that the main reason for this is that high springtime flows and turbidity in the Verde River render it less suitable for eagle foraging than the clear-water habitats of the East Verde River where suckers may concentrate during spawning.

Our fisheries data show that suckers are common and carp are rare in the East Verde River above Km 10, while downstream the opposite condition occurs. This difference in distribution may be a result of temperature differences between the reaches or it may be caused by the interaction between suckers and introduced species of fish.

Specific impacts of reduced flows in the East Verde River cannot be addressed at this time, given the lack of information on temperature requirements or competitive capability of the native suckers. Higher instream temperatures might be expected with reduced flows which might make habitat more favorable for smallmouth bass and carp. If these introduced species increased in abundance, they might inhibit sucker reproduction and/or exclude adult suckers from the area. High temperatures alone may decrease habitat suitability for suckers, and force them further upstream, potentially beyond the foraging range of the eagles. Reduced flows may decrease the suitability of sucker spawning habitat in the upper reach, leading to a reduction in reproductive success of suckers or a change in the distribution of spawning areas. Lower flows might also reduce sucker habitat (adult, juvenile, or fry) during non-spawning periods; the result would be smaller sucker populations. If suckers are simply replaced by equivalent numbers of carp in appropriate size categories for bald eagle foraging, there may be no impact on eagle foraging opportunities on the East Verde. This would not be the case if flow reductions lower the numbers of appropriately-sized suckers *and* carp.

Our data can not demonstrate whether prey availability in the East Verde River is essential to the reproductive success of the breeding pair. We can only observe that the East Verde River, which provided 23.4 percent of the prey biomass in recorded deliveries to the nest in 1987 and 43 percent of the prey items during April (29 March to 25 April), currently acts to enrich the forage base for the East Verde pair.

B4.4.6 Management Recommendations

The East Verde pair sometimes uses nest trees along the river and are vulnerable to potentially damaging disturbance from river boaters. In the event of a tree nesting, ABENWP personnel should be present from the time of egg-laying to increase the chances for nesting success.

B4.5 HORSESHOE BREEDING AREA

The Horseshoe bald eagle breeding area is situated on the Verde River at Horseshoe Reservoir about 72 km north of Phoenix (Figure B4.5-1). The habitat setting differs strikingly from those at Bartlett and Blue Point (also located near reservoirs) in being fed by a free-flowing, rather than a regulated river. Variation in flows in the Verde River, entering Horseshoe Reservoir near the eagles' nest location, are a function of rainfall, snowpack, and natural hydrologic factors, rather than dam operations. The river may seasonally transport large amounts of materials into the reservoir, and the resulting turbidity in both the river and the reservoir may render fish less visible to eagles. However, the organic components coming into the reservoir provide for rich primary and secondary productivity which supports fish, waterfowl, and ultimately eagles. The reservoir is relatively shallow, a factor which probably increases nutrient recycling during turnover. Moreover, the reservoir is periodically drained, becoming riverine in character, which allows vegetation to develop along the dewatered shoreline. This growth not only contributes to nutrient recycling but also provides cover and habitat for juvenile fishes. Temperatures in the river are generally warmer in spring and summer, and possibly colder in winter than regulated river reaches in central Arizona, a factor which may significantly affect the relative abundance and spawning chronologies of fish species important to eagles.

These and other factors render the Horseshoe territory a significant study area where the ecology of the eagles can be compared with those occupying other areas. The results obtained at Horseshoe are in some ways similar to those obtained at the Pinal/Pinto breeding territory where eagles share some of the same kinds of habitat features, but contrast sharply with those acquired at Bartlett and Blue Point whose regulated river/reservoir habitats are different in nature.

During the 1987 and 1988 breeding seasons when we studied the Horseshoe eagles, reservoir elevations were moderately high, and habitat under the nest cliff was mainly lacustrine. However, in various other years, e.g., 1989 and 1990, the reservoir was drained of water, and habitats became entirely riverine in the nest vicinity and throughout the breeding area. The information contained in this section, therefore, describes the ecology of the Horseshoe bald eagles in only one of several states exhibited by this changeable habitat setting.

Horseshoe is within the Lower Sonoran Life Zone (C. H. Merriam 1890, 1898; in Lowe 1964), and surrounding habitat is of the Sonoran Desertscrub Biome, containing species of the Paloverde-Cacti-Mixed Scrub Series and the Creosotebush-Crucifixion-thorn Series (Brown and Lowe 1980, Brown 1982). The riparian habitat is a mixture of the Sonoran Riparian Deciduous Forest and Woodlands Biome, and the Sonoran Riparian Scrubland Biome (see Section D2).

The Verde River upstream of Horseshoe Reservoir meanders through an area alternately bounded by small promontory cliffs, with cottonwoods and willows growing on the opposite bank. Some emergent vegetation occurs along the shallows of the more open shorelines. The river flows past large cottonwoods and willows with emergent vegetation along the east bank, and the hard-snag remains of old nest trees to the west, before turning along the large promontory cliff of Chalk Mountain. This area is lacustrine at high reservoir elevations and contains riffles (including super-riffles) when the reservoir is low. One large willow stands alone where the river turns south to the main body of the reservoir.

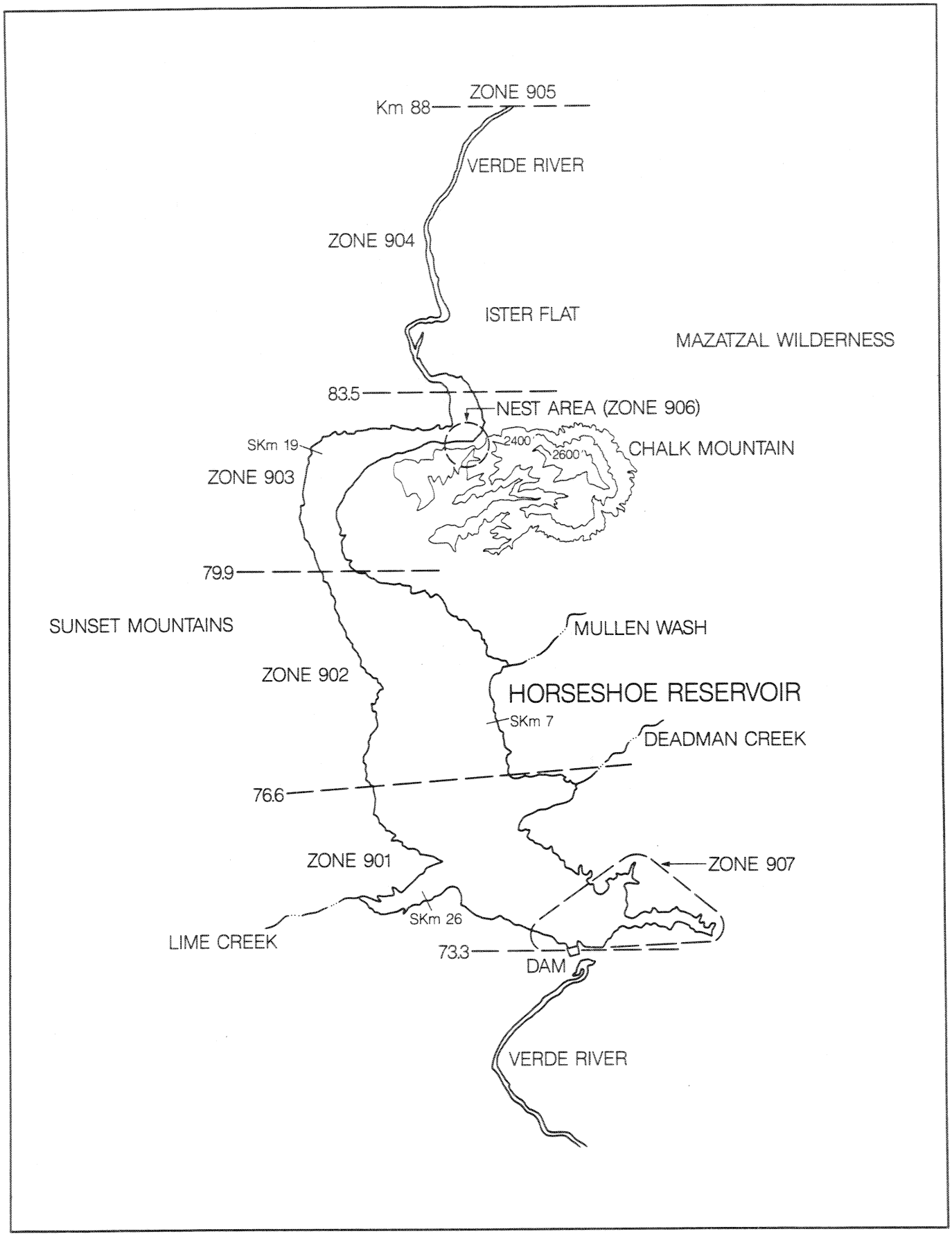


Figure B4.5-1. Horseshoe bald eagle breeding area.

Plate B24. Inflow area of Horseshoe Reservoir (facing south-downstream) during low water (riverine) conditions, February 1989 (photo by D. Driscoll). Box indicates area shown in lower photo.

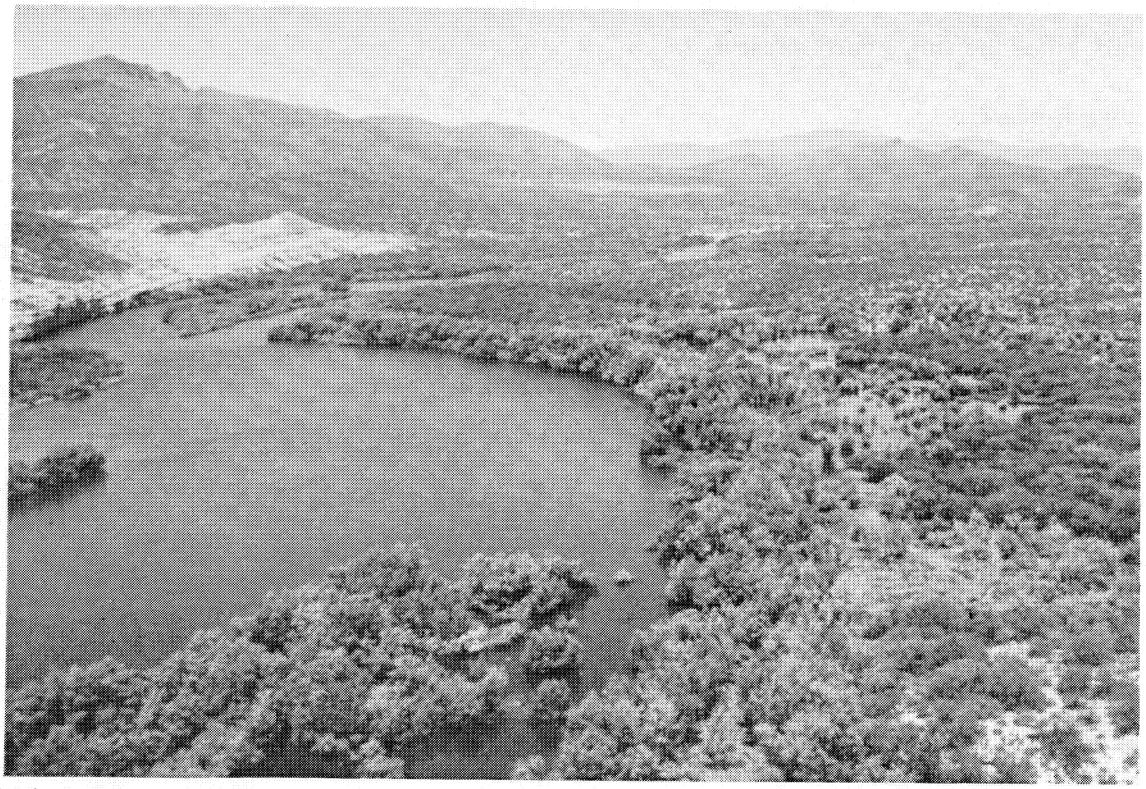


Plate B25. Inflow area of Horseshoe Reservoir (facing north-upstream) during high water levels, May 1991.

As mentioned, Horseshoe Reservoir varies from being only a river channel during many summers to a substantial reservoir in many winters and springs. The reservoir contains some small willow and mesquite snags scattered in coves and along the east shore, although at high reservoir elevations these are inundated. Emergent vegetation, grasses, and cocklebur proliferate at low levels, and waterfowl abound in winter. When the reservoir is full, largemouth bass attract fishermen to the area. Much of the reservoir is devoid of bald eagle perching habitat, with open country to the east and west. However, the reservoir contains four large coves which fill with windblown wood debris at high water levels, forming massive log jams at the base of drowned mesquite snags. Debris is frequently deposited elsewhere along the reservoir shoreline and in backwater areas upstream from Chalk Mountain, where numerous snag perches occur.

Below Horseshoe dam, near the southern edge of the eagles' home range, a single line of cottonwoods grow along the regulated river, with promontory cliffs giving way to open bottomland. A large mesquite bosque containing a campground exists downstream of the dam. The river is braided in this section and supports some emergent vegetation with isolated cottonwoods.

History of Reproduction

The Horseshoe breeding area, found in 1975, currently contains two cliff nests and one tree nest, all located on Horseshoe Reservoir. The nesting territory has been occupied since its discovery and active all years except 1981. The Horseshoe adults, plagued by tree nest inundation due to fluctuating reservoir levels, have laid at least 28 eggs since 1975 and fledged 13 young. An additional four nestlings, two fostered into the Ladders breeding area in 1982, and two into Chino in 1986, also fledged successfully. See Section D4.15 for details on annual productivity and mortality at Horseshoe. During our study, the Horseshoe pair fledged three young in 1987 and one in 1988, but none in 1989 when a great-horned owl apparently killed the single chick present.

Horseshoe Reservoir

In 1946, Phelps-Dodge Copper Products Corporation constructed Horseshoe Dam under a water exchange agreement with the Salt River Valley Water User's Association. Hydraulic height of this structure is 142 ft, and the resulting reservoir has a surface area of 2,720 acres and a total capacity of 139,238 acre-feet. Between 1946 and 1977, annual inflow into this reservoir averaged 342,000 acre-feet. The spillway consists of a concrete-lined channel with radial gates and a flow capacity of 250,000 cfs.

Mean water elevations at the reservoir were similar for 1987 and 1988 (Figure B4.5-2). Annual mean elevation in 1987 was 2002 ft, and was slightly lower in 1988 at 1996 ft. The range in elevations in 1987 varied from 1,967 ft in October to 2,026 ft in May. In 1988, water levels ranged from 1,960 ft in December to 2,025 ft in May. Mean elevation for the first six months of 1989 was much lower than the previous years at 1963 ft; minimum height averaged 1,959 ft in May (66 ft less than in 1987 and 1988) and the maximum was 1,973 ft in February. In 1989, the reservoir was almost completely drained, causing reservoir habitat to be replaced by riverine habitat.

Verde River

Average annual flow in the Verde River above Horseshoe Reservoir (at Tangle Creek) in 1987 was 538 cfs while slightly higher flows occurred in 1988 (555 cfs). Mean monthly flows for 1987 varied

from a low of 121 cfs in July to a high of 2,177 cfs in March (Figure B4.5-3). In 1988, mean monthly flow ranged from 147 cfs in June to 1892 cfs in April. Flow was much lower in 1989 with a mean monthly flow of 238 cfs for the first six months. The range in mean monthly flow in 1989 varied from 114 cfs in June to only 428 cfs in February. Mean monthly flow in 1987 and 1988 generally increased over the first half of the year reaching a peak in the spring (Figure B4.5-3). In 1987, flows were highest in March at 2177 cfs. In 1988, two distinct periods of high flow were evident in February (1489 cfs), followed by the highest peak for the year in April (1892 cfs). Flow in 1989 was much lower, with a peak of only 435 cfs in March.

Water Projects

Safety of Dams (SOD) modifications will be required at Horseshoe Dam. The modifications will include either a fuse plug spillway or a labyrinth spillway, along with other structural reinforcements (U.S. Bureau of Reclamation 1989c, 1990, U.S. Fish and Wildlife Service 1989b). These alternatives appear equivalent in terms of possible effects on eagles in Horseshoe territory, since construction activity, borrow areas, and changes in reservoir levels are similar for both.

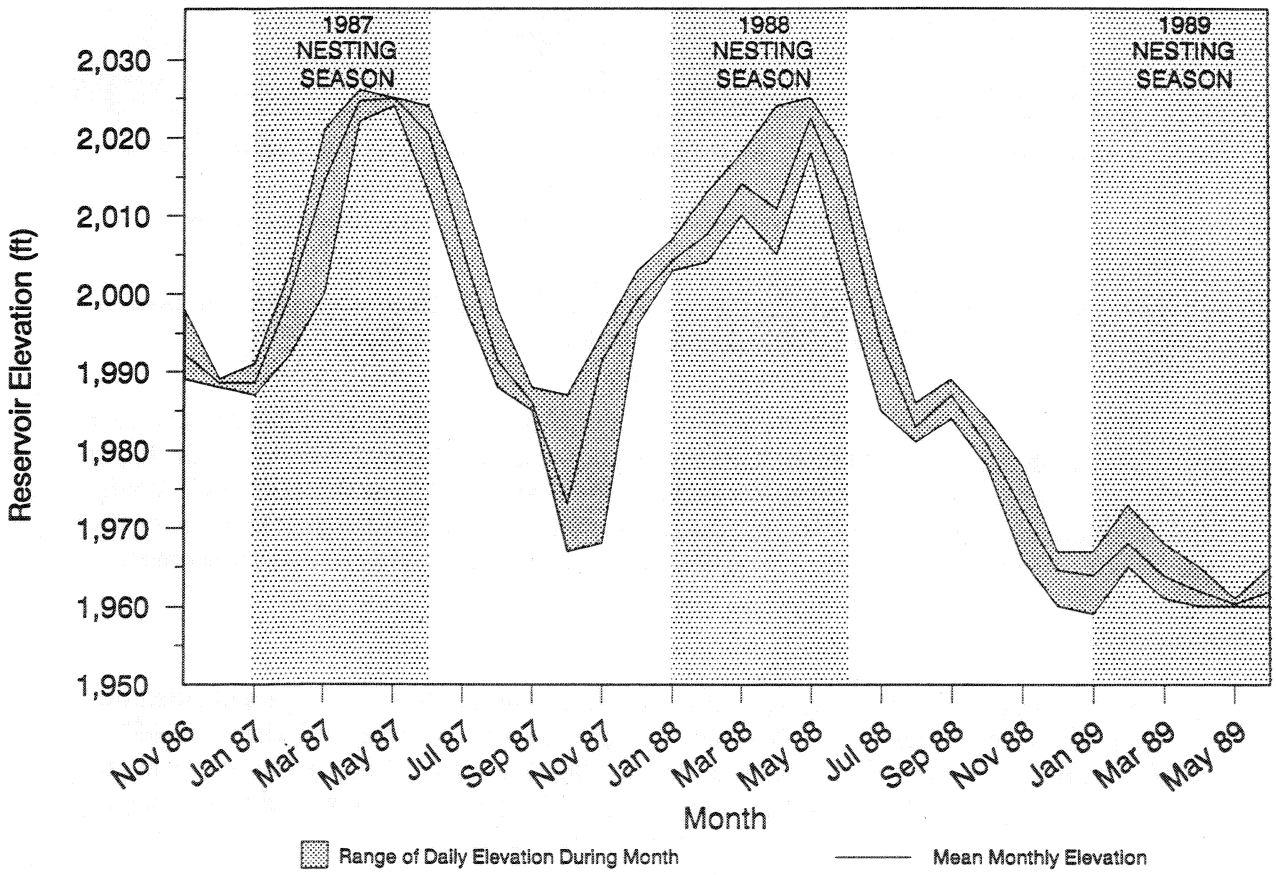


Figure B4.5-2. Mean monthly elevation (MSL) and range of daily elevations in Horseshoe Reservoir from November 1986–June 1989.

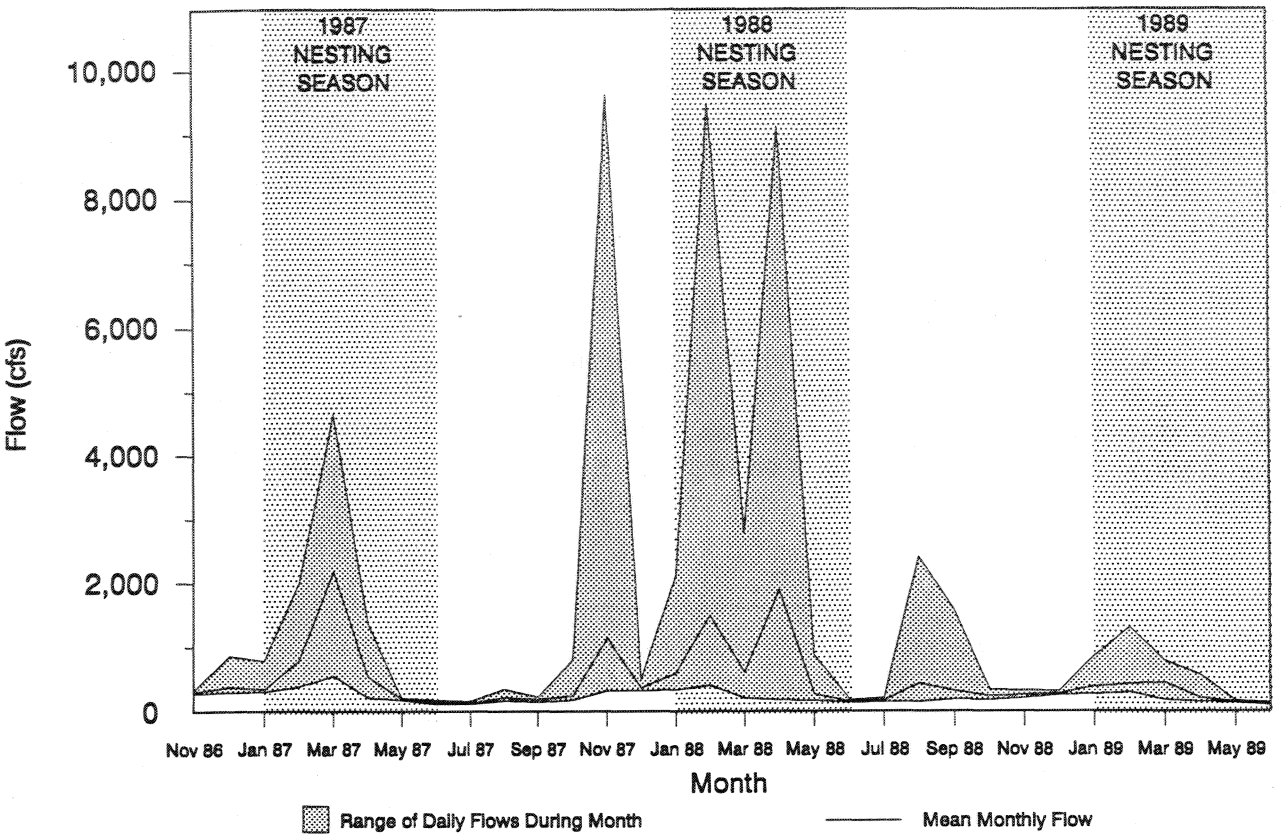


Figure B4.5-3. Mean monthly flows and range of daily flow in the Verde River at Tangle Creek from November 1986–May 1989. Flows measured at USGS Gaging Station located at river kilometer 90.

The possibility of impacts to eagles from construction at Horseshoe Dam is probably minimal because the nest area is at the opposite end of the reservoir from the dam. Water diversions on the upper Verde River and East Verde River (described in Sections B4.3 and B4.4, Ladders and East Verde) might conceivably affect the Horseshoe eagles, but accretion in the considerable distance between the diversions and the reservoir may buffer the loss in flow insofar as its effects on prey fish are concerned.

Schedule of Study

We captured the adult female bald eagle, AF02, at the Horseshoe breeding area and fitted her with a radio transmitter on 30 March 1987. We obtained data on her movements during the 1987 breeding season, but did not use a full tracking team to do so. On 13 January 1988 we captured and tagged her mate, AM03, and began the 1988 tracking operations on 19 January. We obtained more comprehensive data on movements during 1988 when both birds were telemetered.

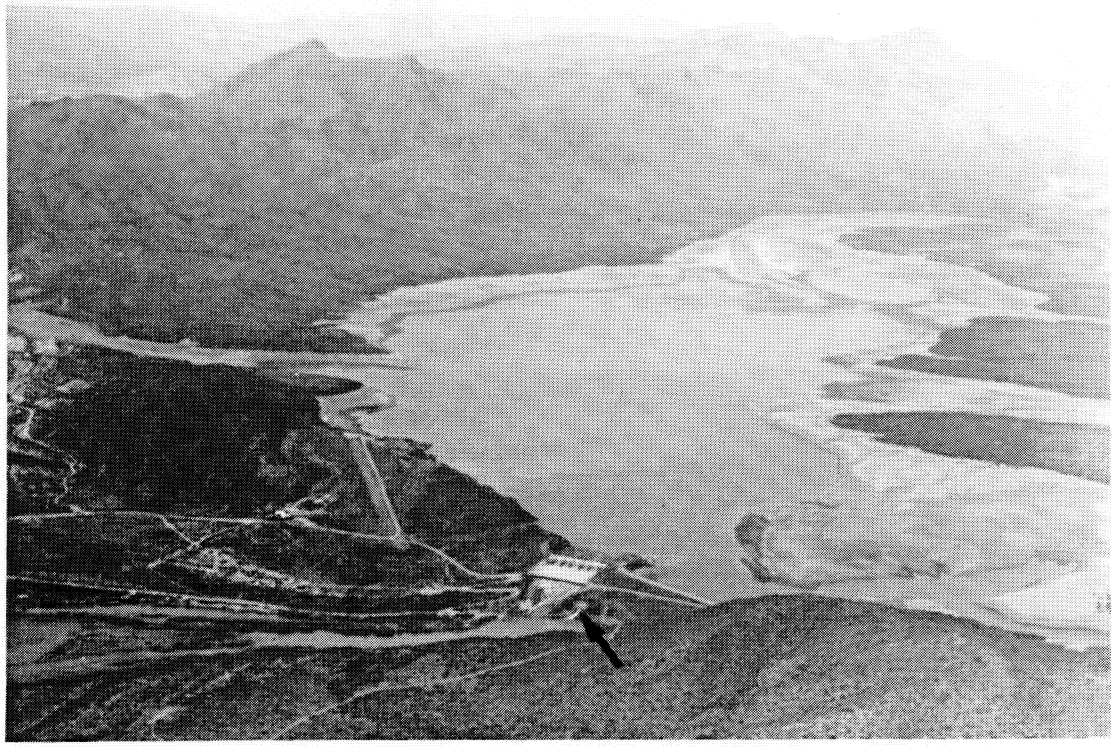


Plate B26. Horseshoe Dam and Reservoir. Note that Horseshoe is a shallow basin. The tunnel (arrow) releases water into the Verde River, February 1989 (photo by D. Driscoll).

We usually used two boats for radio-tracking, positioning them in strategic positions within the study area to provide maximum coverage of each bird's daily activities. The technicians used hand-held radios to maintain communications and coordination of efforts. We tracked the eagles during six study periods in 1988: 19–28 January, 16–25 February, 15–22 March, 26 April–5 May, 10–19 May, and 25 May–2 June.

In 1988 we established a nest observation point on Chalk Mountain, approximately 300 m upstream and about 2 m above nest level. This enabled identification of prey delivered to the nest, though with more difficulty than at other territories with closer and more elevated vantage points. The single juvenile, (J035), fledged successfully on 2 June 1988, at which time we discontinued intensive tracking of the adult eagles.

B4.5.1 Home Range

During the 1987 and 1988 breeding seasons, we recorded AF02 perching from Km 71 to Km 87 on the Verde River, a total of 16 river Kms. Her home range encompassed the whole of Horseshoe Reservoir and river sections both downstream and upstream of the reservoir (Figure B4.5-4). AM03 had a slightly smaller home range (see Section A3.4). During 1988, we observed him perched from Km 73 to Km 87, a total of 14 river Km (see Figure B4.5-4).

Differences in home range use by AF02 and AM03 shown in Figure B4.5-4 illustrate the well known contrasting roles of the raptor sexes during the chick cycle (see Ferrer 1990). The female remained (and foraged) within nest vicinity slightly more so than the male who perched far more frequently in other

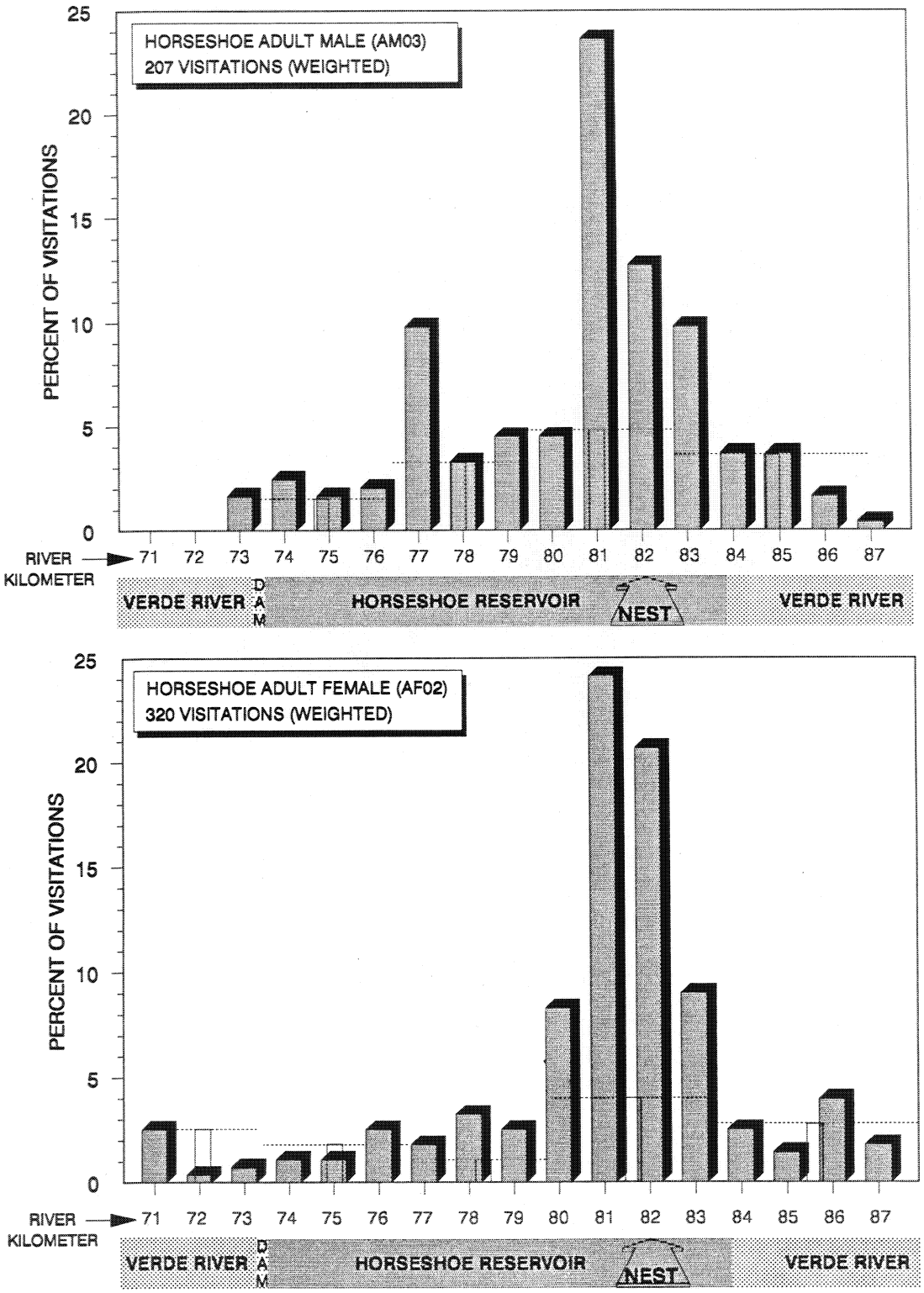


Figure B4.5-4. The home range of the adult telemetered male (AM03) and female (AF02) at the Horseshoe territory during 1987 (female only) and 1988.

parts of the territory. However, the average airline distance of travel from the nest to perch or forage was quite similar among the pair. The male traveled a mean distance of 2.0 km in the weighed sample of visitations while the female's average range was 1.9 km. The female foraged more in the immediate vicinity of the nest than did the male.

Away from the nest their visitations were mainly distributed along Horseshoe Reservoir (ca. 85% of total visitations for both adults) and along the Verde River upstream of the nest. Perches within view of shallow water, though mostly low, were distributed along much of Horseshoe Reservoir. We observed the Horseshoe pair perching along nearly all of the reservoir shoreline except near the dam (Figures B4.5-5 and B4.5-6). AM03 frequented Km 77 where low snags lined the west shore of the reservoir and the water was somewhat shallow; he also perched in and around Mullen wash cove. AM03 and AF02 traveled 4 and 5 Km, respectively, to perch on the river upstream of the nest; the female occasionally visited the area just downstream of the dam, an area within the home range of another eagle pair (Cliff).

B4.5.1.1 Soaring Range. AF02 generally soared over land within the endpoints of her home range as established with telemetry. She occasionally soared over Sunset Mountains, Chalk Mountain, and several Km upstream of the nest. AM03 followed a similar pattern except that he usually travelled further from the nest area; he sometimes soared downstream to Km 71.5 and upstream as far as Km 90. These extended flights were apparently territorial rather than forage-related.

B4.5.2 Foraging Studies

Topographical and logistical conditions at Horseshoe Reservoir enabled us to effectively track the movements and foraging activity of the adult eagles; however, because observation distances were great, including those at the nest, we had a relatively larger proportion of unidentified items in the prey data.

B4.5.2.1 Prey Selection. The prey species taken by the Horseshoe female (AF02) and identified while radio-tracking in 1987 appear in Table B4.5-1. Not included in the table are four prey items incidentally noted for the Horseshoe male, AM03 (then un-radioed) including a black crappie (424 g) taken on 16 May, 1987. The low number of prey items reflects the difficulties identifying species while radio tracking without an observer at the nest.

A more accurate picture of prey selection at the Horseshoe site appears in Table B4.5-2 (AF02) and Table B4.5-3 (AM03). During the winter months of 1988, the Horseshoe eagles utilized some waterfowl (coot, grebe) but also took carp and catfish. In our nest observations from April to June, we noted that AF02 delivered fish primarily (91% of biomass delivered). She captured mostly black crappie (36% of biomass), channel catfish (16%), and carp (16%). AF02 also delivered two flathead catfish and two largemouth bass. Biomass contributions of the two adults were nearly identical for the observation period. The female brought in 26 prey items estimated at 7,646 g biomass; the male brought in 22 items representing 7,655 grams. AM03 delivered mostly crappie (n = 10); however, six delivered carp accounted for the majority (52%) of the biomass. We recorded only one catfish in the male's nest deliveries and three largemouth bass. All prey items brought in by the male were fish. We observed one unknown mammal delivered by the female. The prey items identified by remains collected in the Horseshoe nesting area are found in Section B5.1.5.

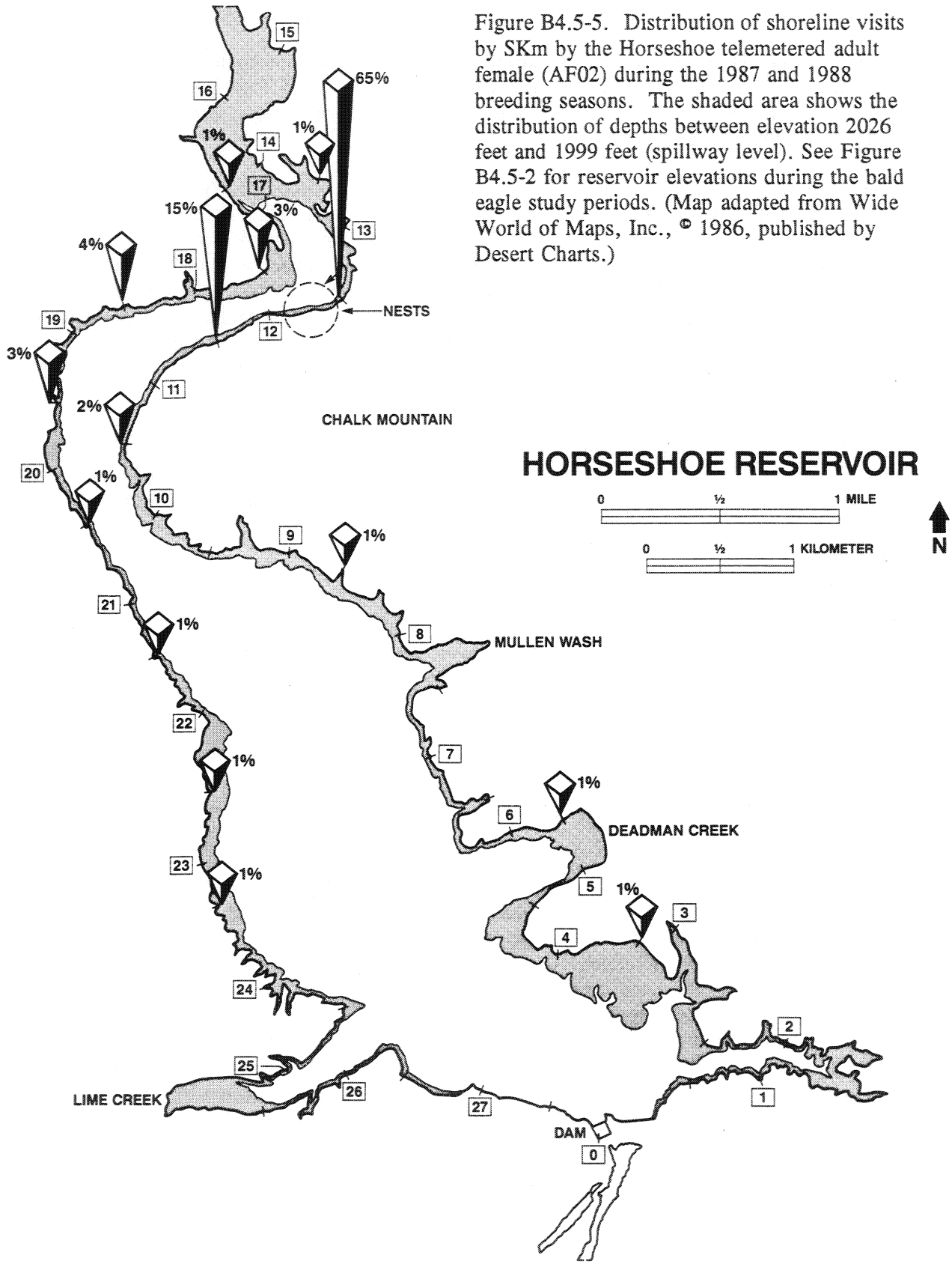


Figure B4.5-5. Distribution of shoreline visits by SKm by the Horseshoe telemetered adult female (AF02) during the 1987 and 1988 breeding seasons. The shaded area shows the distribution of depths between elevation 2026 feet and 1999 feet (spillway level). See Figure B4.5-2 for reservoir elevations during the bald eagle study periods. (Map adapted from Wide World of Maps, Inc., © 1986, published by Desert Charts.)

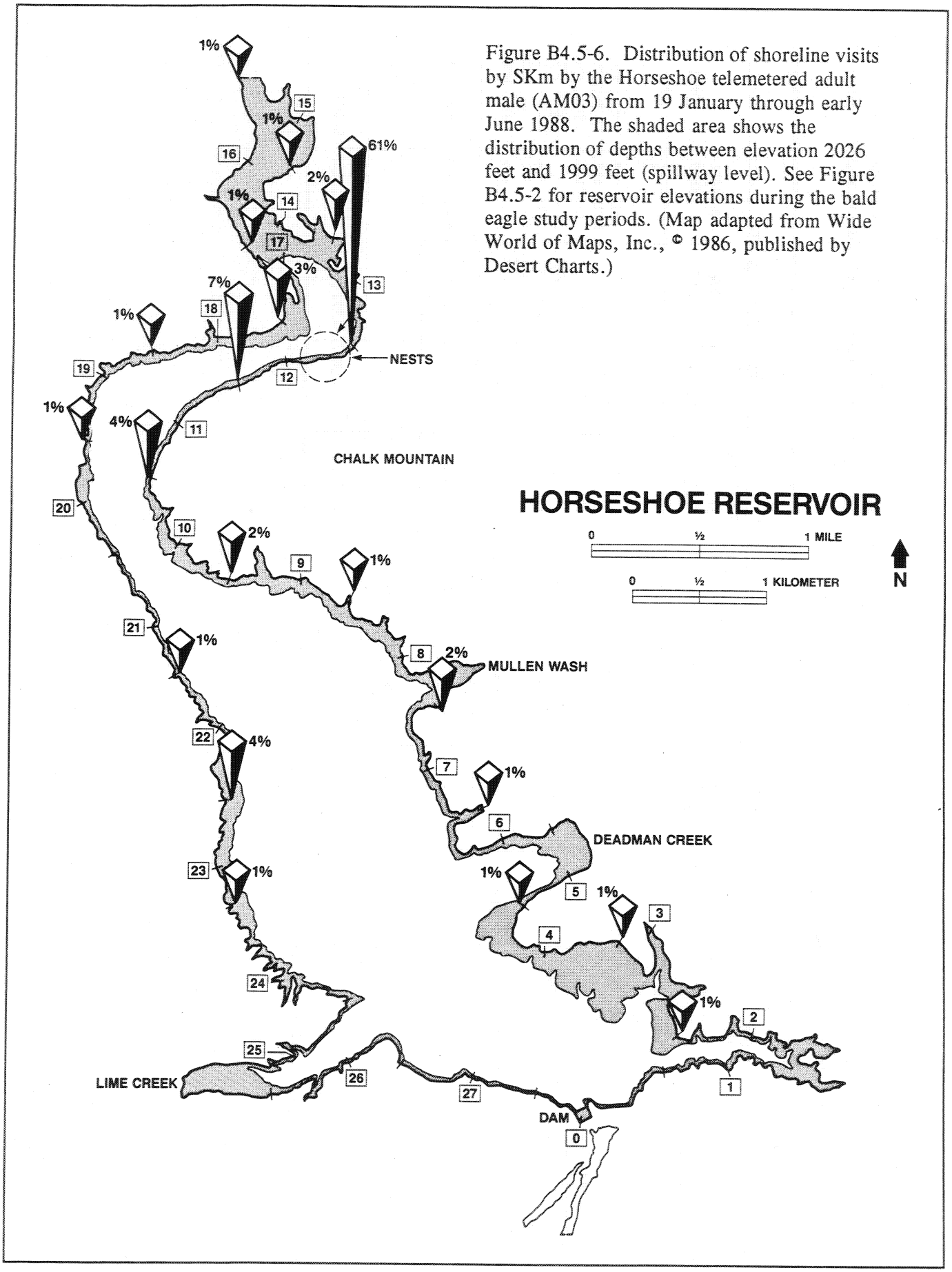


Figure B4.5-6. Distribution of shoreline visits by SKm by the Horseshoe telemetered adult male (AM03) from 19 January through early June 1988. The shaded area shows the distribution of depths between elevation 2026 feet and 1999 feet (spillway level). See Figure B4.5-2 for reservoir elevations during the bald eagle study periods. (Map adapted from Wide World of Maps, Inc., © 1986, published by Desert Charts.)

Table B4.5-1. Prey taken by the female bald eagle (AF02) from Horseshoe breeding area in 1987. Column A indicates number of prey from observed forages. Column B gives estimated whole biomass (grams) of all prey items shown in A. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals					B. Whole Biomass (grams)				
	28-Day Period:					28-Day Period:				
Species	3/01/87–3/28/87	3/29/87–4/25/87	4/26/87–5/23/87	5/24/87–6/20/87	Total	3/01/87–3/28/87	3/29/87–4/25/87	4/26/87–5/23/87	5/24/87–6/20/87	Total
Fish Species										
Carp				1 7%	1 3%				462 6%	462 3%
Flathead Catfish				1 7%	1 3%				3,420 42%	3,420 25%
Channel Catfish				2 14%	2 7%				860 10%	860 6%
Unknown Catfish	1 50%		2 18%		3 10%	151 32%		485 12%		636 5%
Black Crappie			2 18%	1 7%	3 10%			915 22%	324 4%	1,239 9%
Threadfin Shad			1 9%		1 3%			16 0%		16 0%
Unknown Fish	1 50%	2 100%	2 18%	5 36%	10 34%	167 68%	889 100%	888 22%	1,392 17%	3,336 25%
Subtotal	2 100%	2 100%	7 64%	10 71%	21 72%	318 100%	889 100%	2,304 57%	6,458 79%	9,969 74%
Unidentified Carrion			4 36%	4 29%	8 28%			1,768 43%	1,768 21%	3,536 26%
TOTAL	**2 100%**	**2 100%**	**11 100%**	**14 100%**	**29 100%**	**318 100%**	**889 100%**	**4,072 100%**	**8,226 100%**	**13,505 100%**

Table B4.5-2. Prey taken and prey delivered to nest by the female bald eagle (AF02) from Horseshoe breeding area in 1988. Column A indicates number of prey from observed forages plus prey deliveries to the nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals						B. Whole Biomass (grams)					
	28-Day Period:						28-Day Period:					
Species	1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	4/24/88–5/21/88	5/22/88–6/18/88	Total	1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	4/24/88–5/21/88	5/22/88–6/18/88	Total
Fish Species												
Carp		1 13%		2 8%	4 33%	7 14%		534 12%		1,423 16%	1,939 40%	3,896 20%
Flathead Catfish		1 13%		2 8%		3 6%		2,017 43%		337 4%		2,354 12%
Channel Catfish		2 25%	1 50%	2 8%	2 17%	7 14%		315 7%	381 53%	235 3%	951 19%	1,882 10%
Black Crappie				14 54%	2 17%	16 33%				5,138 58%	751 15%	5,889 30%
Largemouth Bass					2 17%	2 4%					480 10%	480 2%
Unknown Bass				1 4%		1 2%				167 2%		167 1%
Unknown Fish		3 38%	1 50%	3 12%	2 17%	9 18%		1,332 29%	343 47%	786 9%	783 16%	3,244 16%
Subtotal		7 88%	2 100%	24 92%	12 100%	45 92%		4,198 90%	724 100%	8,086 92%	4,904 100%	17,912 91%
Other Species												
Coot	1 100%					1 2%	642 100%					642 3%
Unknown Mammal				1 4%		1 2%				281 3%		281 1%
Subtotal	1 100%			1 4%		2 4%	642 100%			281 3%		923 5%
Unidentified Carrion		1 13%		1 4%		2 4%		442 10%		442 5%		884 4%
TOTAL	**1 100%**	**8 100%**	**2 100%**	**26 100%**	**12 100%**	**49 100%**	**642 100%**	**4,640 100%**	**724 100%**	**8,809 100%**	**4,904 100%**	**19,719 100%**

Table B4.5-2. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	4/24/88–5/21/88	5/22/88–6/18/88	Total
Fish Species						
Carp				297 *(1) 8%	939 (2) 24%	1,236 (3) 16%
Flathead Catfish				337 (2) 9%		337 (2) 4%
Channel Catfish				235 (2) 6%	951 (2) 24%	1,186 (4) 16%
Black Crappie				1,999 (7) 53%	751 (2) 19%	2,750 (9) 36%
Largemouth Bass					480 (2) 12%	480 (2) 6%
Unknown Bass				167 (1) 4%		167 (1) 2%
Unknown Fish				15 (1) 0%	783 (2) 20%	798 (3) 10%
Subtotal				3,050 (14) 82%	3,904 (10) 100%	6,954 (24) 91%
Other Species						
Coot						
Unknown Mammal				281 (1) 8%		281 (1) 4%
Subtotal				281 (1) 8%		281 (1) 4%
Unidentified Carrion				411 (1) 11%		411 (1) 5%
TOTAL				**3,742 (16) 100%**	**3,904 (10) 100%**	**7,646 (26) 100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

Table B4.5-3. Prey taken and prey delivered to nest by the male bald eagle (AM03) from Horseshoe breeding area in 1988. Column A indicates number of prey from observed forages plus prey deliveries to the nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals						B. Whole Biomass (grams)					
	28-Day Period:						28-Day Period:					
Species	1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	4/24/88–5/21/88	5/22/88–6/18/88	Total	1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	4/24/88–5/21/88	5/22/88–6/18/88	Total
Fish Species												
Carp	2 50%	1 20%		4 15%	2 25%	9 19%	2,261 75%	571 16%		5,271 45%	576 25%	8,679 40%
Flathead Catfish		1 20%				1 2%		2,017 56%				2,017 9%
Channel Catfish				1 4%		1 2%				128 1%		128 1%
Unknown Catfish		1 20%		1 4%		2 4%		381 11%		218 2%		599 3%
Black Crappie				11 41%	2 25%	13 27%				2,624 22%	494 21%	3,118 14%
Largemouth Bass				2 7%	2 25%	4 8%				340 3%	352 15%	692 3%
Unknown Bass					1 13%	1 2%					445 19%	445 2%
Unknown Centrarchid		1 20%				1 2%		167 5%				167 1%
Unknown Fish	1 25%	1 20%	2 50%	6 22%	1 13%	11 23%	455 15%	444 12%	167 16%	2,306 20%	444 19%	3,816 18%
Subtotal	3 75%	5 100%	2 50%	25 93%	8 100%	43 90%	2,716 90%	3,580 100%	167 16%	10,887 92%	2,311 100%	19,661 91%
Other Species												
Eared Grebe	1 25%					1 2%	297 10%					297 1%
Subtotal	1 25%					1 2%	297 10%					297 1%
Unidentified Carrion			2 50%	2 7%		4 8%			884 84%	884 8%		1,768 8%
TOTAL	**4 100%**	**5 100%**	**4 100%**	**27 100%**	**8 100%**	**48 100%**	**3,013 100%**	**3,580 100%**	**1,051 100%**	**11,771 100%**	**2,311 100%**	**21,726 100%**

Table B4.5-3. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	4/24/88–5/21/88	5/22/88–6/18/88	Total
Fish Species						
Carp				3,539 *(4) 56%	461 (2) 35%	4,000 (6) 52%
Flathead Catfish						
Channel Catfish						
Unknown Catfish				218 (1) 3%		218 (1) 3%
Black Crappie				1,722 (8) 27%	494 (2) 38%	2,216 (10) 29%
Largemouth Bass				167 (1) 3%	352 (2) 27%	519 (3) 7%
Unknown Bass						
Unknown Centrarchid						
Unknown Fish				702 (2) 11%		702 (2) 9%
Subtotal				6,348 (16) 100%	1,307 (6) 100%	7,655 (22) 100%
Other Species						
Eared Grebe						
Subtotal						
Unidentified Carrion						
TOTAL				**6,348 (16) 100%**	**1,307 (6) 100%**	**7,655 (22) 100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

The chronology of prey deliveries is summarized in Table B4.5-4. No trends are discernible for most species, probably due to the relatively short period of nest observations; however, crappie numbers peaked in mid-May. Carp and bass utilization increased during periods when less crappie were delivered.

Table B4.5-4. Summary of estimated biomass (grams) of prey delivered to the Horseshoe bald eagle nest in 1988. Numbers in parentheses refer to number of individuals delivered to the nest. Some species are grouped for analysis. Percentages expressed as percent of column total rounded to nearest whole number.

	OBSERVATION PERIOD/DAYS OBSERVED											
Species	4/24–5/07/88 9 days			5/08–5/21/88 8 days			5/22–6/04/88 8 days			TOTAL 25 days		
Fish Species												
Carp	3,539	(4)	57%	297	(1)	8%	1,400	(4)	27%	5,236	(9)	34%
Catfish sp.	555	(3)	9%	235	(2)	6%	951	(2)	18%	1,741	(7)	11%
Crappie sp.	625	(3)	10%	3,096	(12)	79%	1,245	(4)	24%	4,966	(19)	32%
Bass sp.	167	(1)	3%	167	(1)	4%	832	(4)	16%	1,166	(6)	8%
Unknown Fish	586	(2)	10%	131	(1)	3%	783	(2)	15%	1,500	(5)	10%
Subtotal	5,472	(13)	89%	3,926	(17)	100%	5,211	(16)	100%	14,609	(46)	95%
Other Species												
Unknown Mammal	281	(1)	5%							281	(1)	2%
Unidentified Carrion	411	(1)	7%							411	(1)	3%
Subtotal	692	(15)	11%	0	(0)	0%	0	(0)	0%	692	(2)	5%
TOTAL	**6,164**	**(15)**	**100%**	**3,926**	**(17)**	**100%**	**5,211**	**(16)**	**100%**	**15,301**	**(48)**	**100%**

B4.5.2.2 Geography of Foraging. In previous studies, most foraging at Horseshoe was recorded in the river section (or upper reservoir depending on water levels) below the Chalk Mountain nest cliff (Haywood and Ohmart 1983, Chorpenning and Crane 1984, Lett 1984, Heisler 1985, Grubb 1986a, Hein *et al.* 1986, Becker and Hein 1987, Kennedy and Richey 1990, Richey 1990). Although the eagles were observed flying to other areas and returning with prey, foraging was only observed once away from the nest area (Chorpenning and Crane 1984). All of this visual information on foraging was limited to areas observed by ABENWP workers, and others watching the nest. Although eagles returned with fish from the south, foraging on the main body of the reservoir was difficult to verify due to the visual obstruction of Chalk Mountain (Chorpenning and Crane 1984b, Lett 1984, Heisler 1985, F. Hein, pers. comm.).

Adults were observed on the river below Horseshoe Dam, but it was uncertain whether these eagles were the Horseshoe or Cliff pair (Chorpenning and Crane 1984, F. Hein, pers. comm.).

In the current study, the majority of prey items captured during 1988 nesting observations originated from Horseshoe Reservoir (Table B4.5-5). Most prey species, including black crappie, were taken from the upper, inflow area of the reservoir in late-April and May (73%). More use of the remainder of the reservoir occurred in late May/early June (25% versus 14% for the previous observation period); however, the inflow area remained important (40% of prey captures). We observed eagles favoring similar habitat in the Pinal/Pinto territory on Roosevelt Reservoir (Section B4.6), and relatively little use of the Verde River upstream of Horseshoe Reservoir was recorded during this period.

In January and February 1988, AF02 perched along much of Horseshoe Reservoir and the Verde River (Figure B4.5-7), possibly in response to the presence of waterfowl on the reservoir during this period. She even perched downstream of the dam a few times. In March, after the young hatched, AF02 sharply reduced the distance she would travel and perched and foraged mostly near the nest. During this month, the great majority of AF02's visitations were in Kms 81, 82, and 83. In April, May and early June of 1987 and 1988, AF02 expanded her range but still continued to spend most of her time in the nest area.

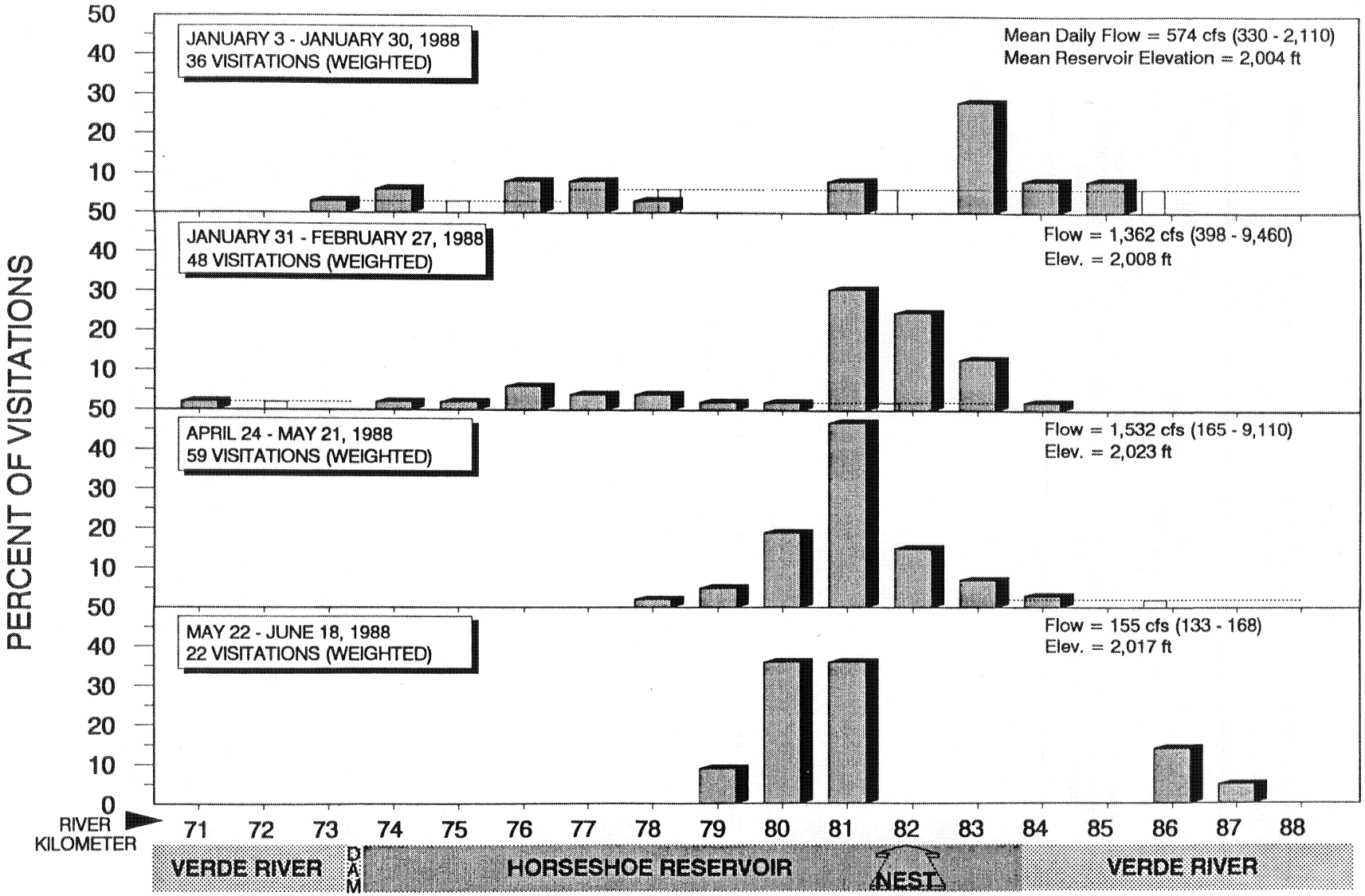
The seasonal changes in AM03's home range followed a similar pattern. During the early part of the 1988 breeding season, he perched throughout his home range, on various parts of the reservoir, and at upstream and downstream locations (Figure B4.5-8). In March, AM03 visited the upstream river section, but only rarely went to locations on the reservoir body. Like AF02, he spent much more time in the nest vicinity during March. After 24 April, AM03 again began using all parts of his home range.

B4.5.2.3 Observed Forages. We observed a total of 128 forages in the Horseshoe territory in 1987 and 1988. Seventy-nine were by the telemetered female, AF02, and 37 were by the telemetered male, AM03. The male was telemetered on 13 January 1988; in 1987 he was observed foraging eight times. We also observed one forage by a juvenile and one by an unidentified adult. All but one observed forage occurred on the reservoir. We remind the reader that, because of circumstantial factors of observer location, these observations of foraging events represent neither the relative numbers of prey species in the eagles' diet nor the actual geographic distribution of foraging (except perhaps in the nest vicinity). Rather, we offer these data on observed forages as a way to increase understanding of the circumstances of prey capture (e.g., prey status, microhabitat features, etc).

B4.5.2.4 Forages for Fish.

Prey Species. Ninety-five forages were known to be for fish, including six fish piracies. The most numerous identified prey fish were black crappie, with 24 crappie taken in the 95 observed forages for fish. Carp were the next most frequently identified (n = 12), followed by channel catfish (n = 9), flathead catfish (n = 5), and unidentified catfish (n = 5). There was one observed forage each for largemouth bass, unknown bass, threadfin shad, and an unidentified centrarchid. No attacks on mammals were observed, and we saw only two forages for waterfowl.

Forages on Horseshoe Reservoir were notable for the large percentage of carrion taken. Of five crappies judged to be alive, we believe all five were probably moribund; nine crappies were definitely carrion, and ten were of unknown status. Of the carp, three were live (and judged to be healthy), three were carrion, and four were of unknown status. Two carp were taken by piracy. One live and four carrion flathead catfish were taken, along with three live, one carrion, and five unknown channel catfish. Of the catfish which could not be identified to species, none were known to be live, two were carrion, two were



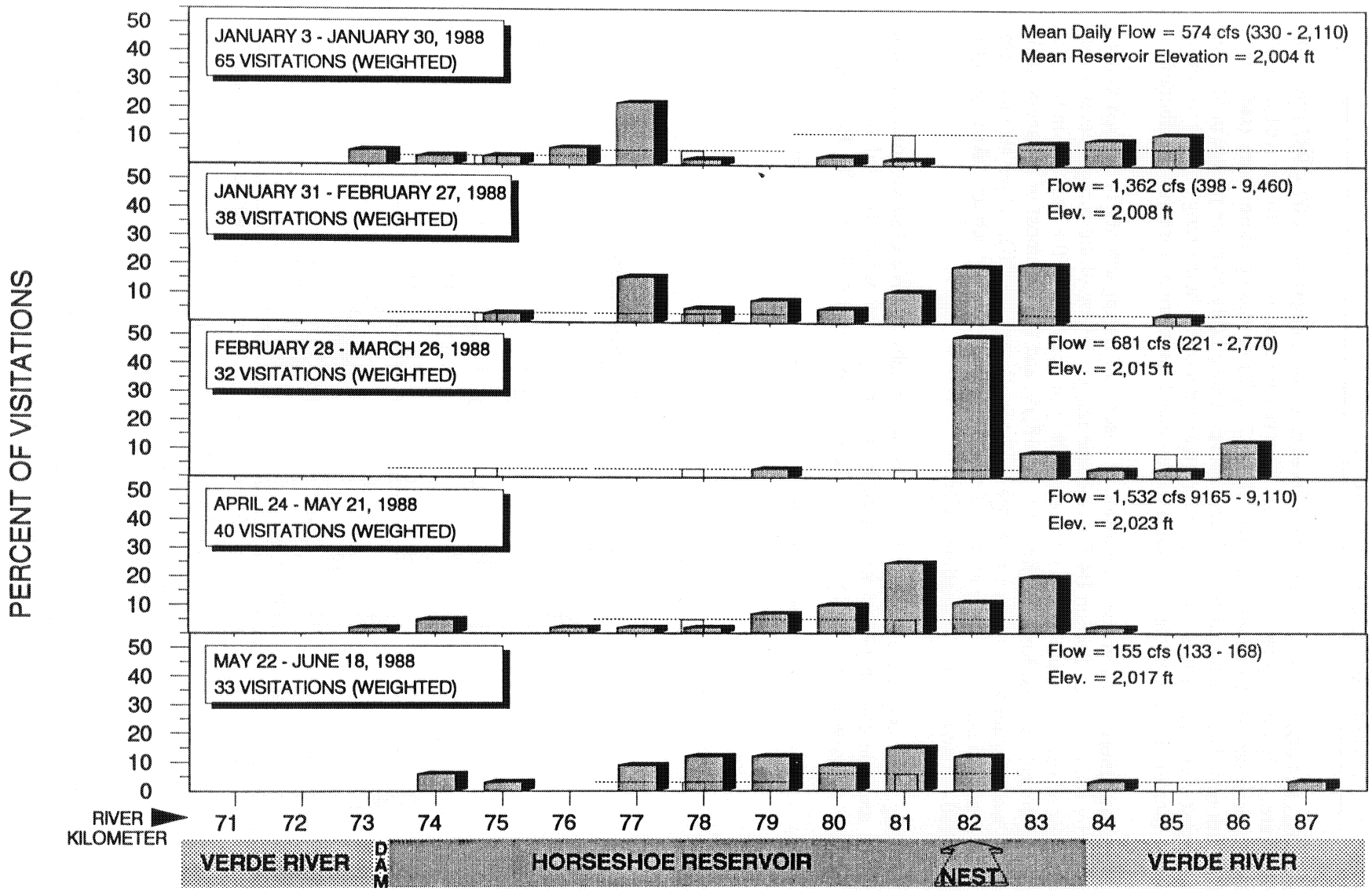
B4.5-7. Seasonal changes in the distribution of visitations (%) by the telemetered Horseshoe adult female (AF02) during 3 January to 18 June 1988. Visitation percentages at Km 82 (nest vicinity) were weighted according to the proportion of total prey deliveries by the female from those segments during each period. Open bars indicate cases where trackers could not precisely locate the eagle, and the dotted lines extending laterally from these bars indicate zones of eagle occupancy for the imprecise locations.

Table B4.5-5. Origin of prey taken by the radio-telemetered Horseshoe male (AM03) and female (AF02) adult bald eagles in 1988. Not all prey items delivered to nest.

		Horseshoe Reservoir					Verde River		
Observation Period	Species	Reservoir Unspecified 998	Dam to Deadman's Cove Km 73.4-76.6 LL 0.0-6.2 901	Deadman's Cove to Bend Km 76.7-79.8 LL 6.3-10.0 902	Bend to Cottonwoods Km 79.9-83.4 LL 10.1-13 903	Nest Area Km 82.6-82.8 906	Ister Flat Km 83.5-88.0 904	Total	
4/24/88-5/21/88	Carp	-	-	1	4	-	-	5	10%
	Channel Catfish	-	-	-	2	-	1	3	6%
	Flathead Catfish	-	-	-	2	-	-	2	4%
	Catfish sp.	-	-	-	1	-	-	1	2%
	Largemouth Bass	-	-	-	1	1	-	2	4%
	Black Bass sp.	-	-	-	1	-	-	1	2%
	Crappie sp.	1	2	2	20	-	-	25	48%
	Unknown Fish	2	-	1	6	-	-	9	17%
	Unknown Mammal	-	-	-	-	-	1	1	2%
	Unknown Prey	1	-	1	1	-	-	3	6%
Total %		4 8%	2 4%	5 10%	38 73%	1 2%	2 4%	52	100%
5/22/88-6/4/88	Carp	-	-	2	3	1	-	6	30%
	Channel Catfish	1	-	-	1	-	-	2	10%
	Largemouth Bass	-	-	-	2	1	1	4	20%
	Black Bass sp.	-	1	-	-	-	-	1	5%
	Crappie sp.	1	-	1	1	-	1	4	20%
	Unknown Fish	1	-	1	1	-	-	3	15%
Total %		3 15%	1 5%	4 20%	8 40%	2 10%	2 10%	20	100%

unknown, and one was taken by piracy. In all, of the 89 other forages for fish (excluding piracies), 18 were judged to be alive, 27 to be carrion, and 44 were fish whose status could not be determined.

Examining the entire sample of 17 forages for fish judged to be alive, seven were apparently floating on the surface when taken, suggesting they were moribund or otherwise incapacitated. Of the remainder, seven seemed to be healthy fish, and three could not be assessed as to whether they were normal or moribund. Of the fish considered to be healthy when taken, three were carp, another was a large carp or bass (ca. 40 cm), and three were unidentified. We conclude from this data on observed forages that carrion and moribund fish were far more important to the Horseshoe eagles than were normal, healthy fish.



B4.5-8. Seasonal changes in the distribution of visitations (%) by the telemetered Horseshoe adult male (AM03) during 1 January to 18 June 1988. Visitation percentages at Km 82 (nest vicinity) were weighted according to the proportion of total prey deliveries by the male from those segments during each period. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from these bars indicate zones of eagle occupancy for the imprecise locations.

Distribution of Observed Forages. Distribution of observed reservoir forages by AF02 (1987 and 1988) and AM03 (1988) are shown in Figure B4.5-9. Most observed forages occurred in the nest area and from Skm 10–13 on the east (nest) shore and from SKm 17 to 20 on the opposite shore (see Figure B4.5-5) for distribution of shoreline kilometers). These data provide a fairly accurate picture of foraging distribution in the nest vicinity, but it is less reliable for other parts of the home range owing to chance factors in observer location (visitation data provide a better overall measure of foraging distribution).

As in the visitation data, there was a greater proportion of observed foraging activity in the nest vicinity by the female than by the male (see Section B4.5.1 on home range). Many of the foraging events took place in the vicinities of reservoir shallow areas–for example, just upstream of the nest and in the bend area downstream of the nest around Km 81 (SKms 10, 11, 18,19, and 20), but most of the actual strike points were in deep water, again suggesting carrion (see below for Forage Depths). These shallow water habitats may be spawning areas, providing a source of carrion and spent fish which are taken by eagles after they have drifted out away from the shallow water.

Of 24 observed forages for crappie, 18 occurred in open water habitat. We observed one forage in reservoir shallows, and one carrion pickup was made from shore. Four were observed in reservoir coves. Two of these coves were at SKm 18.5, one at 18.8, and one was at SKm 10.8. For crappie,

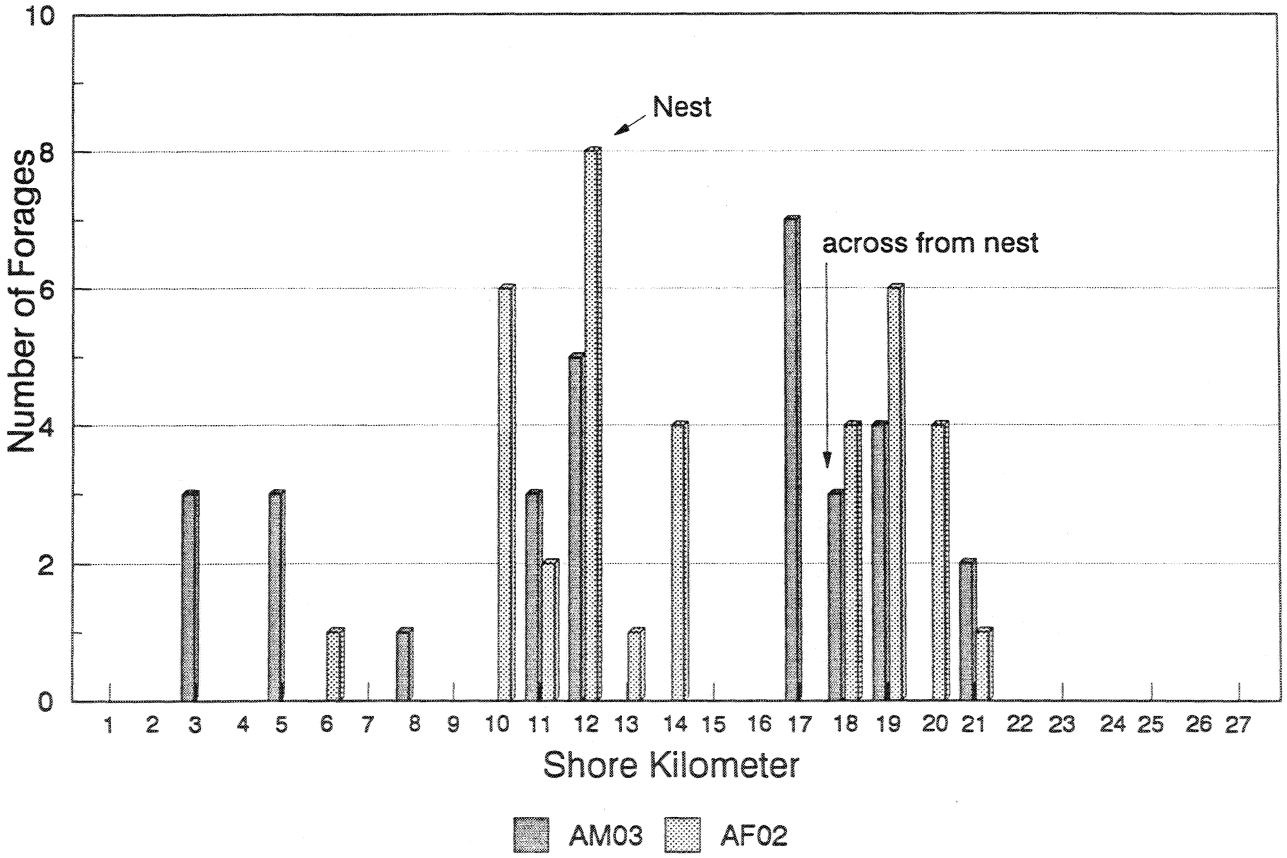


Figure B4.5-9. Distribution by shore kilometer of observed reservoir forages in 1988 by the telemetered Horseshoe male and female, AM03 (n = 27) and AF02 (n = 34). The nest is in SKm 12. Does not include piracies or forages for waterfowl. See B4.5-5 for distribution of shoreline kilometers.

water depths at strike points corresponded to open water habitats: of 23 forages in water, 19 were in water deeper than 200 cm, and only one of the remaining four measurements was less than 100 cm. This pattern suggests that most or all the crappie taken were floating dead or dying on the surface.

Figure B4.5-10 shows the locations of observed forages for crappie and other fish species in Horseshoe Reservoir. The highest number of forages, in SKm 18, is at the downstream end of a shallow area centered on SKm 17.5, directly across the reservoir from the nest area and therefore visible from the nest cliff. Four of the ten forages for carp occurred in SKm 16–19, near the shallows upstream of, and across the reservoir from the nest area. Reservoir habitat for four forages was open reservoir, with two forages in reservoir shallows and one each in backwater and reservoir cove. The reservoir cove was at Hell Canyon (SKm 19.6). One carrion carp was taken from shore, and habitat for one forage was not observed.

Reservoir Habitat. Excluding piracies, we observed 119 forages on the reservoir. Habitat for 75 (63%) of these was noted as open water reservoir. Of the remaining habitats, 16 (13%) were in reservoir coves, 13 (11%) in reservoir shallows, eight (7%) backwater, and seven miscellaneous (see Figure B4.5-5 for distribution of coves and shallows). Five of the eight backwater forage points were concentrated at SKm 17.5.

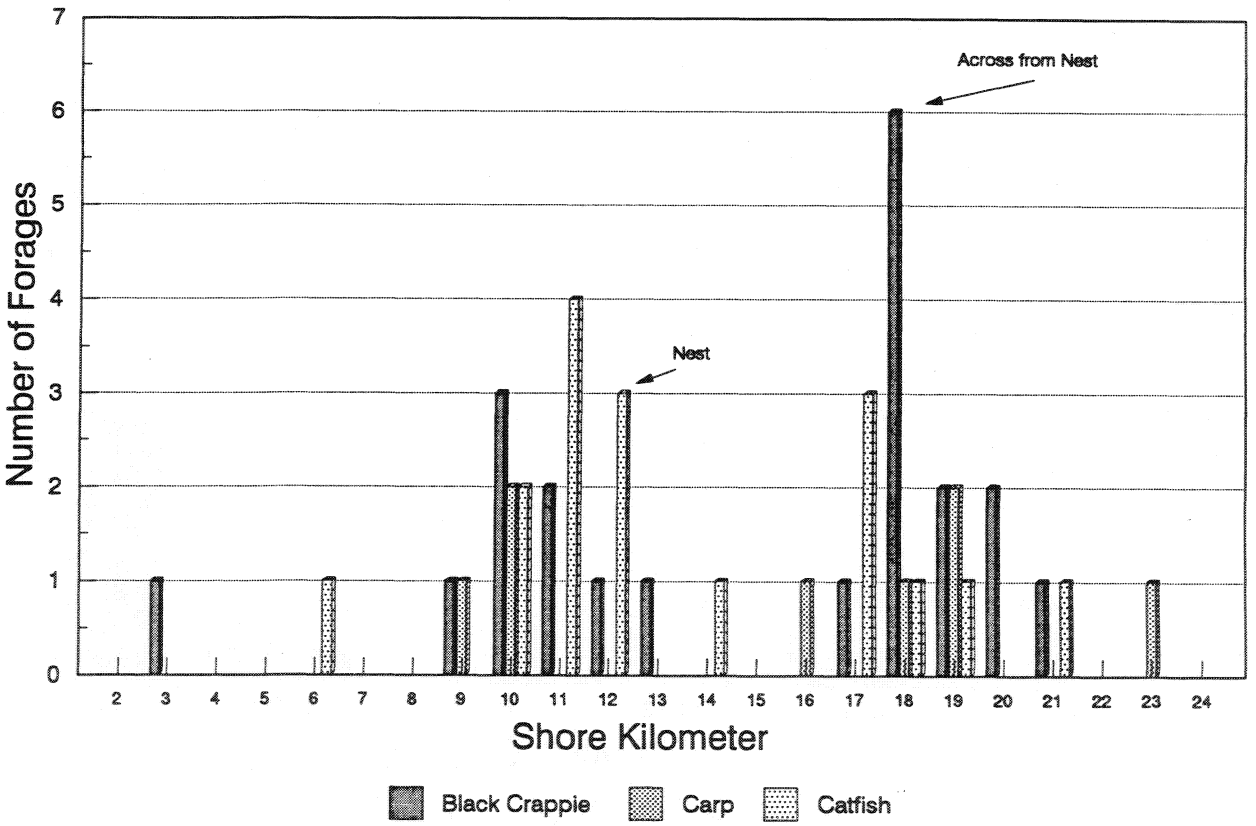


Figure B4.5-10. Distribution by shore kilometer of observed forages for three fish species which make up the majority of prey taken in Horseshoe Reservoir. Data are from both 1987 and 1988. See B4.5-5 for distribution of shoreline kilometers.

B4.5.2.5 Microhabitat.

Turbidity, Water Velocity, and Temperature. Since we were able to verify so few forages for live, healthy fish, it is not surprising that microhabitat measurements at strike points for the entire data set (alive, carrion, and unknown) were largely unproductive. One difference among species was that overall mean temperatures at strike points averaged warmer for black crappie (23°C, n = 23) than for carp (22°C, n = 7) or catfish species (18°C, n = 17); but this was due to the relatively restricted timing of observed forages for crappies, i.e., there were no forages for crappies in observed in winter.

Seven depth measurements at strike points for live, healthy fish in the reservoir were 50 cm (carp), 51 cm (carp), 110 cm (unidentified), 160 cm (unidentified), 195 cm (unidentified), and two were at depths of over 200 cm (both unidentified). There was virtually no detectible current at any of the strike points except for one carp forage with a current of about 0.5 m/sec.

Forage Depths. Figure B4.5-11 shows the observed distribution of foraging depths for live fish, carrion, and fish of undetermined status. Most fish of all three categories were taken in deep water, and there is no apparent relationship between water depth and prey category. Most individuals of each species were taken in deep water. Figure B4.5-12 compares the distribution of foraging depths in the entire reservoir and in the nest zone, where most forages occurred. There is little measurable difference in depth

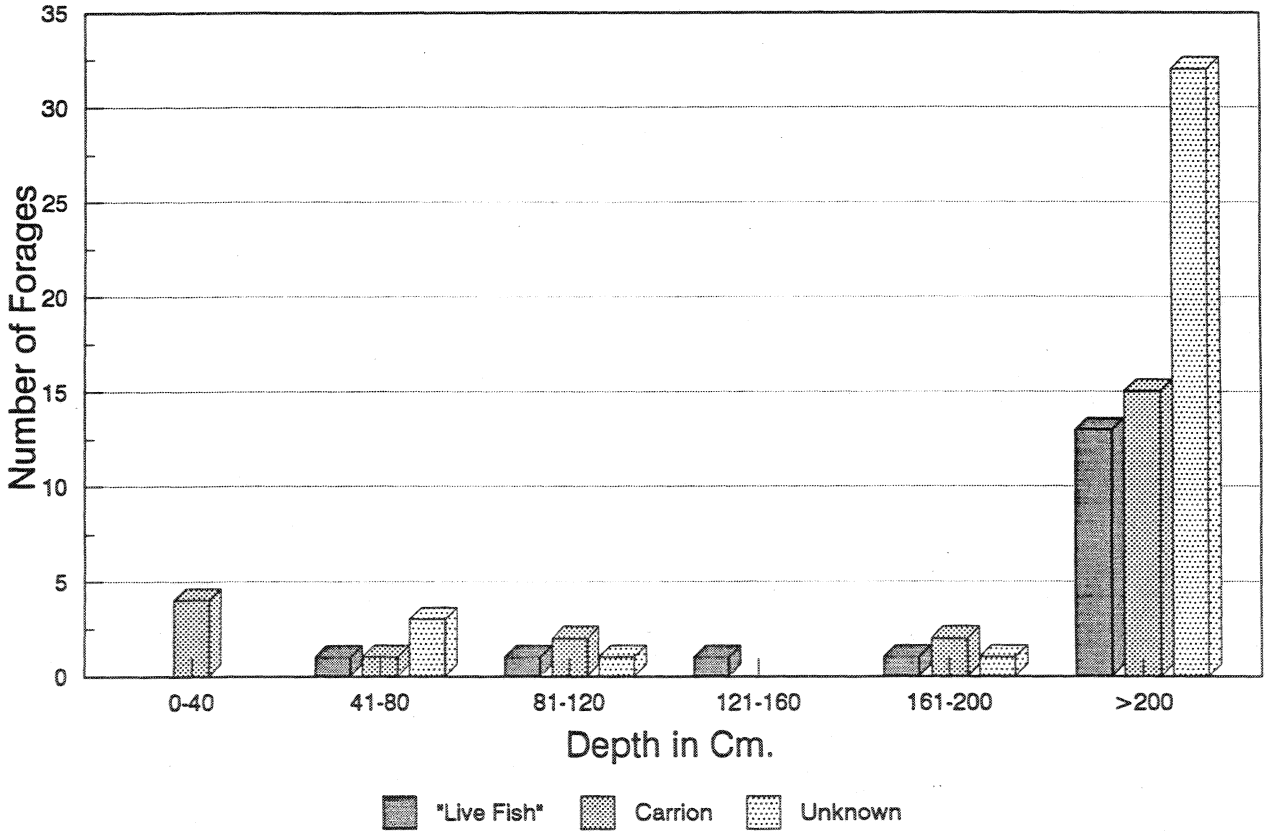


Figure B4.5-11. Distribution of reservoir forage depths for observed forages for fish (not including piracies) by the Horseshoe male (AM03) and female (AF02) in 1987 and 1988. At least 7 of the 17 "live" fish were moribund when taken.

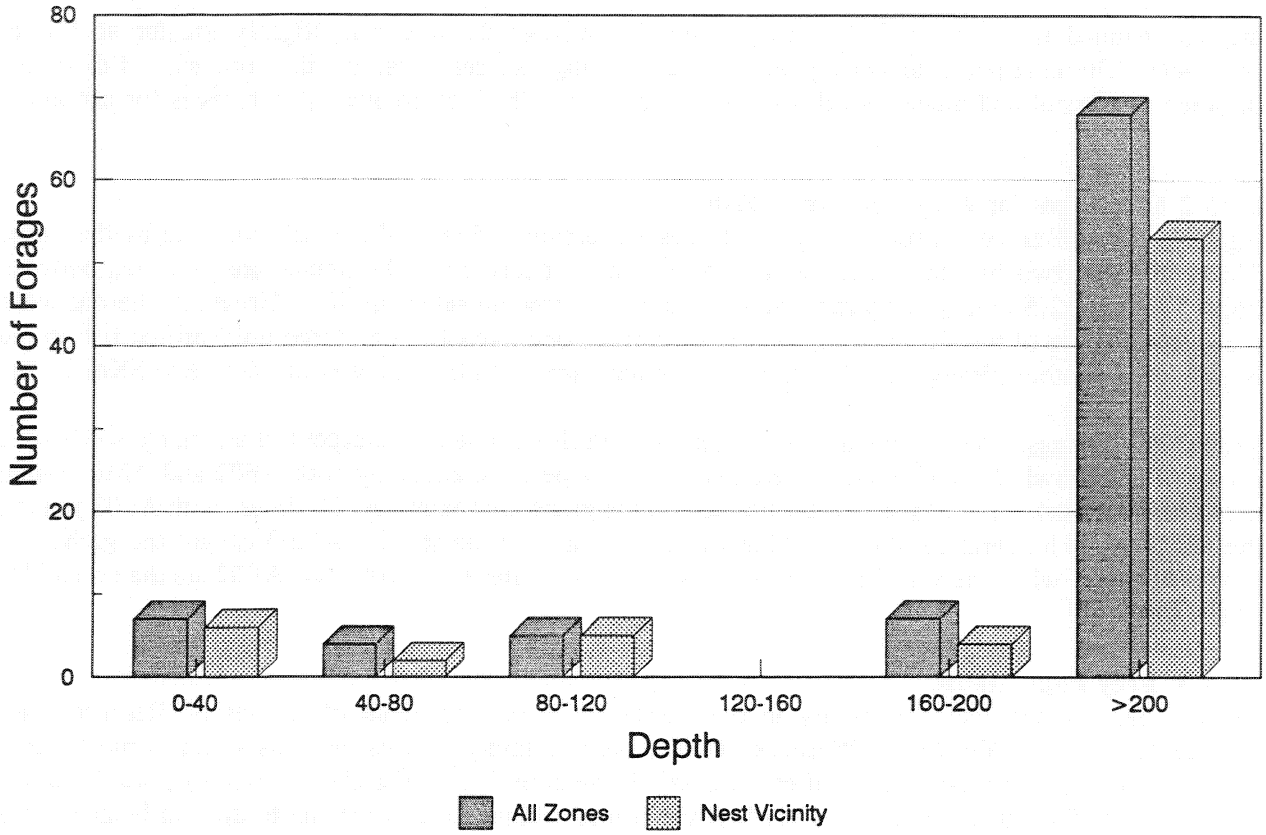


Figure B4.5-12. Distribution of reservoir forage depths for observed forages by the telemetered Horseshoe male and female, AM03 and AF02 in 1987 and 1988 (does not include piracies or forages for waterfowl). Distribution is shown for all zones (n = 91) and for the nest vicinity (zone 903, n = 70).

distribution, indicating that foraging preference in the nest area cannot be explained on the basis of a more favorable bottom profile. Again, this observation supports the conclusion of a preponderance of carrion in the diets of the eagles.

Shore Distance. Except for two measurements of 200 m or greater, distance from shore to strike point was generally quite short, ranging from 4 to 100 m (n = 42); six were 15m or less from shore. Except for one forage at 200 m, carp were consistently taken close to shore; six strike points for carp averaged 8 m from shore (range 1–17 m), while 22 black crappie forages averaged about 23 m, and 14 catfish averaged about 22 m from shore.

Perches. Cliffs accounted for 49 of 90 identified forage perches (48 on cliff ledges and one cliff top), but 38 forages started from snags, a high proportion compared with other territories we studied. Mesquite snags were the most numerous in the data (n = 12), followed by sticks and stumps close to the water (n = 8), "hard" snags (those with only the main branches (n = 5), and deciduous snags (n = 4). Nine perches could only be identified as "snags."

Perch to strike point distances varied widely, with a shortest distance of 1 m and a longest of 500 m for attacks made directly from the perch to the water; the average distance was 122 m (n = 66). Successful

attacks spanned the same 1–500 m range, but the average distance was slightly greater at 136 m (n = 49). The long perch to strike point distance, the high success rate, and the similarity of distances between successful and unsuccessful forages may be due to the high frequency of forages for carrion.

B4.5.2.6 Forages for Prey other than Fish.

Piracies. We observed six piracies in the Horseshoe territory, five by the female and one by the male. Three of these, two by the female and one by the male, occurred in the immediate nest area between SKm 12.3 and 12.5. Only one piracy, at SKm 23.2, occurred outside zone 903. Great blue herons were victimized in five of the six piracies, losing one catfish, one live carp, and three unidentified fish to the eagles. In the other piracy, two ravens lost a carrion carp to AF02 (this was the forage at SKm 23.2).

Waterfowl Forages. We observed two forages for waterfowl, one an unsuccessful attack by AF02 on a group of waterfowl close to shore. The other was a cooperative attack by both AF02 and AM03 on an eared grebe. During the attack, AM03 stooped on the grebe approximately 20 times, with AF02 joining the attack while he perched, then perching while he continued the attack. AM03 caught the grebe and took it to shore, where he was flushed from it by a coyote. After the coyote left, AF02 ate the remainder of the bird.

B4.5.3 Prey Populations

Current data on the fish community in the Verde River just upstream of Horseshoe Reservoir are apparently not available, but J. Warnecke (AGF, pers. comm.) advises that this reach is most likely dominated by carp, catfish and smallmouth bass. In Section B4.5.3 (Ladders Territory), we discussed changes in the fish community of the Verde River from Perkinsville downstream to the confluence of the East Verde River. We concluded that carp and catfish becoming increasingly abundant as one proceeds downstream, while suckers become relatively uncommon. Not surprisingly, then, we did not record a single sucker taken by the eagles either in prey deliveries or prey remains, while carp and catfish were frequently taken by the eagles.

The most comprehensive recent data on the relative abundance of potential prey fish in Horseshoe Reservoir are obtained from surveys by the AGF in 1987 (Warnecke 1988). A total of 1,413 potential prey fish were collected during electrofishing and seining surveys on the reservoir. Largemouth bass (38% of catch), green sunfish (37%), and bluegill (17%) comprised the bulk of the fish caught. Carp (6%) and black crappie (2%) were less abundant in the survey catch in 1987. Prey fish caught but comprising less than one percent of the total catch include goldfish, catfish spp., and smallmouth bass. The abundance of crappie was strongly under-represented in surveys because they prefer open water areas of the reservoir where electrofishing and seining is far less efficient. J. Warnecke (AGF) told us that Horseshoe Reservoir contains a large population of black crappie which attracts many anglers to the reservoir. He also noted that black crappie in Arizona are relatively short-lived, rarely exceeding four years old, and that spring die-offs of 3–4 year old crappie are quite common in the reservoir. Post-spawning mortality appears to be the reason for the die-offs. Other reservoirs containing large populations of crappie are Bartlett, Roosevelt, and San Carlos reservoirs.

In Horseshoe Reservoir, black crappie were significantly utilized by bald eagles from late April to June suggesting they were taken during their spawning season. Crappie begin spawning in the spring when water temperatures exceed 15–17°C and continues into early summer (Minckley 1973). Water temperatures in Horseshoe Reservoir when the eagles preyed on crappie were well within the spawning requirements of crappie, ranging from 18–28°C. Although crappie move into relatively shallow water

(< 1 m) to construct nests for spawning, 18 of 24 forages on crappie were in the deep pelagic zone of the reservoir rather than the shallow littoral zone, indicating that these fish were not taken off their spawning nests. Further, 19 of 24 crappie were taken in water deeper than 200 cm, despite secchi disk measurements of less than 200 cm at the forage site. These data imply that the crappie were taken from either the surface of the water or in the water column off the bottom, not from nest locations. Since crappie prefer to construct nests near cover, it would have been difficult for the eagles to locate spawning fish; turbidity in the reservoir probably also prevented eagles from locating crappie nests. All data indicate that most or all the black crappie taken on Horseshoe Reservoir were dead or dying fish floating on the water surface.

In the Mississippi River, Kittle (1966) found that black crappie suffered high mortality after age three. In California, Calhoun (1966) noted extensive spring die-offs of adult crappie. Causes of these deaths in California were undetermined but appeared to be due to natural mortality of older fish during and following spawning. In Horseshoe Reservoir, we observed dead and dying crappie floating on the surface on numerous occasions in May. We also found dead crappie floating in Bartlett Reservoir in late spring. In both reservoirs, many of the dead fish examined released gametes but had no obvious physical damage. We conclude that they died after spawning. Curiously, we also found small dead channel catfish (ca. 15 cm in length) on Horseshoe Reservoir during late spring, but there was no suggestion of the cause of mortality. We observed a similar die-off of catfish in Roosevelt Reservoir in 1989 (see Section B4.6.4).

Carp were also used throughout the study (20 January–1 June 1988) at Horseshoe Reservoir. The propensity of carp for feeding and spawning in shallow water contributes to their vulnerability throughout the nesting season. However, carp become even more available to eagles during spawning when they form large schools and move into shallow water. It is not uncommon to see several fish in a group with their dorsal fins protruding from the water. Minckley (1973) reported that carp may spawn in Arizona from late February through July. We observed carp spawning in Horseshoe Reservoir in May, however, we do not know when spawning first began. Water temperatures at all but one of the strike points ranged from 19° to 28°C. Although carp may begin spawning when temperatures reach 15°C, optimal water temperature for spawning is 18–24°C.

It is not uncommon for carp to migrate from reservoirs into rivers to spawn. M. Jakle (Reclamation, pers. comm.) observed spawning runs by carp from Pleasant Reservoir into the Aqua Fria River in March 1988. We also observed spawning migrations of carp into the Salt River from Roosevelt Reservoir in spring 1989. Spawning runs by carp from Horseshoe Reservoir to the Verde River probably also occur and may provide foraging opportunities for the eagles. Four super-riffles are present in Verde River just upstream from the nest (Kms 84.2, 85.0 to 85.5, 86.6, and 87.1) which migrating carp must cross to enter and travel up river.

Two tributaries in the Horseshoe Territory, Lime Creek and Sycamore Creek, were apparently not used by the eagles for foraging in 1987 or 1988. A visual survey in the lower 3 km of Lime Creek on 23 January revealed only one small fish (<7.5 mm TL). Flow in the creek in January was less than 0.5 cfs, and the majority of habitat was less than 12.5 cm deep. Habitat for large reservoir fish suitable as eagle prey was unavailable for spawning because of low flow in the creek. On 23 February 1988, we surveyed Sycamore Creek from its confluence with the Verde River to 3 km upstream. No fish over 15 cm were observed in the creek at this time. Several pools (> 1 m deep) behind beaver dams were present, but they held no large fish. Riparian vegetation along the creek was quite dense, often forming a complete canopy over the streambed. Even if adult fish were present in the creek, we question if the eagles could have foraged there.

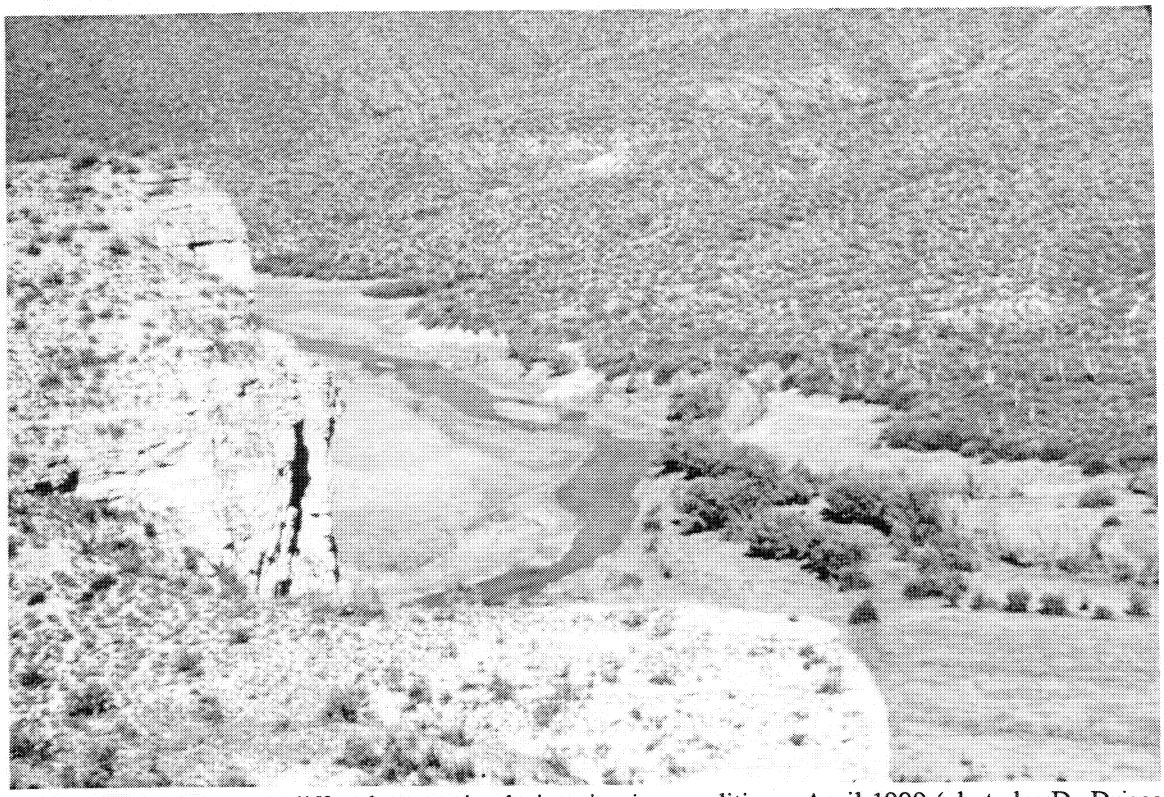


Plate B27. Horseshoe nest cliff and reservoir, during riverine conditions, April 1990 (photo by D. Driscoll).

Plate B28. Horseshoe nest cliff and reservoir at high water level, May 1991 (photo by D. Driscoll).

B4.5.3.1 Carrion. In nine carrion surveys on Horseshoe Reservoir (one in September 1987, two in January, one in February, one in March, one in April, and two in May 1988), we found 20 carp, 4 crappie, 2 channel catfish, 1 bluegill, 1 green sunfish, 1 shad, 1 striped skunk, and 1 adult javelina. At least 16 of the carrion carp (44–59 cm) were found at the shoreline (12 on 25 January, and 4 on 22 February), and were evidently angler caused mortalities. All four crappie were found in May.

B4.5.3.2 Waterfowl. Table B4.5-6 shows the results of waterfowl surveys conducted on Horseshoe Reservoir during December through May 1988. Two of the bald eagles favored prey in Arizona were common in these surveys: coots and eared grebes. Coots were seen in all months with a peak in January, and eared grebes were seen in January and February. Among other putative waterbird prey, many western grebes were seen in February, and mallards were noted in December and January.

B4.5.4 Human Impacts

The Horseshoe Territory, though not as easily accessible as other sites, has fairly high numbers of public users, mainly in boats, but also occasionally in helicopters. Amounts of public use probably vary in relation to the elevation of the reservoir, that is, whether the reservoir is lacustrine or riverine. During the two nesting seasons of this study (1987 and 1988), water levels remained high, making the reservoir more attractive to anglers because of easier boat access and because the higher water levels enhanced spawning and foraging habitat for bass and crappie, the two main sport fishes of the reservoir.

Public users had two main ways to access Horseshoe Reservoir: (1) an unimproved boat ramp at the lower end of the reservoir which is about a 30-km drive from Carefree, AZ (the nearest town) and includes approximately 11 miles of dirt road; and, (2) a road from the north side of the reservoir which requires fording the river (four-wheel drive vehicles), and driving another 3 miles to access the reservoir from the east side.

During the two years of our study, the breeding pair of eagles nested on the cliffs of Chalk Mountain, well above campers and reservoir traffic. In previous years, the pair has also nested in some of the drowned willows or on an artificial nesting platform provided by the Forest Service on the upper end of the reservoir, sites that made the eagles more vulnerable to disturbances by virtue of their being closer and more visible to people using the reservoir and/or to those camping on the south end of Ister Flat.

During 1984–1987, nestwatchers recorded fairly high numbers of public use incidents at Horseshoe, compared to other breeding territories (see Section D4.15); however, four of five nest watch reports said eagles rarely did more than watch public users, and no more than three flushes were recorded in a given breeding season.

On an incidental basis, we obtained 54 records of public use events in 1987 and 1988 (Table B4.5-7). These occurrences were recorded throughout the territory whenever they occurred within 100 m of an eagle. Distribution of data depended on the location of the telemetered eagles and the trackers and does not represent the distribution of public users on Horseshoe Reservoir.

The data indicate that Horseshoe territory had the highest percentage (48%) of flushing incidents compared to other sites and ranks third in the number of public use incidents recorded. The Horseshoe territory has no closure, a factor that probably played a part in the number of incidents recorded as well as the overall number of flushing incidents. The upper part of Horseshoe Reservoir is somewhat narrow, as are the riverine portions upstream to which boats have access during high water; this brought people

Table B4.5-6. Water birds observed in surveys at Horseshoe breeding area (1988). Asterisk denotes occurrence in prey remains.

Species	Avg. No. Individuals per Survey	% Species/Month				
		December	January	February	March	May
Western Grebe	12.8 (n = 77)	1.6	—	43.9	—	—
Eared Grebe*	5.8 (n = 35)	—	17.2	14.6	—	—
Pied-billed Grebe	1 (n = 6)	1.6	—	2.3	—	5.6
Double-crested Cormorant	7.7 (n = 46)	16.1	—	2.3	39.4	49.9
Canada Goose	1.8 (n = 11)	8.9	—	—	—	—
Mallard	6.8 (n = 41)	21.8	24.2	—	—	—
Green-winged Teal	4.7 (n = 28)	—	—	16.5	—	—
Ring-necked Duck	1.3 (n = 8)	5.6	1.7	—	—	—
Bufflehead	0.3 (n = 2)	—	3.4	—	—	—
Great Blue Heron*	7.8 (n = 47)	8.1	—	14.0	21.2	33.3
Coot*	14.8 (n = 89)	36.3	51.8	3.5	21.2	5.6
Gull sp.	1 (n = 6)	—	—	2.9	—	5.6
Other Waterbirds	1 (n = 6)	—	1.7	—	18.2	—
		n = 124 (one survey)	n = 58 (one survey)	n = 171 (one survey)	n = 33 (one survey)	n = 18 (two surveys)

Table B4.5–7. Summary of public-use incidents and eagle responses at Horseshoe territory in 1987 and 1988.

Type Public Use	No. Public Use Incidents	Percent of Total Incidents	Duration (min)	Percent Duration	Response to Public User		
					N	W	F
Fishing, non–motorized boats	1	1.8	7	1.3	—	—	1
Fishing, boats not using motors	5	8.9	102	19.4	2	—	3
Fishing, boats using motors	23	41.0	71	13.5	7	6	10
Camping	1	1.8	29	5.5	1	—	—
Boating, using motors	10	17.9	236	44.8	6	—	4
Airplane	3	5.4	45	8.6	—	1	2
Helicopter	12	21.4	14	2.7	3	2	6
Sonic Boom	1	1.8	22	4.2	—	1	—
Total	56	100%	526	100%	19	10	26

N = No response; W = Watching; F = Flush.

and eagles into greater proximity. Hence, among 33 boating events where eagles and people were within 100 m, there were 16 flushes (48%). In all but one of the flushing events involving boats, the birds were perched less than 10 m above the water; and in the remaining incident, less than 30 m. No boats were noted to have flushed eagles from the nest.

The number of helicopter incidents in the two seasons (n = 11) seems large, and the rate of flushing (55%), high. Why so many events occurred is unknown to us. In four of the 11 events, the helicopter was judged to be within 25 m of the eagle, and in a fifth event, within 50 m.

B4.5.5 Discussion

The niche of the Horseshoe pair is not unlike that of Britton Reservoir on the Pit River in northern California, a very rich habitat for bald eagles where a free-flowing river enters a relatively small reservoir (BioSystems Analysis, Inc. 1985); six pairs of eagles nest on Britton Reservoir, the highest known density of nesting pairs in northern California. During the nesting season these pairs, particularly those on the upstream end of the reservoir, feed mainly on fishes that have died from spawning stress. Carrion is especially common at the river's inflow to the reservoir where fish dying upstream are washed down. Other fish, spawning in the reservoir, die from stress and become available as carrion.

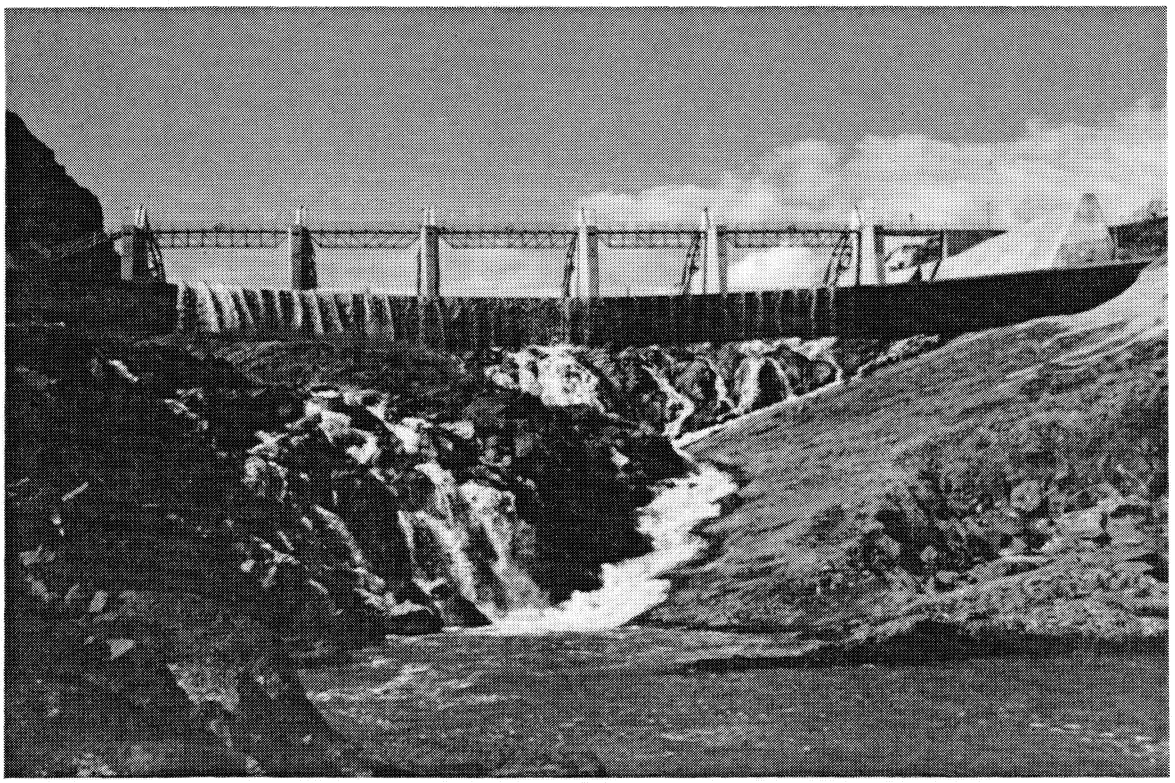


Plate B29. Horseshoe Dam releasing water into the regulated Verde River (photo by P. Becker).

Observed forages at Horseshoe were primarily on the reservoir; we observed only one forage on the river. Forages were concentrated near the nest and across the reservoir from it, and there was no apparent difference in the distribution of general foraging locations for the various fish species taken. Black crappie were the most frequently observed prey fish, followed by carp and channel catfish. This

was the case even though the crappies were caught during a more restricted period than were other prey species.

Prey taken in this territory was notable for a high percentage of carrion; this was known from both direct observation and inference on the basis of water depths at strike points and foraging strike characteristics. Although most forage points were close to shore, regardless of prey species, and although the forages were often near shallow areas, most water depths were greater than 200 cm, suggesting that the eagles were taking dead or moribund fish from the water surface. This was true both in the zone where most forages occurred and in the reservoir as a whole.

We did not study the Horseshoe pair of eagles in 1989 to observe their foraging behavior under what would have been far different conditions. The reservoir was riverine in the nest vicinity throughout the 1989 and 1990 breeding seasons. One young hatched from two eggs laid in 1989 but was apparently killed by a great horned owl. Two young fledged in 1990. It is therefore apparent from this that lacustrine habitat in the nest vicinity, prevalent during our study, is not a necessary ingredient to the success of this pair. In our studies of bald eagles foraging in riverine habitats at most of the other priority territories, we found super-riffles to be a highly significant habitat feature. It is therefore probably relevant to note that each of the first four river Kms upstream of the nest area contains super-riffles, one of which is among the most extensive of all we surveyed on the Salt and Verde rivers. In addition, when the reservoir is low, both Kms 82 and 83 (beneath the Chalk Mountain cliff nests) contain super-riffles.

The question of what happens to prey populations in Horseshoe Reservoir as a result of drawdowns is intriguing. During drawdowns, prey populations are forced into a smaller habitat area which may increase competition. Poor water quality (i.e., low dissolved oxygen concentration) at low reservoir elevation might lead to fish kills which would temporarily increase food for eagles but might reduce prey populations in succeeding years.

However, drawdowns are used as a management tool in many reservoirs throughout the U.S. to force forage fish from cover (i.e., vegetation beds in the littoral zone) and make them more available to game species (i.e., largemouth bass and crappie). Often, significant improvement in the growth rates of gamefish occur during a drawdown. The "cost" of a drawdown to reservoir species is lower reproductive success due to increased competition and predation on young-of-the-year fish. The loss of a complete year class of a prey species may result from poor reproductive success during drawdowns possibly reducing foraging opportunities of the eagles in future years. These effects would probably be most evident in centrarchid populations (i.e., crappie, bass, bluegills) since these fishes do not occur in large numbers in the river and would not be supplemented by dispersal of fish from the river, as would be the case for carp and catfish.

However, though reproductive rates may drop during a drawdown, when the reservoir is filled, conditions improve markedly. Nutrients in the reservoir may significantly increase when vegetation is flooded leading to higher zooplankton populations (zooplankton is the first food of most fish species). This phenomenon is often termed the "new" reservoir effect and allows many older reservoirs to maintain high productivity. Further, recently flooded vegetation is ideal habitat for the young-of-the-year of most fish species and serves as spawning habitat for carp.

In sum, we do not know the net effect of drawdowns on eagle prey at Horseshoe. However, despite a history of frequent drawdown, the richness of Horseshoe Reservoir as a source of food for bald eagles

in the years of our study was apparent in the relatively small foraging range of the pair, with little emphasis on long-distance travel to outlying foraging locations or even to riverine habitats close by (see Section A3.4). We must conclude that the *status quo* is working quite well for the eagles.

B4.5.5.1 Water Project Impacts. Construction activity and alterations to the dam itself are unlikely to affect eagle nesting in this territory. The nest area, which has been used every year since at least 1975, is roughly 6 airline km upstream of the dam, and this distance should prevent any direct effect on nesting activity. Similarly, construction at the dam would have a negligible effect on bald eagle foraging on the reservoir since little foraging occurred near the dam. Some foraging occurred in the shallow areas on the west shore of the reservoir about one or two Kms north of the dam; however, this was not an important foraging area.

Indirect effects on foraging opportunities should also be minimal, since reservoir elevations, release rates, and release elevations are not expected to change (U.S. Fish and Wildlife Service 1989b). Peak elevations would be restricted in spring, but no fish kill is predicted (U.S. Bureau of Reclamation 1990). Given the large percentage of reservoir carrion in the diet of this eagle pair, fish kills would presumably be a short term benefit to them so long as kills are not large enough to threaten future fish populations. Since the reservoir has been essentially riverine in some years, with no apparent effect on eagle productivity, food supplies are apparently not threatened.

The borrow area for construction is below the dam in an area occasionally visited by the Horseshoe pair. Although disturbance and siltation there would probably not affect the Horseshoe pair, increased turbidity might affect the pair at Cliff territory, a short distance downstream, especially if young were present.

We are unable to say if foraging opportunities for the Horseshoe eagles might be affected by a trend in reduced flows in springtime in the Verde River as might result from 1) drought, 2) from water diversions from the upper Verde and East Verde rivers upstream of Horseshoe Reservoir, or 3) from a combination of these.

B4.5.6 Management Recommendations

In years when the Horseshoe pair uses tree nests, there has been the problem of inundation during flooding. The agencies have correctly responded by monitoring the nest and by saving the eggs or chicks on a number of occasions, and have succeeded in successfully fostering young to other sites (see Section D4.15). Another problem associated with the tree nests is that bass anglers fish in the area around the nest, and even sometimes tie their boats to the nest tree. In addition, a waterfowl hunting blind, used in 1989, is located 300–400 meters to the south of the current nest tree (Nest 9). In years of tree nesting, a closure is recommended.

B4.6 PINAL AND PINTO BREEDING AREAS

The Pinal and Pinto breeding areas are located 109 km east of Phoenix on the Salt River drainage near Roosevelt Reservoir (Figure B4.6-1). The two territories are considered together in this report because during the years of our study the Pinto female came to reside in a part of the home range of the long-established Pinal pair, forming a polygynous but unproductive relationship with the Pinal male. For study purposes we refer to the area containing the Pinal and Pinto nests and the home ranges of the three adults as the "Pinal/Pinto" breeding area. Sections D4.22 and D4.23 contain more information about these eagles, including data on years of occupancy, reproduction, mortality, and a review of various reports to the agencies.

The habitat setting at Pinal/Pinto is similar to that occupied by the Horseshoe pair in being near an area where an unregulated river section enters a reservoir; eagles of both breeding areas use both the riverine and lacustrine habitats. However, these differ distinctly from those used by the Bartlett and Blue Point eagles who exploit regulated, deep-release river sections and reservoirs fed by regulated river reaches. In this section we will continue to show that habitat and prey selection by the nesting eagles reflect such habitat differences.

We were also concerned with understanding the ecology of the Pinal/Pinto eagles because of proposed changes to Roosevelt Dam and the diversion dam upstream of the reservoir, and because recreation development projects on the Salt arm of the reservoir were anticipated by the Forest Service.

Pinal/Pinto is within the Lower Sonoran Life Zone (C. H. Merriam 1890,1898; in Lowe 1964), and surrounding habitat is of the Sonoran Desertscrub Biome, containing species of the Paloverde-Cacti-Mixed Scrub Series and the Jojoba-Mixed Scrub Series (Brown and Lowe 1980, Brown 1982). The riparian habitat includes Fremont cottonwood, Goodding willow, mesquite spp., tamarisk, and some emergent vegetation along scattered cliffs and cutbanks.

Upstream of the Pinal nest, located near the mouth of Pinal Creek, the Salt River passes through a somewhat narrow canyon between Redmond Mountain and Black Mesa. It then flows into an 'S' curve bounded by cliffs and large pinnacles at Km 113-114 ("White Cliffs"). Pinal Creek, flowing out of the Pinal Mountains, enters the Salt River at Km 112.7. The creek contains few fish, possibly because of tailings from copper mines in the Globe area. Just downstream of the Pinal Creek confluence, the Salt River emerges from the mountains into the broad expanse of Tonto Basin at Km 112.2 where State Road 288 bridges the river. The river then passes over the Roosevelt Diversion Dam at Km 110.8, and into the Meddler Point area, a wide bend with abundant cottonwoods. The river continues through shallow sandy flats and passes under "Red Cliffs" which overlook a marshy area containing cottonwoods and emergent vegetation on the opposite shore. Just downstream, the river enters Roosevelt Reservoir in the vicinity of Cougar Point (Km 101); however, the location of the inflow depends on reservoir elevation.

This is the beginning of Campaign Bay, a broad shallows at the mouth of Pinto Creek (Km 100), bounded at its downstream end by Schoolhouse Point and the main body of the reservoir. At the downstream end of the eagles' home range is Windy Hill and Salome Cove at Km 87.5 where there are a few cottonwoods. Otherwise, the reservoir shore below Schoolhouse Point contains few perch trees other than small mesquites, paloverde, and saguaro cactus; isolated cutbanks also offer eagles a view of the water.

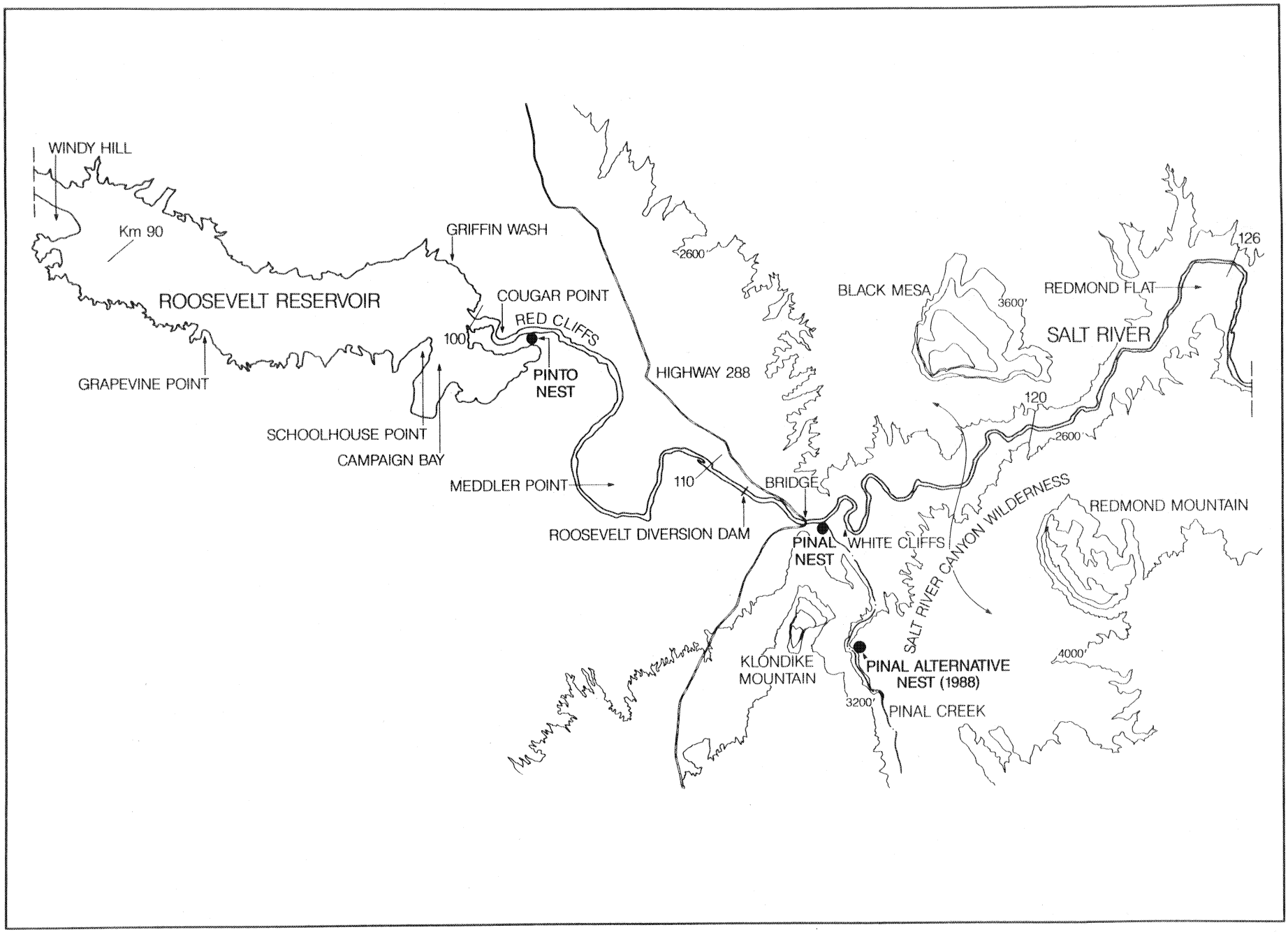


Figure B4.6-1. The Pinal/Pinto bald eagle breeding area.

Plate B30. Free-flowing Salt River entering Roosevelt Reservoir. Note the shallow inflow area of Campaign Bay, an important foraging area of the Pinal/Pinto eagles, May 1989 (photo by D. Driscoll).

History of Reproduction

Discovered in 1978, the Pinal breeding area contains two cliff nests (1, 2) and one pinnacle nest (3), all overlooking Pinal Creek, near the confluence of the free-flowing Salt River (see Section D4.22 and Part F for nest locations). The eagles used only Nest 2 during 1978–1985. Sporadic nest checks during the 1986 breeding season revealed only one adult in the area; however, a new nest (3) was found in 1988 and contained old eggshell fragments, indicating previous use (possibly 1986). Nest 3 was used by the Pinal eagles in 1988 and 1990, while Nest 1 was used in 1989. The Pinal eagles have laid eggs from 24 January to 16 February, hatched young from 28 February to 23 March, and fledged eaglets from 20 May to 10 June. There have been at least 19 eggs since 1978, and the pair has been successful in 9 of 12 years, fledging 12 young.

Adults apparently abandoned the nest, which contained two eggs, in 1980. In 1981 one young died in the nest, cannibalized a few days after hatching (Haywood and Ohmart 1982), and the second eaglet fledged. A nestling died in 1982, but a foster eaglet from the "76" breeding area fledged from the nest (Haywood and Ohmart 1983). One eaglet, entangled in monofilament fishing line, died in the nest in 1988. Another also died in the nest in 1989, although its sibling fledged. See Section D4.22 for details on annual productivity and mortality at Pinal.

We radio-tagged a second adult female in December 1987 in Campaign Bay at the inflow of Roosevelt Reservoir in December 1987. This bird, the Pinto female (AF03) mated with the polygynous Pinal male (TM01) and attempted to unsuccessfully to nest in Km 102 across from Red Cliffs. Figure B4.6-1 displays the relative positions of the Pinal and Pinto nests.

Roosevelt Reservoir

The Bureau of Reclamation completed Theodore Roosevelt Dam in 1911, which was the first major structure built on the Salt River. Located 70 miles northeast of Phoenix and 30 miles northwest of Globe, Arizona, this thick-arch dam spans the Salt River and forms Roosevelt reservoir with a surface area of 17,300 acres and a hydraulic height of 234 feet; its total capacity is 1,381,580 acre-feet. The spillway allows a flow capacity of 150,000 cfs.

Reservoir elevations were very similar in 1987 and 1988; annual mean water elevation was 2125 ft in both years. The range of water heights varied from 2118 ft (October) to 2136 ft (May) in 1987; and in 1988, minimum elevation was 2118 ft (August) and the maximum level was 2133 ft (May) (Figure B4.6-2). Mean elevations over the first half of 1989 were lower with an average height of 2121 ft (4 ft below 1987 and 1988); water levels ranged from 2106 (June) to 2125 ft (March).

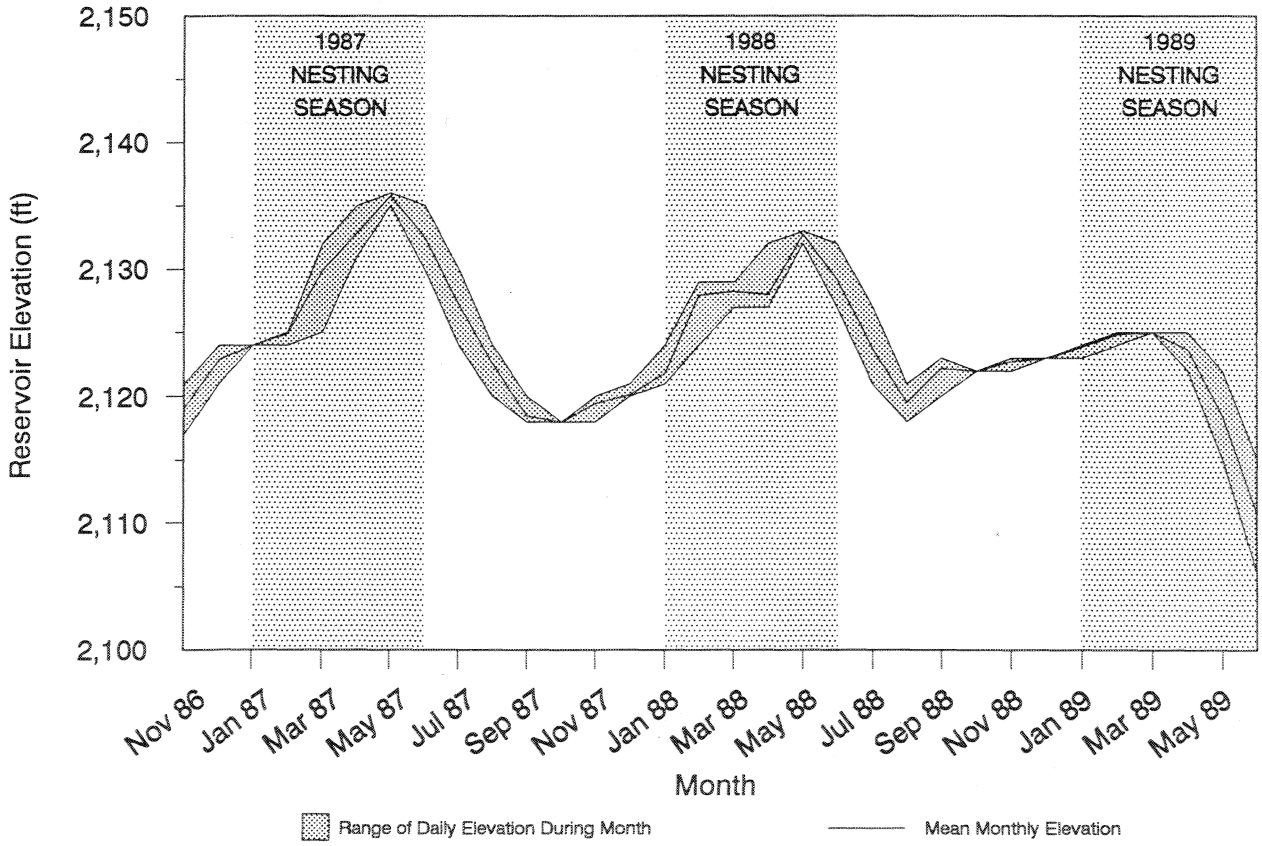


Figure B4.6-2. Mean monthly elevation and range of daily elevations in Roosevelt Reservoir from November 1986–May 1989.

Salt River (Pinal/Pinto area)

Mean annual flows in the Salt River entering Roosevelt Reservoir were also similar in 1987 and 1988 (919 cfs and 867 cfs, respectively). Mean monthly flows in 1987 ranged from 220 cfs (September) to 3104 cfs (April), while mean monthly flows in 1988 ranged from 243 cfs (November) to 1785 cfs (April)(Figure B4.6-3). Spikes in mean daily flow occurred in the spring of both years, peaking during the months of March and April in 1987 and February and April 1988. In 1988, considerable rain also occurred during the summer months (June–August) resulting in several peaks in mean daily flows. Mean daily flows in the Salt River during April and May, when carp and catfish were making spawning runs out of the reservoir into the river, averaged 2207 cfs in 1987 and 1496 cfs in 1988.

In contrast, mean monthly and peak daily flows during the nesting season in 1989 were considerably lower than in the two previous years (Figure B4.6-3). Mean monthly flows in 1989 during the nesting season peaked at 1165 cfs (March) compared to 3104 cfs in April 1987 and 1785 cfs in April 1988. Although a peak in mean daily flow was observed during spring 1989, the maximum flow measured in 1989 was only 1880 cfs compared to 5300 cfs in 1987 and 6780 cfs in 1988. Further, mean daily flows in the river in 1989 during the migration period of carp and catfish were considerably lower than in

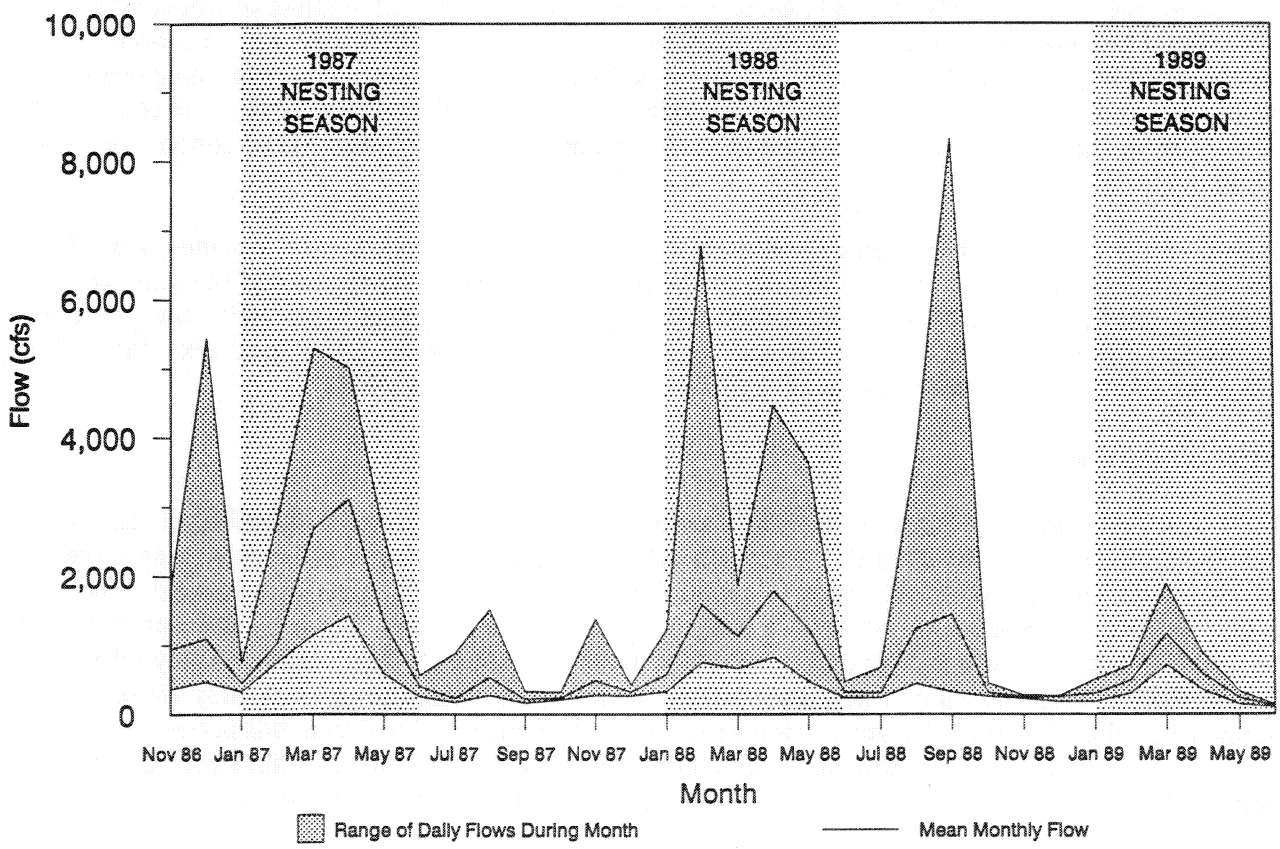


Figure B4.6-3. Mean monthly flows and range of daily flow in the Salt River at Roosevelt Reservoir from November 1986–May 1989.

previous years averaging only 405 cfs; this was 1000 cfs lower than in 1988 and 1800 cfs lower than in 1987 during the same period.

Water Projects

Planned or recently completed water projects potentially affecting the Pinal/Pinto territories include modifying Theodore Roosevelt Dam by increasing its height (U.S. Bureau of Reclamation 1983, 1990), and the modification of the diversion dam upstream of the reservoir to act as a fish barrier with human safety features.

The diversion dam upstream of the reservoir was modified in November 1989 to provide safer river conditions for recreationists in the area. Hydraulics below the dam have been altered by constructing a concrete step apron downstream, creating a weaker undertow. This modification improved public safety conditions in the area of the diversion dam, without requiring the removal of the dam. SRP had determined that the diversion dam has functioned as an effective fish barrier, restricting the movement of non-native fish in the reservoir upstream into the Salt River (SWCA Consultants report to SRP).

Proposed modification of Roosevelt Dam, a National Historic Monument, would involve increasing the height of the dam to elevation 2218, 77 ft higher than the current structure. Prior to construction, Roosevelt Reservoir would be drawn down to elevation 2115 by October of the first year of construction. This would become the reservoir's top of conservation during the construction period (the normal top of conservation is elevation 2136). It is expected that normal downstream deliveries, beginning in April of each year, would drop the reservoir to elevation 2095 by each September period. After dam construction is completed, the reservoir would be allowed to fill up until it reaches its new top of conservation level at about elevation 2151.

Runoff would be collected through late summer and released when storage volume becomes available in the downstream reservoirs. During the life of the project, an average of one-half of the sediment pool (134,000 acre-feet) would be used for additional storage, with the maximum conservation pool extending up the Salt arm to Meddler Point and up the Tonto arm to A-Cross Road near Ash Creek. In a typical year, reservoir levels would fluctuate 23 ft (U.S. Bureau of Reclamation 1983).

Schedule of Study

Home range studies in the Pinal breeding area concentrated on two telemetered adult female bald eagles. We captured the adult female AF01 (at Black Mesquite) and fitted her with a radio transmitter on 13 December 1986. Continued efforts to capture the adult male TM01 were unsuccessful. Intensive radio-tracking and monitoring of AF01's daily activities began in early January 1987 and continued periodically until mid-March, and then resumed for two periods during May, June, and July. The Pinal female lost her radio transmitter near the nest site in early May; thus, during 6–10 May we could only observe her visually. We distinguished the female from the resident male during this period by a broken secondary on her left wing. However, maintaining contact with the birds for uninterrupted periods to obtain time-lines of habitat selection without the use of radio telemetry was impossible.

We recaptured the female on 13 June and attached a new transmitter, after which we were able to obtain better data on the foraging behavior of the male, for his movements often coincided with those of the female, especially during winter.

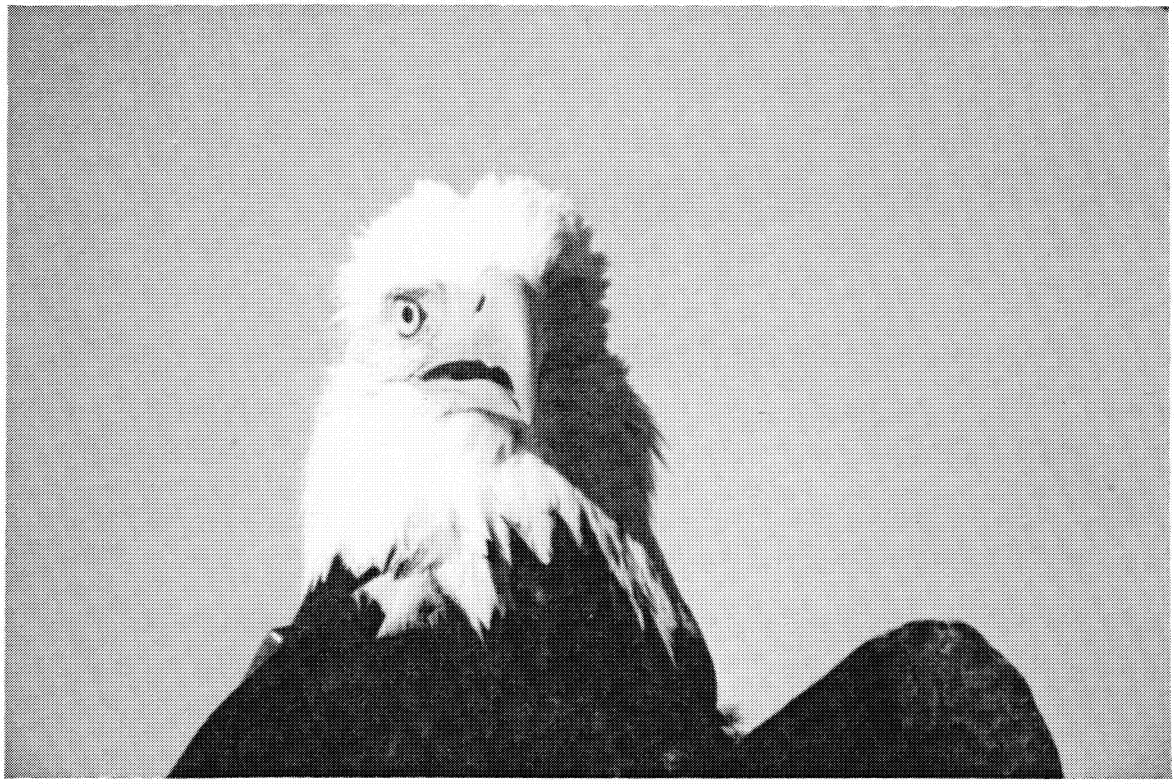


Plate B31. Pinal female (AF01) captured 13 December 1986 on Roosevelt Reservoir (photo by D. Driscoll).

On 17 December 1987 we telemetered another adult female (AF03) who had joined in a polygynous triangle with the Pinal pair by taking over the downstream end of AF01's home range. During 1988 we obtained more data on the foraging ecology of AF01, as well as data on the Pinto female, AF03.

We had planned to monitor prey deliveries at the Pinal nest in 1988, but the single nestling died soon after hatching when it became entangled in monofilament (see Sections C3.3 and D4.22).

We continued trying to capture the Pinal male through early spring 1989 but were unsuccessful. AF01's transmitter failed in mid-April 1989, but we were able to observe prey deliveries to the nest during part of the chick cycle (see below). Trackers monitored the eagles from locations near Highway 288, from Schoolhouse, Grapevine, and Cougar points, from a boat on Roosevelt Reservoir, and from a ridge that runs along the north side of the Salt River opposite the 1987 nest site.

B4.6.1 Home Range

B4.6.1.1 Home Range of AF01. The home range of AF01 differed between the two years of study (Figure B4.6-4). In 1987, AF01 ranged almost daily into the Salt Arm of Roosevelt Reservoir from her nest, 7 airline km distant. In January, she used a variety of small cutbank perches along the reservoir between Km 91 and 99, but the two perches used most often were the drowned cottonwood at Km 100 in Campaign Bay and the top of Red Cliffs (Km 101) overlooking the Salt River near where it enters Roosevelt Reservoir (Figures B4.6-1 and B4.6-5). In February, AF01 used a smaller portion of the Salt Arm and continued to prefer the drowned cottonwood over any other perch away from the nest. In March, she began using less of the reservoir and more of the river for perching and foraging. In April,

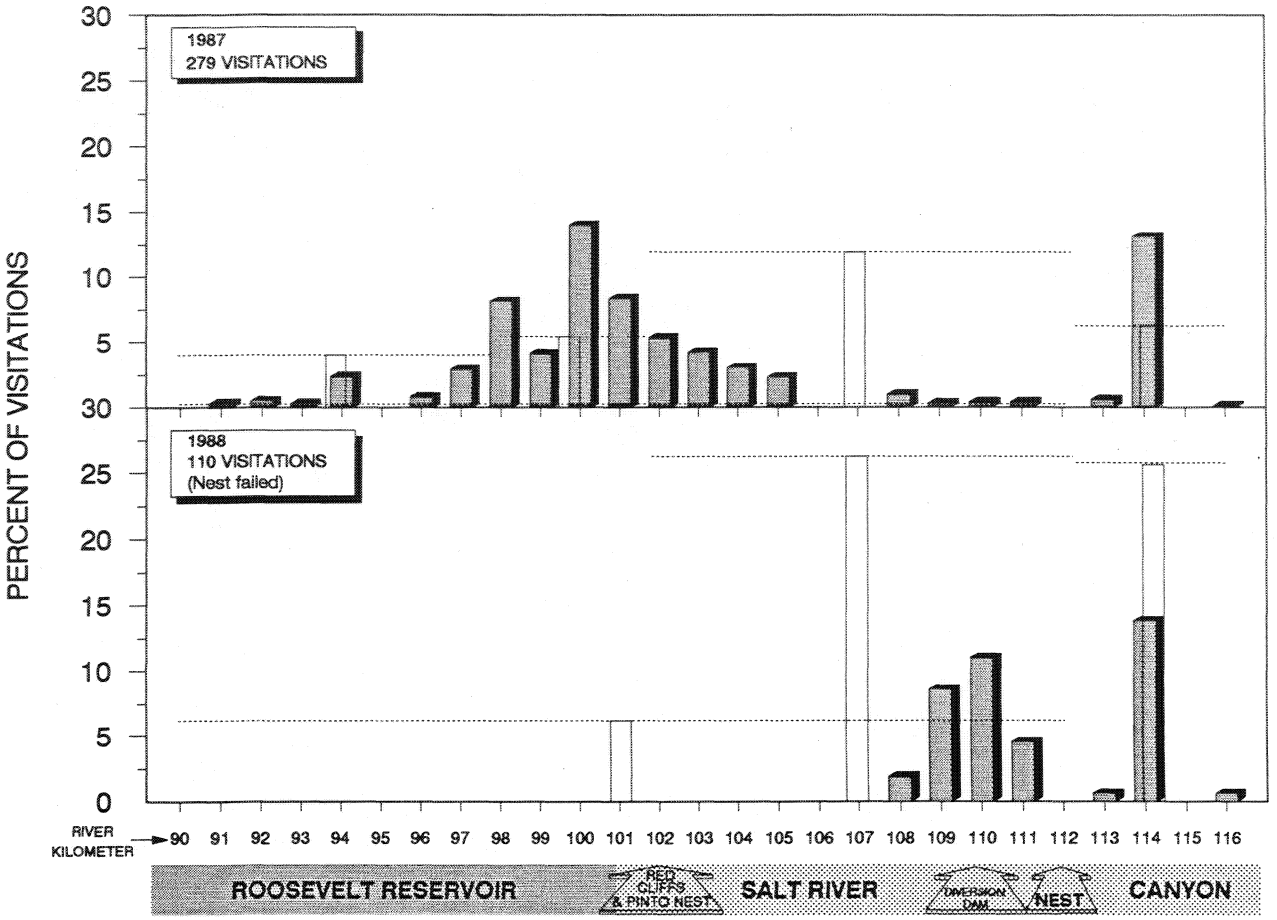


Figure B4.6-4. Home range of the Pinal adult female (AF01) during the 1987 and 1988 breeding seasons. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from those bars indicate zones of eagle occupancy for the imprecise locations. Visitation percentages at Km 112 (the nest area) were weighted according to foraging rates (no prey captures were recorded in Km 112).

she spent significant amounts of time at the reservoir and in the mainstem area just upstream of the nest. However, we never observed foraging in Km 112 where the nest was located. During this period, when she did visit the reservoir, AF01 mainly used cutbanks between Km 97 and Km 99 and other perches (including Red Cliffs) between Km 101 and Km 103 (the reservoir inflow area).

During the 1988 breeding season, AF01 sharply reduced the size of her home range, probably in response to the presence of AF03 on the reservoir and lower river (Figs. B4.6-4). During January through March, AF01 routinely flew downstream to use perches along the river just above and below the diversion dam at Km 110.9. As in 1987, AF01 also frequented Km 114 upstream of Pinal Creek and traveled downstream to the diversion dam. We did not observe AF01 using any portion of Roosevelt Reservoir during the 1987 breeding season.

We located AF01 soaring as far east as the Redmond Flat area at Km 126 and the Cherry Creek confluence at Km 138, but we did not confirm any perching there; however it was often not possible to receive AF01's signal when she traveled far upriver. AF01 may have shifted her home range upstream

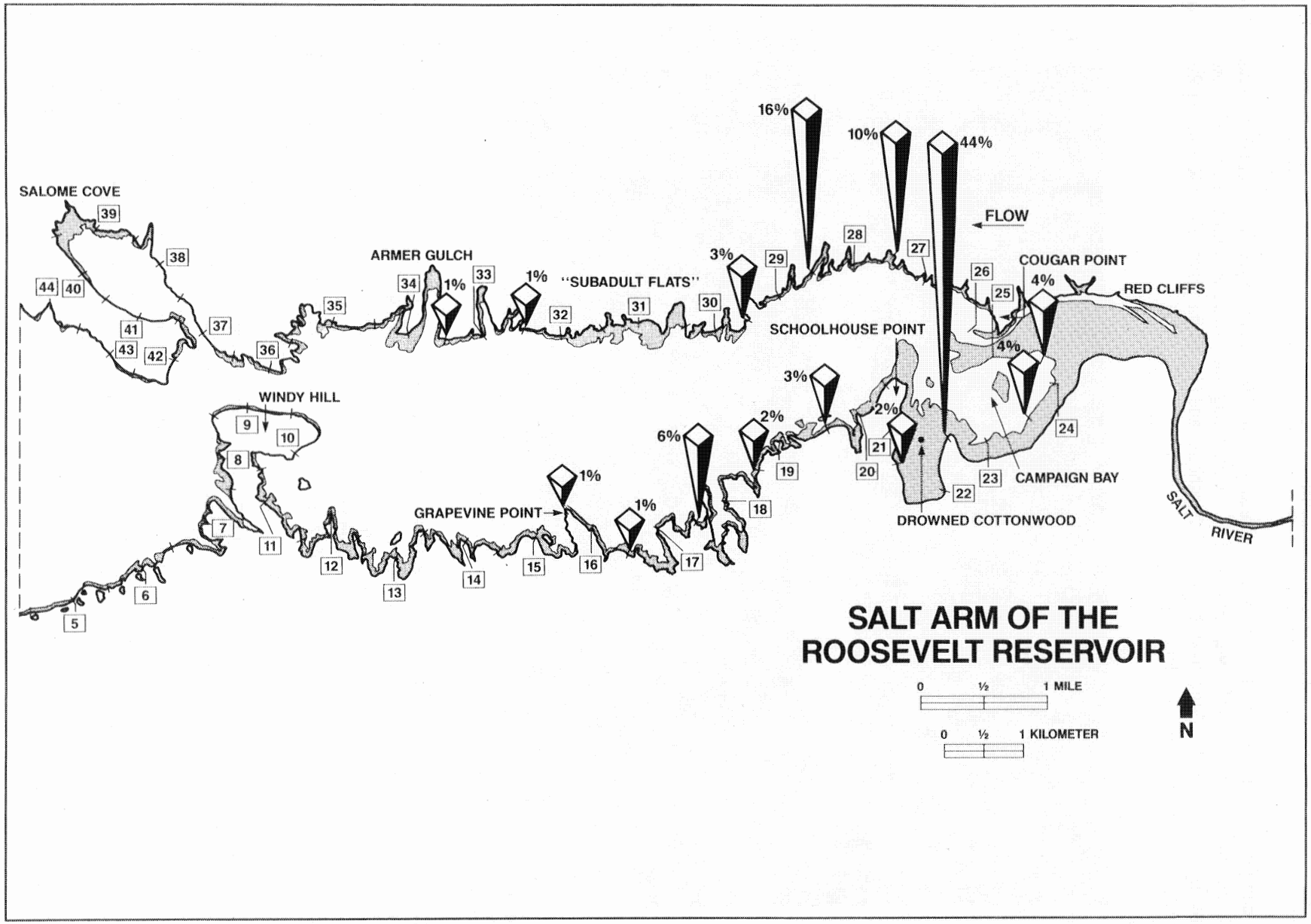


Figure B4.6-5. Distribution of shoreline visits by the Pinal telemetered adult female (AF01) from 4 January to 23 May 1987. These scores, totaling 90 visitations, are expressed as percentages. (Map adapted from Wide World Maps, Inc., © 1986, published by Desert Charts).

to compensate for the loss of territory downstream of Km 109. Interestingly, after AF03 disappeared for the summer in May 1988, we found AF01 again using the Meddler Point area and once as far downstream as Km 93 (Zone 909), between Schoolhouse and Grapevine points along Roosevelt Reservoir. (See Figure B4.6-6 for zone locations).

Plate B32. "Red Cliffs" at the inflow area of Roosevelt Reservoir was a favored area of both telemetered females AF01 (Pinal) and AF03 (Pinto), February 1987 (photo by C. Himmelwright).

B4.6.1.2 Home Range of AF03. As mentioned, AF03 was part of a polygynous triangle with the Pinal pair. Beginning in late January, we often observed the Pinto female (AF03) in the company of the Pinal male (TM01). They perched, flew, and foraged close together and copulated on several occasions on Red Cliffs and on the drowned cottonwood in Campaign Bay. AF03 was involved in nest building activities with TM01 in a cottonwood tree located in a heron rookery at Km 102.5, but it is not known if eggs were laid in 1988.

The home range of the Pinto female (AF03) extended from Salome Bay (Km 87) upstream to Meddler Point (Km 108) for a total of 21 river Kms (Figure B4.6-7). Her home range encompassed much of the area previously used by the Pinal female. Most of AF03's reservoir visitations were to the prominent drowned cottonwood in Campaign Bay favored by AF01 the year before (Figure B4.6-8). She also frequented Red Cliffs from Km 101 through Km 103, a cottonwood snag at Km 105, and various shoreline promontories. However, AF03 less frequently (than AF01) used the main body of the reservoir between Schoolhouse Point and Salome Bay except for a few visits to Grapevine Point. However, she did visit Salome Bay in January and February.

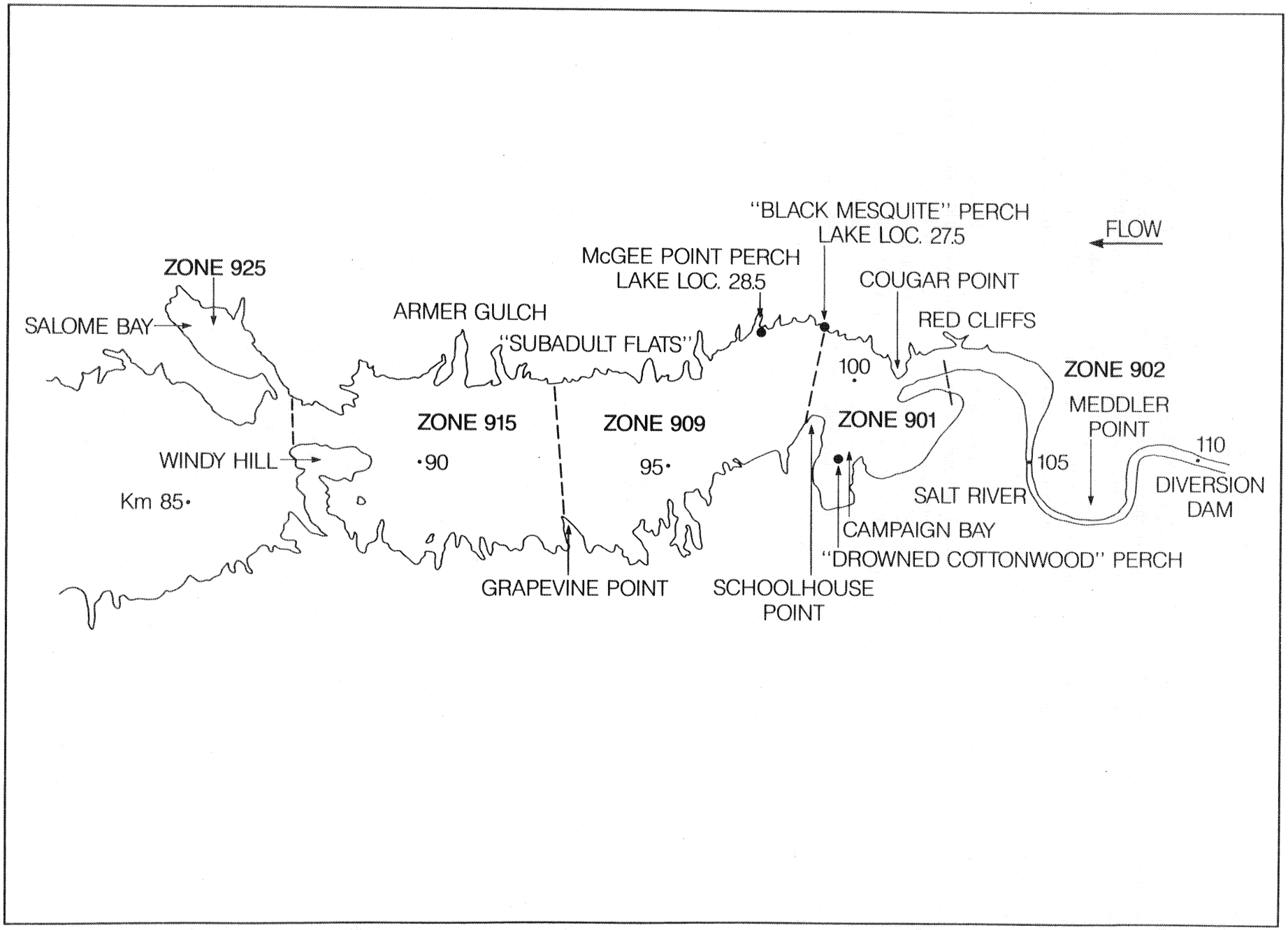


Figure B4.6-6. Salt Arm of Roosevelt Reservoir (with tracking zones indicated).

The Pinto female changed her home range during the 1988 study period. In January, she was observed from Km 87 through Km 102, but she most frequently perched in Campaign Bay (Km 100) and along Red Cliffs (Km 101 and Km 102). In February, in addition to the areas used in January, AF03 extended her home range upstream and began frequenting the riparian habitat between the reservoir and the Meddler Point area. Her favorite perches were a cottonwood snag at Km 105.5 and a few shoreline promontories. During April, AF03 used the area primarily between Red Cliffs and the diversion dam. Like AF01, AF03's home range was larger early in the breeding season than later in the year.

B4.6.1.3 Home Range of the Pinal Male TM01. During telemetry tracking of both females, we obtained incidental data on the movements of the Pinal male (TM01) because his locations often coincided with those of AF01 and AF03, at least prior to the onset of incubation around 4 February 1988. He seemed significantly occupied with AF03 during this period, and even after incubation started at the Pinal nest, TM01 continued to appear downstream of Km 109 in the vicinity of AF03, but less frequently and for shorter periods than previously. The home range of the Pinal male, based on observations in both 1987 and 1988, appeared to follow the Salt River and the Salt arm of Roosevelt Reservoir. We do not know the extent to which he used the Salt River upstream of Km 114.

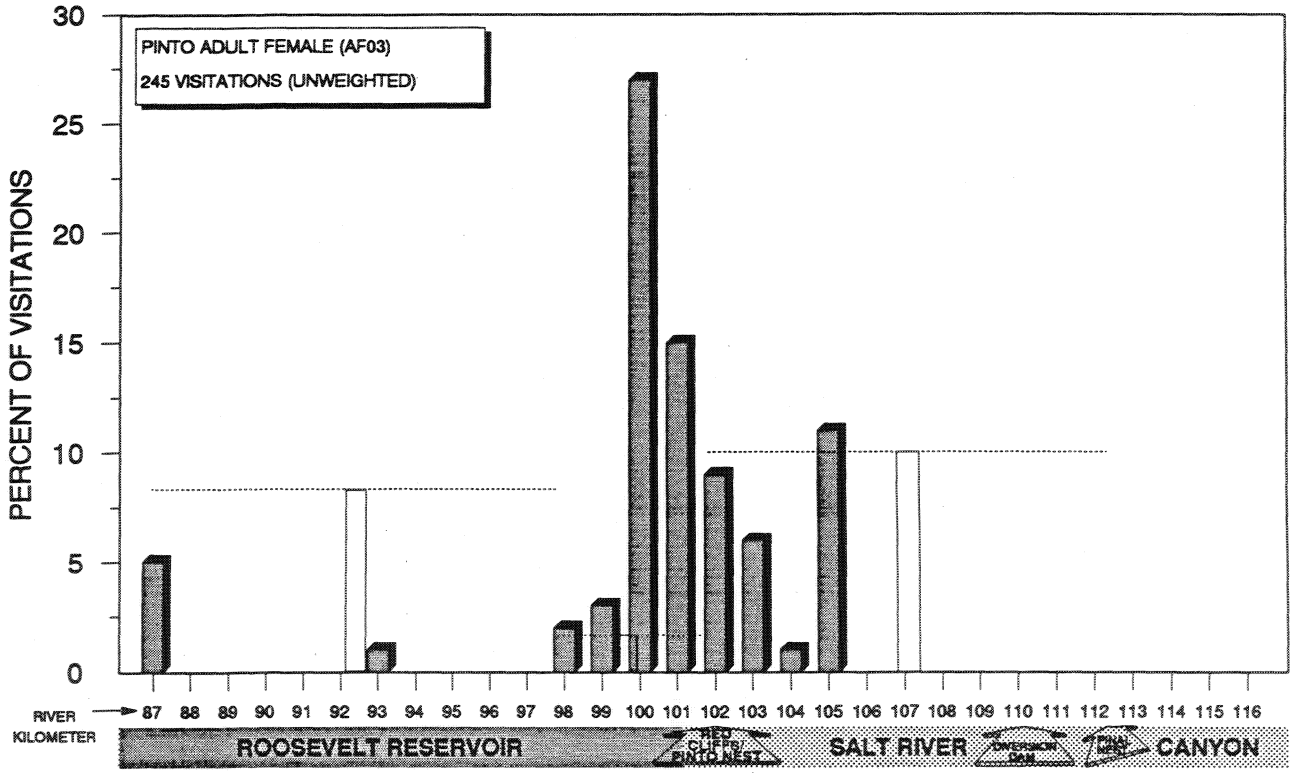


Figure B4.6-7. Home range of the telemetered adult female (AF03) during the 1988 breeding season. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from those bars indicate zones of eagle occupancy for the imprecise locations. The visitation scores are not weighted according to foraging rates in the nest vicinity.

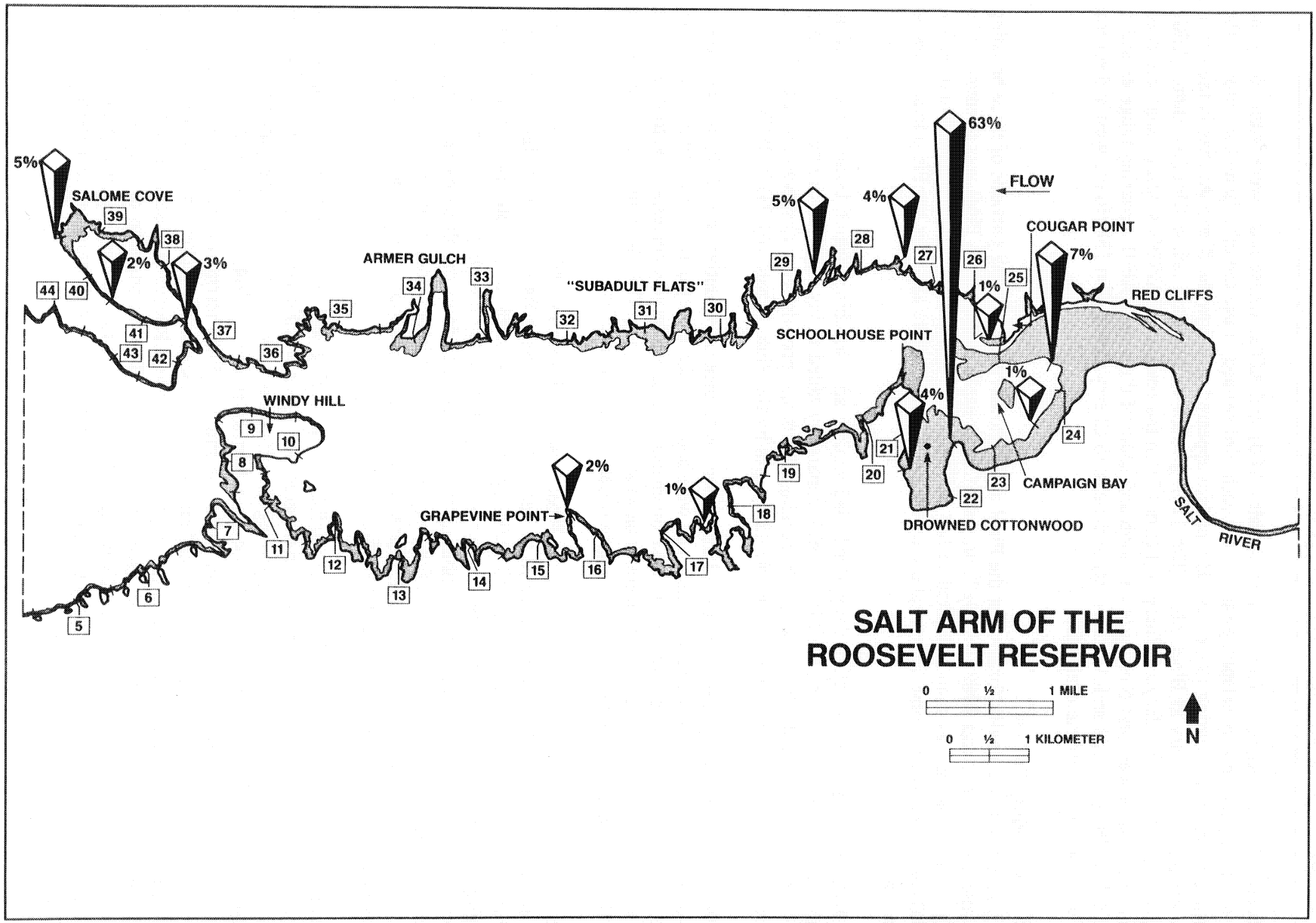


Figure B4.6-8. Distribution of shoreline visits by the Pinto telemetered adult female (AF03) from 3 January to 23 April 1988. These scores, totaling 92 visitations, are expressed as percentages. (Map adapted from Wide World Maps, Inc., © 1986, published by Desert Charts).

B4.6.1.4 Soaring Range. The two adult females AF01 and AF03, whose nests were within 6 airline kms of one another had overlapping ranges, but each bird seemed to use the other's nest location as the outer boundary of its soaring range. AF03's pattern appeared to follow the Sierra Anchas in the north, with an eastern boundary at Black Mesa (Km 117), a southern boundary below Klondike Butte (AF01 nest) and a western boundary at Windy Hill (Km 87) on the reservoir. AF03's soaring range extended 15 air kms east to west and 6 or more km north and south of the river. AF01's soaring range extended from Red Cliffs (Km 103 and AF03's nest) in the east to Cherry Creek (Km 138) in the west and several kms north and south of the drainage.

B4.6.2 Foraging Studies

We investigated bald eagles foraging at the Pinal and Pinto territories during portions of three breeding seasons: 1987, 1988, and 1989. In 1987, only the female eagle (AF01) from Pinal was telemetered so foraging information was mainly limited to her activities. In 1988, we telemetered the Pinto female (AF03) and were able to compare habitat use by the Pinal female before and after the Pinto female nested in the area.

In 1988, after the single nestling from Pinal died shortly after hatching (which became entangled in monofilament fishing line) and the Pinto female apparently failed to lay eggs, we limited our foraging studies at Pinal/Pinto and concentrated our tracking efforts and prey delivery observations at territories where young were present. We did observe 12 forages by the Pinto female (AF03) in 1988.

In 1989, the Pinal male did not assist the Pinto female with incubation duties and the Pinto nest failed. However, the Pinal birds fledged one chick, and were able to observe prey deliveries, mainly by the Pinal male. This bird was not telemetered, but his movements, which had largely corresponded to those of his telemetered mate in previous years, were somewhat predictable in 1989, allowing us to identify the general location of most forages culminating in observed prey deliveries.

B4.6.2.1 Prey Selection. Prey taken by the Pinal female and male in 1987, the Pinto female in 1988, and the Pinal male in 1989 are summarized in Tables B4.6-1 through B4.6-4. Nest failure, transmitter malfunction, and our inability to trap and radio-tag the male resulted in the collection of only partial foraging data in a given year. However, a fairly good picture of the foraging ecology of eagles on the reservoir and river was obtained by combining the foraging data from the three eagles. In general, waterfowl comprised the major portion of the eagles diet in the winter (January and February) although carp and catfish were occasionally taken. Eared grebes, American coots, and green-winged teal were common winter prey of the eagles at Pinal/Pinto.

The eagles foraged heavily on carp and catfish in the spring and early summer; catfish became increasingly important as the nesting season progressed. Black crappie were important in the diet only in late April and early May when post-spawning die-offs occur. We observed similar patterns of black crappie use by eagles at Horseshoe (B4.5.4) and Bartlett reservoirs (B4.1.4). Like Horseshoe, we observed no suckers taken by eagles from either the Pinto or Pinal territories during the entire study, although we did identify two Sonora suckers and one razorback sucker in prey remains (see Section B5.1.5). Suckers are somewhat rare in the Salt River near Roosevelt Reservoir, comprising less than one percent of potential prey fish (see Section E2.1). The introduction of carp and catfish to Roosevelt Reservoir and the upper Salt River might be responsible for limiting sucker populations in the area (see Section E2). Analyses of prey remains collected in the Pinal territory are discussed in Section B5.1.5.

Table B4.6-1. Prey taken by the female bald eagle (AF01) from Pinal breeding area in 1987. Column A indicates number of prey from observed forages. Column B gives estimated whole biomass (grams) of prey items shown in A. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals					B. Whole Biomass (grams)				
	28-Day Period:					28-Day Period:				
Species	1/04/87–1/31/87	2/01/87–2/28/87	3/01/87–3/28/87	6/21/87–1/02/88	Total	1/04/87–1/31/87	2/01/87–2/28/87	3/01/87–3/28/87	6/21/87–1/02/88	Total
FishSpecies										
Carp	1 17%	3 33%		1 11%	5 20%	462 8%	2,997 49%		368 6%	3,827 20%
Probable Carp				2 22%	2 8%				1,158 18%	1,158 6%
Flathead Catfish	1 17%			1 11%	2 8%	3,872 63%			1,663 27%	5,535 29%
Channel Catfish		2 22%			2 8%		1,204 20%			1,204 6%
Black Crappie										
Largemouth Bass										
Unknown Bass	1 17%				1 4%	88 1%				88 0%
Unknown Fish		2 22%		2 22%	4 16%		565 9%		216 3%	781 4%
Subtotal	3 50%	7 78%		6 67%	16 64%	4,422 72%	4,766 78%		3,405 54%	12,593 66%
Other Species										
Coot	1 17%	1 11%			2 8%	642 10%	642 11%			1,284 7%
Eared Grebe	1 17%				1 4%	297 5%				297 2%
Western Grebe				1 11%	1 4%				1,477 24%	1,477 8%
Green-winged Teal										
Unidentified Waterfowl	1 17%				1 4%	767 13%				767 4%
Subtotal	3 50%	1 11%		1 11%	5 20%	1,706 28%	642 11%		1,477 24%	3,825 20%
Unidentified Carrion		1 11%	1 100%	2 22%	4 16%		693 11%	693 100%	1,386 22%	2,772 14%
TOTAL	**6 100%**	**9 100%**	**1 100%**	**9 100%**	**25 100%**	**6,128 100%**	**6,101 100%**	**693 100%**	**6,268 100%**	**19,190 100%**

Table B4.6-2. Prey taken by the male bald eagle (TM01) from Pinal breeding area in 1987. Column A indicates number of prey from observed forages. Column B gives estimated whole biomass (grams) of prey items shown in A. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals					B. Whole Biomass (grams)				
	28-Day Period:					28-Day Period:				
Species	12/7/86–1/3/87	1/4/87–1/31/87	2/1/87–2/28/87	3/1/87–3/28/87	Total	12/7/86–1/3/87	1/4/87–1/31/87	2/1/87–2/28/87	3/1/87–3/28/87	Total
Fish Species										
Carp		1 25%	1 14%		2 14%		288 18%	814 21%		1,102 15%
Channel Catfish			1 14%		1 7%			920 24%		920 13%
Unknown Centrarchid			1 14%		1 7%			409 11%		409 6%
Unknown Fish	1 50%		1 14%	1 100%	3 21%	711 71%		711 19%	711 100%	2,133 30%
Subtotal	1 50%	1 25%	4 57%	1 100%	7 50%	711 71%	288 18%	2,854 75%	711 100%	4,564 64%
Other Species										
Eared Grebe	1 50%	2 50%	1 14%		4 29%	297 29%	594 38%	297 8%		1,188 17%
American Coot			1 14%		1 7%			642 17%		642 9%
Carrion		1 25%	1 14%		2 14%		693 44%	36 1%		729 10%
Subtotal	1 50%	3 75%	3 43%	0 0%	7 50%	297 29%	1,287 82%	975 25%	0 0%	2,559 36%
TOTAL	**2 100%**	**4 100%**	**7 100%**	**1 100%**	**14 100%**	**1,008 100%**	**1,575 100%**	**3,829 100%**	**711 100%**	**7,123 100%**

Table B4.6-3. Prey taken by the female bald eagle (AF03) from Pinto breeding area in 1988. Column A indicates number of prey from observed forages. Column B gives estimated whole biomass (grams) of prey items shown in A. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Number of Individuals					B. Whole Biomass (grams)				
	28-Day Period:					28-Day Period:				
Species	1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	3/27/88–4/23/88	Total	1/03/88–1/30/88	1/31/88–2/27/88	3/01/88–3/26/88	3/27/88–4/23/88	Total
Fish Species										
Carp				1 100%	1 8%				962 100%	962 13%
Black Crappie		1 17%			1 8%		890 25%			890 12%
Largemouth Bass		1 17%			1 8%		529 15%			529 7%
Unknown Bass			1 33%		1 8%			630 42%		630 9%
Unknown Fish		1 17%	2 67%		3 25%		508 14%	880 58%		1,388 19%
Subtotal		3 50%	3 100%	1 100%	7 58%		1,927 53%	1,510 100%	962 100%	4,399 60%
Other Species										
Coot	2 100%	1 17%			3 25%	1,284 100%	642 18%			1,926 26%
Green-winged Teal		1 17%			1 8%		341 9%			341 5%
Subtotal	2 100%	2 33%			4 33%	1,284 100%	983 27%			2,267 31%
Unidentified Carrion		1 17%			1 8%		693 19%			693 9%
TOTAL	**2 100%**	**6 100%**	**3 100%**	**1 100%**	**12 100%**	**1,284 100%**	**3,603 100%**	**1,510 100%**	**962 100%**	**7,359 100%**

Table B4.6-4. Prey taken and prey delivered to nest by the male bald eagle (TM01) from Pinal breeding area in 1989. Column A indicates number of prey from observed forages plus prey deliveries to the nest. Column B gives estimated whole biomass (grams) of all prey items shown in A. Column C shows biomass (whole or partial) actually delivered to nest. Percentages expressed as percent of column total rounded to nearest whole number.

	A. Total Number				B. Total Biomass			
	28-Day Period:				28-Day Period:			
Species	3/26/89 4/22/89	4/23/89– 5/20/89	5/21/89– 6/17/89	Grand Total	3/26/89– 4/22/89	4/23/89– 5/20/89	5/21/89– 6/17/89	Total
Fish Species								
Carp		4 9%	1 6%	5 8%		3,598 9%	2,480 22%	6,078 12%
Flathead Catfish		4 9%		4 6%		18,773 46%		18,773 36%
Channel Catfish	1 33%	16 36%	10 63%	27 42%	218 31%	7,181 18%	6,078 53%	13,477 26%
Unknown Catfish			1 6%	1 2%			574 5%	574 1%
Black Crappie		9 20%		9 14%		4,387 11%		4,387 8%
Largemouth Bass		4 9%	1 6%	5 8%		1,900 5%	137 1%	2,037 4%
Unknown Centrarchid		2 4%		2 3%		699 2%		699 1%
Unknown Fish	2 67%	4 9%	3 19%	9 14%	493 69%	2,707 7%	2,133 19%	5,333 10%
Subtotal	3 100%	43 96%	16 100%	62 97%	711 100%	39,245 97%	11,402 100%	51,358 97%
Other Species								
Coot		1 2%		1 2%		642 2%		642 1%
Unidentified Carrion		1 2%		1 2%		693 2%		693 1%
Subtotal		2 4%		2 3%		1,335 3%		1,335 3%
TOTAL	**3 100%**	**45 100%**	**16 100%**	**64 100%**	**711 100%**	**40,580 100%**	**11,402 100%**	**52,693 100%**

Table B4.6-4. (Continued)

Species	C. Biomass Delivered to Nest (grams) 28-Day Period: 3/26/89–4/22/89	4/23/89–5/20/89	5/21/89–6/17/89	Total
Fish Species				
Carp		2,065 *(2) 12%	124 (1) 3%	2,189 (3) 10%
Flathead Catfish		2,869 (3) 17%		2,869 (3) 13%
Channel Catfish	218 (1) 31%	5,284 (12) 31%	3,681 (9) 93%	9,183 (22) 42%
Unknown Catfish				
Black Crappie		3,926 (9) 23%		3,926 (9) 18%
Largemouth Bass		1,816 (4) 10%	137 (1) 3%	1,953 (5) 9%
Unknown Centrarchid				
Unknown Fish	493 (2) 69%	711 (1) 4%		1,204 (3) 5%
Subtotal	711 (3) 100%	16,671 (31) 96%	3,942 (11) 100%	21,324 (45) 97%
Other Species				
Coot		642 (1) 4%		642 (1) 3%
Unidentified Carrion				
Subtotal		642 (1) 4%		642 (1) 3%
TOTAL	**711 (3) 100%**	**17,313 (32) 100%**	**3,942 (11) 100%**	**21,966 (46) 100%**

* Numbers in parentheses refer to number of prey items in Column A actually delivered to nest. Those not delivered were consumed elsewhere by adults.

We were able to monitor the foraging activity of the breeding Pinal male from several observation points during April to June 1989. Remarkably, he delivered all but one of the 47 prey items to the nest; the female brought only one item (Table B4.6-5). This unusual foraging imbalance between the sexes possibly resulted from Pinto female's exclusion of the Pinal female from the reservoir.

Table B4.6-5. Summary of estimated biomass (grams) of prey delivered to the Pinal territory bald eagle nest in 1989 by the adult male (TM01). Numbers in parentheses represent number of individuals delivered to the nest. Some species are grouped for analysis. Percentages expressed as percent of column total rounded to nearest whole number.

	OBSERVATION PERIOD/DAYS OBSERVED											
Species	4/09–4/22/89 3 days			4/23–5/06/89 8 days			5/07–5/20/89 8 days			5/21–6/03/89 8 days			TOTAL 27 days		
Fish Species															
Carp				997	(1)	13%	1,068	(1)	11%	124	(1)	3%	2,189	(3)	10%
Catfish sp.	218	(1)	31%	2,399	(5)	31%	5,754	(10)	59%	3,681	(9)	93%	12,052	(25)	55%
Crappie sp.				3,090	(6)	41%	836	(3)	9%				3,926	(9)	18%
Largemouth Bass				421	(1)	6%	1,395	(3)	14%	137	(1)	3%	1,953	(5)	9%
Unknown Fish	493	(2)	69%	711	(1)	9%							1,204	(3)	5%
Subtotal	711	(3)	100%	7,618	(14)	100%	9,053	(17)	93%	3,942	(11)	100%	21,324	(45)	97%
Other Species															
American Coot							642	(1)	7%				642	(1)	3%
TOTAL	**711**	**(3)**	**100%**	**7,618**	**(14)**	**100%**	**9,695**	**(18)**	**100%**	**3,942**	**(11)**	**100%**	**21,966**	**(46)**	**100%**

Fish species dominated the male's prey deliveries and represented 97 percent of the biomass delivered during the observation periods. Catfish were the most important prey, both numerically (54%) and by percent biomass (55%). Considering biomass, crappie (18%) were next most important, followed by carp (10%) and largemouth bass (9%). As reported above, catfish use increased in the late spring when crappie utilization from post-spawn die-offs declined.

B4.6.2.2 Geography of Foraging. Bald eagles at the Pinal breeding area have been known to forage on the Salt River, from the bend upstream of the nest (Km 114) to the cliffs east of Cougar Point (Km 102)(Haywood and Ohmart 1982, Haywood and Ohmart 1983, LaValley and LaValley 1983, Grubb *et al.* 1983, Browne *et al.* 1984, Grubb 1984, Secunda 1985, Myers 1985, Grubb 1986a, Behn and VonGonten 1987, Day and Bond 1989). The eagles were reported soaring over Roosevelt Reservoir and the washes on the north shore of the reservoir (LaValley and LaValley 1983, Browne *et al.* 1984,

Secunda 1985, Myers 1985, Behn and VonGonten 1987, Day and Bond 1989); however, these earlier workers observed only one forage on the reservoir: along the shore near School House Point (LaValley and LaValley 1983). Although ABENWP nestwatchers noted the eagles flying to the reservoir, they usually lost sight of the birds, so most observed foraging was on the river. In contrast to other years, LaValley and LaValley (1983) reported mostly mammal prey and upland forages. Several observers noticed a shift to use of the river upstream of Pinal Creek after the beginning of May (Haywood and Ohmart 1983, Browne *et al.* 1984, Behn and VonGonten 1987). This shift coincided with lower flows in the Salt.

In the current study, the eagles foraged on both the river and the reservoir. As shown above, habitat use by the Pinal female (AF01) from telemetry data clearly differed between 1987 and 1988. In 1987, she made numerous visitations to Roosevelt Reservoir in January and February where she preyed mainly on waterfowl. Later in the nesting season, visitations to the reservoir decreased and the female spent more time in the nest area. She also used the Salt River during the nesting season preferring the area between Meddler Point and Campaign Bay. In 1988, we recorded no visits by AF01 to the reservoir or to the Salt River between Meddler Point and Campaign Bay. The shift in habitat use between the two years was probably related the appearance of the Pinto female and the fact that the Pinal nest failed at an early stage in the chick cycle.

B4.6.2.3 AF01's Movements in Winter and Early Spring 1987. During winter, all foraging observations of the Pinal pair occurred on Roosevelt Reservoir. Given the constancy of telemetric and visual observation, the high frequency of observed forages, and the home range limits described above, it is probable that all or almost all prey attempts by AF01 during this period occurred on the reservoir, although the male may occasionally have foraged elsewhere (Figure B4.6-9).

Prior to 23 January, all observed forages had occurred west of a north-south line through river Km 96.5, the open water of Roosevelt Reservoir off Grapevine Point. During this period both adults flew directly to the area in the early morning, typically perching in a live mesquite east of Griffin Wash, or on McGee Point. The eagles occasionally "strafed" large rafts of eared grebes and American coots, but appeared to take live single grebes from the open water. We observed that the numbers of eared grebes decreased at about the time the eagles stopped frequenting the Grapevine Point area. Several of the grebes appeared to be asleep when the eagles took them, as they showed no evasive action (J. Linthicum notes).

After 23 January, bald eagle foraging was concentrated in Campaign Bay east of Schoolhouse Point and to a lesser extent in the waters west of Schoolhouse Point (Figure B4.6-9). In Campaign Bay AF01 often perched in a large drowned cottonwood upon arrival at the reservoir, and both members of the pair frequently hunted from this tree, using it to survey the area. Activity in the bay included piracies as well as direct attempts on live and carrion fish and live waterfowl. We observed two piracies by bald eagles from northern harriers that had killed American coots, several from common ravens with carrion, and one piracy from a great blue heron with an unknown prey item.

Several features of Campaign Bay appeared to attract foraging eagles. The bay is enclosed on three sides, probably acting to trap carrion drifting downriver into the reservoir or carrion blown from the open water areas of the reservoir. The bay also provides protection for a diversity of waterfowl feeding in the shallows. Some fish species may move into shallow water to feed during the day (e.g. carp) and may be more vulnerable to eagle attacks there. This small bay contains an estuary-like habitat created by the inflow area of the river. These features, a variety of shoreline vegetation, and seasonal dewatering (see

also Horseshoe breeding area, Section B4.5) apparently support a rich food base for prey species and more diverse foraging opportunities for eagles than other areas within the Pinal pair's home range.

In the latter part of February, AF01 began frequenting the riparian habitat between the reservoir and the diversion dam, especially the Meddler Point area. Two attempted forages on waterfowl, one on an American coot and one on a mixed group of ducks, occurred in the river channel below the diversion dam.

B4.6.2.4 AF01's Movements in Late Spring-Early Summer 1987. Visual and telemetry data during late-spring–early-summer indicated that eagles shifted their core-use area from the reservoir to the Salt River. The most evident differences in the birds' habitat-use patterns noted during early summer included: (1) infrequent use of the reservoir; (2) use of the riverine habitat between Meddler Point and the mouth of the Salt River; and, (3) use of Km 114 ("White Cliffs") upstream of the nest site.

Only one of 13 observed foraging attempts in late spring and early summer occurred on Roosevelt Reservoir, although the eagles perched occasionally at the inflow area. However, they hardly used the drowned cottonwood in Campaign Bay which they frequented in winter and early spring. We saw the male perched in this tree only once in May.

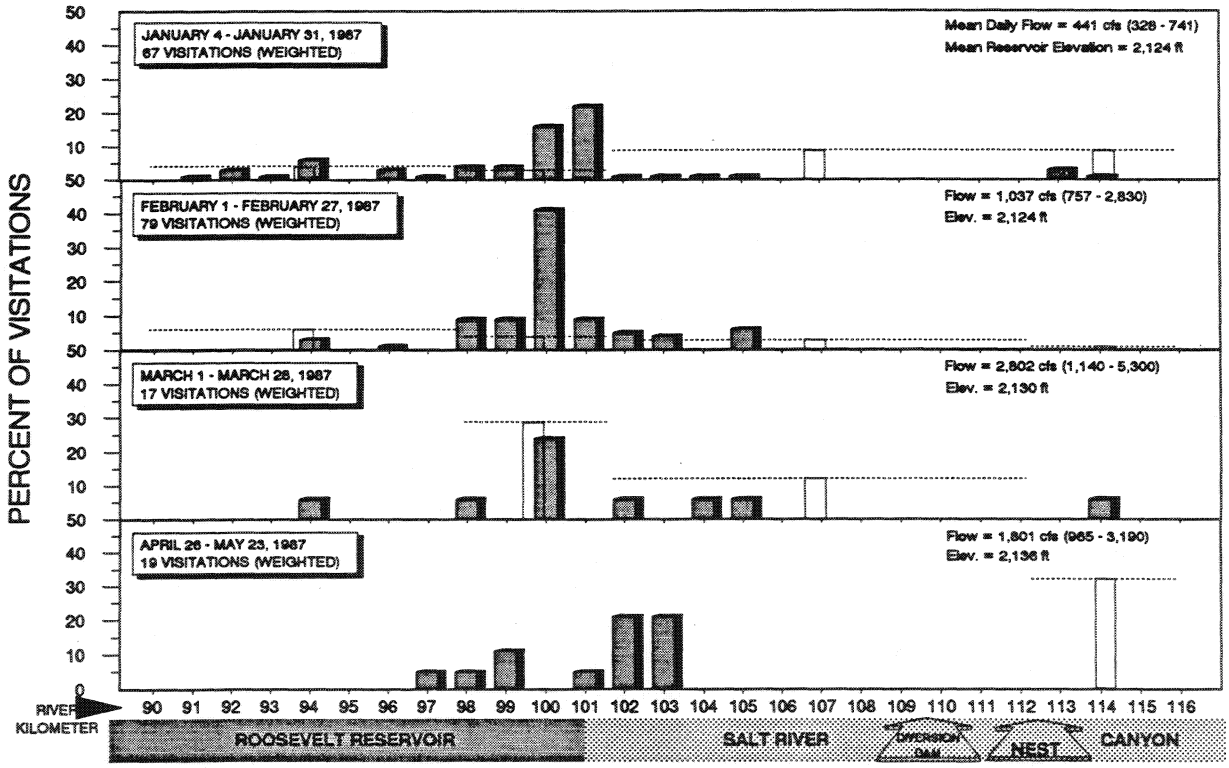


Figure B4.6-9. Seasonal changes in the distribution of visitations (%) by the telemetered Pinal adult female (AF01) during 4 January to 23 May 1987. Visitation percentages at Km 112 (nest vicinity) were weighted according to the proportion of total prey deliveries by the female from those segments during each period. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from these bars indicate zones of eagle occupancy for the imprecise locations.

Plate B33. Daniel Driscoll collecting bald eagle prey remains from the "drowned cottonwood" in Campaign Bay on Roosevelt Reservoir, February 1987. The snag-top tree was a favored perch of the Pinal and Pinto eagles (photo by C. Himmelwright).

The Pinal birds used the area from Meddler Point to the mouth of the river from May to July; the female perched on various shoreline promontories there. Habitat characteristics which may have contributed to the attraction of this area included long, slow, shallow runs and several shallow riffles near Meddler Point. Terrestrial shoreline habitat consisted of many large gravel bars and islands plus long sections of vertical cut-banks or cliffs roughly 25 m in height. Two extensive stands of mature riparian vegetation, one dominated by cottonwood and the other by mesquite and willow, flanked the reach. Emergent and aquatic vegetation, while not widespread or well-developed, was locally abundant at several sites in this

area. The potential for human disturbance was relatively low compared to Campaign Bay. By mid-June, shallow water impeded boat access upstream beyond Km 103.

Shallow water conditions from Meddler Point to the inflow of the reservoir not only provided favorable habitat for eagles hunting for live fish, but apparently acted as a natural carrion trap. Turkey vultures (as many as 34 on one occasion) were seen on a regular basis at the western end of Meddler Point. As an example, while conducting an incidental carrion survey along this section of the river, we found the remains of two suckers and six flathead catfish, ranging in total length from 45 to 65 cm.

The segment of the Salt River below the diversion dam to Meddler Point was a popular spot for people fishing for largemouth bass and catfish. Some of the carrion observed downstream probably originated from anglers discarding unwanted fish and fish parts and from other angler-induced mortality. AF01 took carrion on three of six (50%) successful forages along this section of the river; on one occasion she displaced several turkey vultures from a carrion item.

Shortly before the fledging of two young on 25 May and 29 May, the Pinal bald eagles shifted their normal perching location from the nest site to Km 114 further upstream. The male began using the area first. Once the juveniles fledged, both adults and young invariably roosted and perched along this section of the Salt River (White Cliffs). Before 2 July, we never recorded the juveniles outside this area or the vicinity of the nest, except for once (22 June) when AF01 and one of the young fed on carrion at Meddler Point (Km 105.5). Two of the 13 (15%) forage attempts observed in late spring and early summer occurred in Km 114.9 and 114.5. The one successful attempt yielded a flathead catfish.

During this period, the aquatic habitat found from Km 113.5–115.5 included two deep pools and several slow to moderately fast shallow runs interspersed with three super-riffles. A series of cut-banks, cliffs (>25 m in height) and debris slopes at various distances from the water's edge dominated the terrestrial habitat on the south side of the river. In contrast, a large gravel/sand bar gradually sloping into the river defined the right shoreline. A 180-degree bend in the river formed an amphitheater providing numerous perches overlooking the river. The orientation of cliffs at this site provided shaded perches, a probable benefit to the eagles as summer temperatures increased.

B4.6.2.5 Telemetry Studies in 1988. In 1988, we did not record any visitations to Roosevelt Reservoir by the Pinal female. Similarly, the female eagle did not appear to frequent the Salt River between Meddler Point and Campaign Bay. AF01 restricted her visitations to the Salt River above Km 108, and many of her visitations to the Salt River outside the nest area were between Km 109 and 111. In 1987, we had not recorded a single visitation to this area of river. Although AF01's nest failed in 1988, strongly reducing foraging requirements, differences in visitations by the Pinal female in 1987 and 1988 were no doubt largely a direct response to the Pinto female nesting along the Salt River in Km 101. The exclusion of AF01 from the area by the Pinto female in 1988 is suspected because AF01 apparently did not visit the reservoir even before the loss of her young in early April, whereas the previous year she had frequented the reservoir throughout the winter and early spring. The Pinal male copulated with both female eagles and he foraged freely in the Salt River and Roosevelt Reservoir.

Telemetry data of the Pinto female (AF03) in 1988 illustrates her occupation of much of AF01's former home range. In the winter, the Pinto female made frequent visitations to the Salt Arm of Roosevelt Reservoir presumably foraging on the abundant waterfowl present (Figure B4.6-10). Much of her activity was concentrated in Campaign Bay. The Pinto female also used the Salt River from Meddler Point to

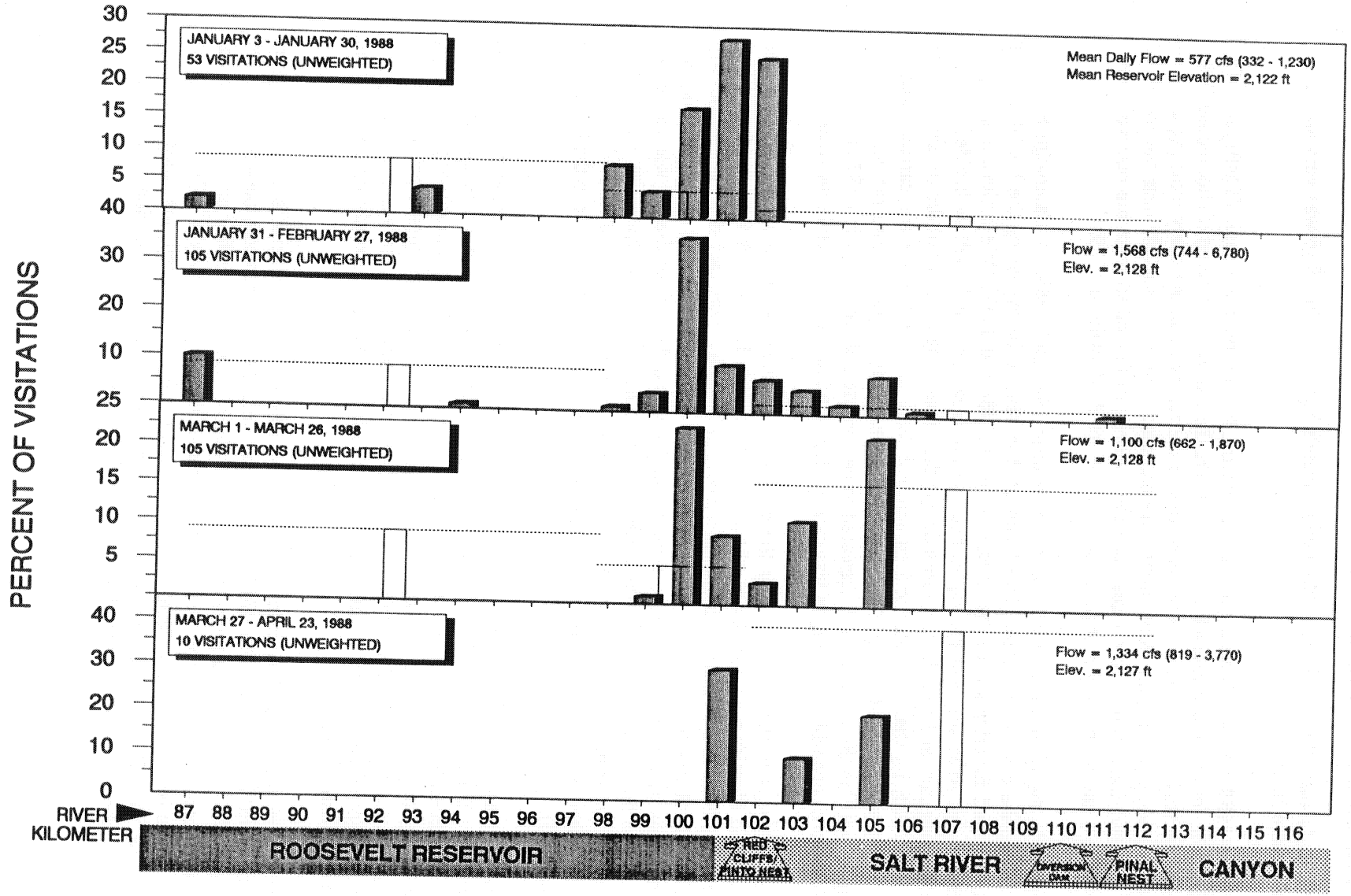


Figure B4.6-10. Seasonal changes in the distribution of unweighted visitations (%) by the telemetered Pinto adult female (AF03) during 3 January to 23 April 1988. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from these bars indicate zones of eagle occupancy for the imprecise locations.

Campaign Bay from January through April. The Pinto female's habitat use in 1988 was very similar to that of the Pinal female in 1987.

B4.6.2.6 Studies in 1989. Although we do not have telemetry data for the male eagle (TM01) in 1989, we frequently saw him foraging in Roosevelt Reservoir where the Salt River entered (Schoolhouse Point to Cougar Point). In May, TM01 made daily visitations to the reservoir in the early morning and late afternoon to forage mainly on catfish. Most prey were captured from the reservoir near the mouth of the Salt River. Observations at the nest revealed that the majority of fish taken from the reservoir were carrion. Table B4.6-6 shows the origin of prey captured by the Pinal male in 1989.

The water elevation in the reservoir in 1989 was lower than in 1987 and 1988, so Campaign Bay was dewatered. Although we cannot be certain, TM01 appeared in May to be bypassing the Meddler Point area that was a preferred foraging site of the female eagles in 1988 and 1987. We believe that in past years the Meddler Point Area attracted the eagles because the area contained shallow braided riverine habitat which migrating carp and catfish must cross during their spawning runs out of the reservoir. The Meddler Point area, with its shallow water and numerous bends, also probably traps carrion floating downriver. In 1989, low spring flows probably resulted in less fish migrating into the Salt River to spawn. Angling activity on the river in 1989 appeared to be considerably less than in 1987 or 1988 due to low water conditions, probably resulting in less carrion deposited in the Meddler Point Area.

We conducted six surveys in the reservoir near the confluence of the river in late May to determine carrion abundance and identify potential causes of fish die-offs (Table B4.6-7). A total of 29 potential prey items were found dead in the reservoir in the six surveys in late May, with catfish (n = 15) and carp (n = 7) being the most abundant items. Only one out of 16 fish examined contained a fishing hook, and none showed any signs of external damage, so it seems unlikely that the catfish die-off was caused by recreational activity in the area. Neither did the catfish appear to have died from spawning stress; most were not in reproductive condition. No external or internal parasites were detected in the carrion fish we examined. We observed a similar die-off of channel catfish on Horseshoe Reservoir in the late-spring in 1988 (Section B4.5).

We do not know the cause of the catfish die-off in Roosevelt Reservoir in 1989 or whether the event was a normal occurrence. During the commercial production of catfish, mortality of 20–30 cm fish is not uncommon and is generally attributed to a virus (pers. comm. M. Beem, Parasitology Division, Oklahoma Fish and Wildlife Service). However, this virus rarely accounts for significant mortality in wild populations. Biologists in Arkansas have observed die-offs of catfish in reservoirs caused by low dissolved oxygen in combination with an outbreak of a bacterial disease (M. Armstrong pers. comm. Arkansas Game and Fish Comm.).

We took 14 measurements of dissolved oxygen in the Roosevelt Reservoir and several isolated ponds near the confluence on 31 May 1989 between 0745 and 1020 hr., and 29 measurements between 1100 and 1815 hr., to check if low D.O. was a problem; the lowest D.O. measured was 6.9 ppm. Catfish can tolerate D.O. as low as 1 ppm but grow best at D.O. greater than 3 ppm (Moyle 1976). Therefore, D.O. did not appear to be a contributing factor in the catfish die-offs. A. Mitchell, toxicologist with the Arkansas Game and Fish Department, thinks that toxins released from ingested blue-green algae or dinoflagelates are a likely cause of the die-offs in Roosevelt Reservoir.

Table B4.6-6. Origin of prey taken by the Pinal adult male bald eagle in 1989. Not all prey items delivered to nest. Numbers in parentheses are forages observed of AF03, the Pinto female, and are not included in totals.

Observation Period	Species	West of Schoolhouse Point 900	Salome Bay to Grapevine Point Km 88.0-93.0 915	Grapevine Point to Schoolhouse Point 93.0-97.9 909	Schoolhouse Point to River Mouth 98.0-101.7 901	River Mouth to Hwy 88 Bridge 101.8-112.3 902	Diversion Dam Area 108.5-110.9 919	Nest Cliff Area Km 0.4 Pinal Creek 904	White Stripe Cliffs Km 113-115 911	Unknown 444	Total
4/9/89-4/22/89	Carp	-	-	-	(1)	-	-	-	-	-	0 0%
	Channel Catfish	-	-	-	-	-	-	-	1	-	1 33%
	Unknown Fish	-	-	-	-	-	-	-	1	1	2 67%
Total	**%**	**0 0%**	**0 0%**	**0 0%**	**0 0%**	**0 0%**	**0 0%**	**0 0%**	**2 67%**	**1 33%**	**3 100%**
4/23/89-5/20/89	Carp	-	-	-	3	-	-	-	1	-	4 9%
	Channel Catfish	2	-	1	10	1	-	1	-	1	16 36%
	Flathead Catfish	-	-	-	2	-	-	-	2	-	4 9%
	Largemouth Bass	-	-	-	1	-	-	-	-	3	4 9%
	Crappie sp.	-	1	1	7	-	-	-	-	-	9 20%
	Lepomis sp.	-	-	-	1	-	-	-	-	-	1 2%
	Unknown Centrarchid	-	-	-	1	-	-	-	-	-	1 2%
	Unknown Fish	-	1	-	2	-	-	-	-	1	4 9%
	American Coot	-	-	-	1	-	-	-	-	-	1 2%
	Unknown Prey	-	-	-	1	-	-	-	-	-	1 2%
Total	**%**	**2 4%**	**2 4%**	**2 4%**	**29 64%**	**1 2%**	**0 0%**	**1 2%**	**3 7%**	**5 11%**	**45 100%**

Table B4.6-6. (Continued)

Observation Period	Species	West of Schoolhouse Point 900	Salome Bay to Grapevine Point Km 88.0-93.0 915	Grapevine Point to Schoolhouse Point 93.0-97.9 909	Schoolhouse Point to River Mouth 98.0-101.7 901	River Mouth to Hwy 88 Bridge 101.8-112.3 902	Diversion Dam Area 108.5-110.9 919	Nest Cliff Area Km 0.4 Pinal Creek 904	White Stripe Cliffs Km 113-115 911	Unknown 444	Total
5/21/89-6/3/89	Carp	-	-	-	-	-	-	-	-	1	1 6%
	Channel Catfish	-	-	-	8	-	-	-	-	2	10 63%
	Catfish sp.	-	-	-	1	-	-	-	-	-	1 6%
	Largemouth Bass	-	-	-	1	-	-	-	-	-	1 6%
	Unknown Fish	-	-	-	2	-	1	-	-	-	3 19%
Total	**%**	**0 0%**	**0 0%**	**0 0%**	**12 75%**	**0 0%**	**1 6%**	**0 0%**	**0 0%**	**3 19%**	**16 100%**

Table B4.6-7. Summary of carrion observed in Roosevelt Reservoir in late May 1989.

Date	Start Time	End Time	Survey Route	Method	Carrion Found	Total Length	Reproductive Status	Notes
5/16/89	845	1030	Schoolhouse Pt.	Boat	Channel catfish	659	Spawned out	No food/hooks
					Channel catfish	171		Stomach empty
					Carp	300		
5/18/89	830	—	Schoolhouse Pt. to Windy Pt.	Boat	Largemouth bass	341	Regenerated	No food/hooks, found in open water
					Flathead catfish	579	Regenerated	No food/hooks, found in open water
					Carp	393		Algae in gut, found in open water
					Flathead catfish	750		Being eaten by vultures; no hooks, found on shore
					Grebe/coot			Badly decomposed
					Black crappie	341	Spawned out	Hook in throat
					Blue gill	183	Milt released	Badly decomposed; found in open water
5/27/89	1350	1512	Schoolhouse Pt. to Windy Pt.	Boat	Carp	368		No hooks, 60 m offshore
					Channel catfish	295		No hooks, 30 m offshore
					Channel catfish	240		No hooks, est. on length tail gone
					Channel catfish	290		No hooks
					Unid. bird			300 m offshore
5/28/89	656	1200	Mud flat–Campaign Bay	Boat	Channel catfish	233		No hooks
					Channel catfish	200		No hooks, ½ eaten
					Carp	598	Spawned out	Male, no hooks
					Carp	400	Spawned out	Male, no hooks
					Channel catfish	360	Spawned out	No hooks
					Carp	455		No hooks
5/29/89	808	1008	Schoolhouse Pt. to Windy Hill	Boat	Channel catfish	250		Half eaten, no hooks
					Carp	370		Partly decomposed, no hooks
5/30/89	1500	1610	Mud Flat–Campaign Bay	Snorkeling	Channel catfish	255		
					Channel catfish	222		
					Channel catfish	255		
					Channel catfish	222		
					Largemouth bass	337		

B4.6.2.7 Observed Foraging. During 1987–1989, we observed 168 forages. Eighty-four (50%) of these observations were of the resident male, TM01, even though he had no radio-tag. We observed 41 forages (24%) by the Pinal female AF01, and 14 (8%) by the Pinto female AF03; the remainder of the observed forages were of other eagles.

Observed forages in this breeding area were primarily on the reservoir, although we recorded forages on both fish and waterfowl on the river. Figure B4.6-11 shows the general distribution of observed forages in this breeding area. Foraging on the reservoir was observed mainly occurred in Zone 901, the portion of reservoir closest to the river inlet and including Campaign Bay. The attraction of the Pinal and Pinto eagles on the inflow area suggests that the estuary of the free-flowing Salt River is at least as richly productive of eagle prey and carrion as the inflow of the Verde River into Horseshoe Reservoir where a productive eagle pair obtains the bulk of its food. If anything, Campaign Bay would seem to be intrinsically better suited to eagles because of its far more extensive shallows.

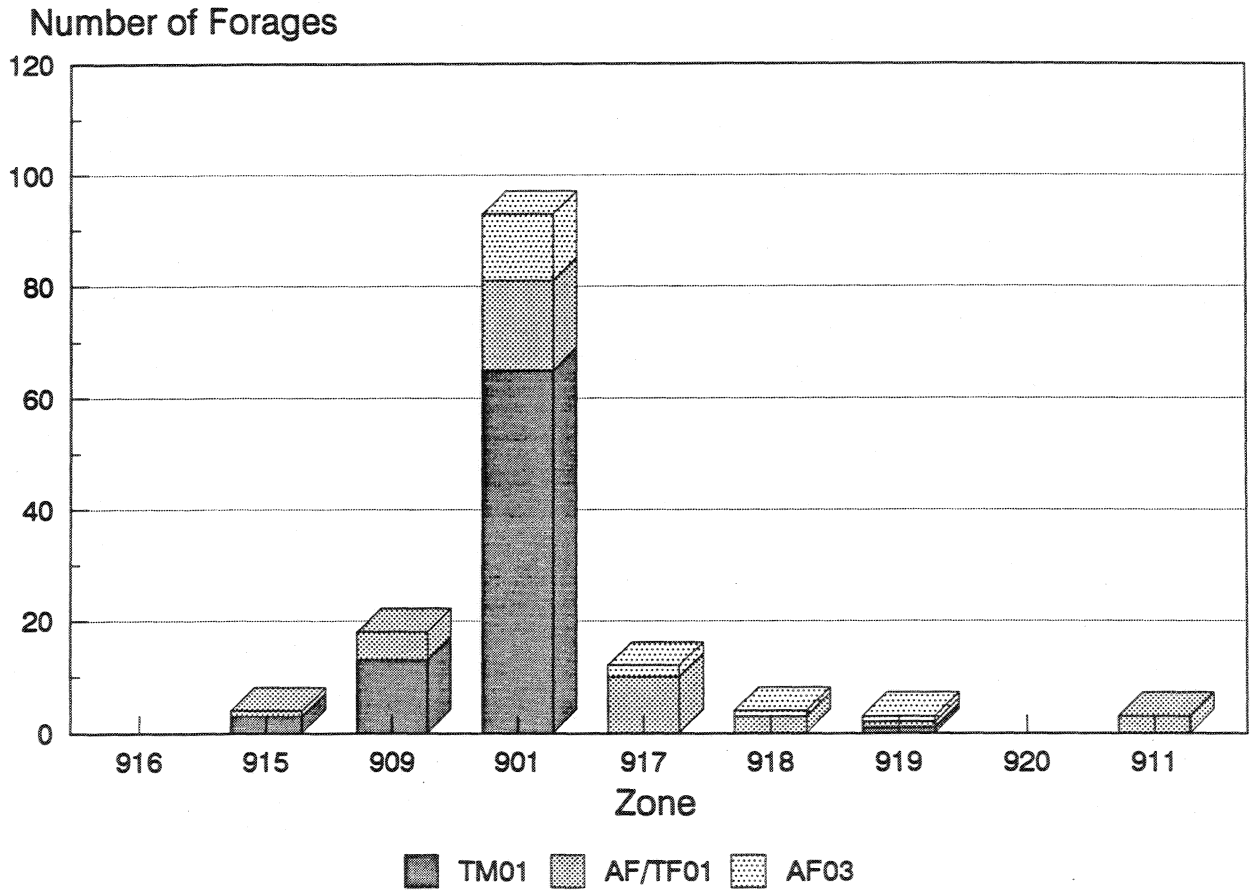


Figure B4.6-11. Frequencies of observed forages, by zone, of three adult bald eagles in the Pinal breeding area during 1987–1989. The male, TM01, probably foraged more extensively in the river sections than indicated, but he was not telemetered and is, thus, not readily detectable in much of the riverine area. Zones 916–901 are on the reservoir, while the river includes Zone 917, and the remaining zones on the right of the figure. See Figure B4.6-6 for major foraging zone locations; minor zones are described in Section E8.2.9. The foraging distribution shown is biased by observer location.

However, the relative importance of Campaign Bay (compared to the upstream river sections) in sustaining the Pinal and Pinto eagles was less clear to us than the significance of the inflow at Horseshoe because the distribution of observed forages at Pinal/Pinto was more biased by observer location. The problem was that much of the river, particularly upstream of the nest area and the vicinity of Meddler Point, was more difficult to see than the open reservoir, the river sections within site of Red Cliffs, or the reach between the diversion dam and the nest. Visitation data, shown for example in Figure B4.6-4, provided a more accurate picture of the foraging range and seasonal changes in foraging distribution.

Thus, we observed TM01 (the adult male with no radio) foraging almost entirely on the reservoir between Cougar Point and Salome Bay (Zones 901, 909, and 915, see Figure B4.6-6 for zone locations), with the exception of one forage in the diversion dam area (Zone 919). Not surprisingly, the forages on the river we did observe were primarily those of telemetered birds, AF01 and AF03. In summary, while our visitation data clearly implies the significance riverine habitats to the Pinal and Pinto bald eagles, the number of observed forages likely underestimate this habitat.

B4.6.2.8 Observed Forages on the River.

Fish. We observed 14 forages for fish on the river in Pinal breeding area (plus one piracy); 11 of these occurred downstream of the nest area. Five forages were in the two Kms closest to the river mouth, where the channel is narrow and lined with cliffs on the north side (Kms 102 and 103). One was in Km 104 by Cottonwood Acre, and three occurred in Km 105 on the downstream side of Meddler point. Two (plus the piracy) were in Km 110, near the diversion dam. The only forages observed upstream of the nest were in Km 114. Table B4.6-8 gives specific information on these forages. The small number of these forages, and the fact that no identified species is represented more than once, makes analysis of microhabitat impossible.

Table B4.6-8. Identified prey fish from the Salt River, Pinal territory.

Species	Date	Status	Habitat	(cm)	(°C)	(m/sec)
Flathead Catfish	6/22/87	Carrion	Run	-	-	-
Channel Catfish	6/24/87	Unknown	Riffle	-	21	0.5
Probable Carp	7/02/87	Live	Run	-	-	-
Carp	10/09/87	Unknown	Riffle	40	19	0.5
Largemouth Bass	2/22/88	Live	River bend	0	12	0.1
Unknown Bass	3/09/88	Live	Riffle	15	10	0.3

Eight unidentified fish on 3/06/88 and between 5/07/87 and 7/02/87, seven in runs, one in riffle.

Seven of the 14 forages for fish were made from cut banks along the river, and two more were made from cliff tops. Two were from large cottonwood trees, one from a mesquite snag, one from an unidentified deciduous tree, and one from a eucalyptus tree. Perch to strike point distances ranged from 20 to 200 m for attacks in which the eagle saw the prey from the perch, with an average distance of 87 m

(n = 9). Three attacks in which the eagle evidently saw the prey from the air covered 700, 900, and over 1000 m. Ten of 14 river forages for fish were successful, and distance from the perch did not seem to be a factor: four of six forages were successful at less than 100 m, and five of seven were successful at over that distance.

Waterfowl. We observed five forages for waterfowl on the river, all in winter; two (both coots) were successful. All were in the 2 Kms closest to the river mouth (Kms 102 and 103). Two of these forages were by AF01, two by AF03, and one by an unidentified immature eagle.

As with forages for fish, foraging perches were largely on cliffs: identified perches were two cliff ledges, one cut bank, and one cottonwood. Perch to attack point distances were also similar. Three attacks where the eagle saw the prey from the perch covered 30, 100, and 400 m, while attacks in which the eagle apparently saw the waterfowl from the air covered 300 and over 1000 m from the perch. The two successful forages were both by AF03; distances from perch to strike point were 300 and 400 m. This area of the river is a narrow channel and may offer attacking eagles an advantage in restricting the mobility of the waterfowl. However, we observed one coot avoid capture by simply remaining in the water directly against the north side cliff face, where the eagle could not maneuver to grasp its prey.

B4.6.2.9 Observed Forages on the Reservoir.

Fish. We observed 99 forages for fish on the reservoir; sixteen were piracies (Table B4.6-9). Overall, there was a high proportion of carrion to live fish, with three times as many carrion fish identified as live (75:25%). Channel catfish were the most numerous identified prey, representing at least 25 percent of the fish taken. However, since we observed prey deliveries to the nest only from 15 April to 01 June 1989, most identified fish date from forages in that period. Other fish taken in significant numbers in the reservoir included carp, black crappie, and bass (spp.).

Channel Catfish. We observed 26 forages for channel catfish on the reservoir, with seventeen identified as carrion and only one identified as alive when caught. Habitat for one forage was recorded as backwater, and one carrion fish was taken from shore. The other forages were divided between reservoir shallows (n = 6) and open reservoir. Strike points were generally close to shore: of twenty recorded distances, 15 were 75 m or less, three were from 76–150 m, and two were over 150 m. Seven of sixteen recorded water depths were less than 30 cm, with six depths of over 200 cm and three between 75 and 200 cm. We observed forages for channel catfish in early February of 1987 and 1988, but in 1989 observed forages for these catfish were all during 29 April to 29 May when prey deliveries were being observed.

Carp. We observed 14 forages for carp, but four were piracies. Of the remaining ten forages, three were for live fish and six for carrion, with the status of one unknown. Seven of the ten forages were noted as being on open reservoir, with one in reservoir shallows and one in backwater. Four shore distances were between one and 25 m, with two others noted as 110 and 400 m. Depths from 5–8 cm were measured at three strike points, and two were entered at greater than 200 cm. We observed forages for carp during two periods: 12 December 1986 to 10 February 1987, and 02 May to 17 May, 1989. The latter period is within the time we observed prey deliveries to the nest; however we observed deliveries for two week periods before and after these deliveries without observing other carp.

Locations of Reservoir Forages. Figure B4.6-11 shows that observed forages were most numerous in Zone 901, which includes Campaign Bay and the portion of Roosevelt reservoir furthest upstream by the

Table B4.6-9. Fish species taken on Roosevelt reservoir, Pinal territory, 1987 to 1989.

Species	Total	Live	Carrion	Piracies	Unknown
Flathead Catfish	6	0	5	1	0
Channel Catfish	26	1	17	2	6
Black Crappie	8	2	0	4	2
Carp	14	3	6	4	1
Unknown Bass	6	1	3	1	1
Largemouth Bass	3	0	1	2	0
Centrarchid, unknown	2	0	1	0	1
Catfish, unknown	1	1	0	0	0
Probable Barp	1	0	0	0	1
Lepomis spp.	1	0	1	0	0
Unknown Fish	31	6	7	2	16
Total	99	14	41	16	28

river mouth. Just downstream of the river inlet (at reservoir elevations obtaining in 1987 and 1988), there is a series of cutbanks and coves along the north shore, not far from the river channel. South of the channel, the reservoir opens out into the shallows of Campaign Bay (see Figure B4.6-5). Observed forages in this zone were fairly evenly distributed (Figure B4.6-12), although those observed in SKm 25–28 were primarily by the male. This distribution is probably not biased by the fact that the male lacked a radio, since SKms 25–28 were not necessarily nearest our observation points. The apparent difference in distribution may or may not indicate foraging habitat selection of the inflow area because this male, known to us to be wary, may have simply been avoiding the greater rate of public use at School House Point and on the south shore in general.

A greater proportion of channel catfish was noted in the sample of fish taken in Zone 901 (the inflow area and Campaign Bay) than in Zone 909 (the area downstream of Schoolhouse Point (see Figure B4.6-6 for orientation). Most forages for these catfish, mainly carrion, were observed along the north shore of the reservoir below the river mouth, in SKms 26–27. In addition to the forages noted by SKm in Figure B4.6-12, we observed five forages for these fish along the center channel of the reservoir between Km 99.4 and 100.1, corresponding approximately to SKm 26.5 to 27.5. Thus 18 of 21 forages for channel catfish in this zone were in an area downstream of the river mouth, bounded by SKms 25–28 on the north shore and by the center channel on the south. This section of the north shore is composed of cliffs overlooking the water. In reviewing these details of where the channel catfish were taken, it appears possible that many died or became moribund upstream in the river channel and were taken by the eagles as they drifted into the reservoir or thereafter washed up along shore.

Reservoir Waterfowl Forages. We observed 22 forages for waterfowl on the reservoir. As with forages for fish, most of these were in Zone 901, at the upstream end of the reservoir. Sixteen of the observed forages were in this zone, compared to six downstream. Almost all observed forages for waterfall occurred before March: we observed waterfowl forages from 9 December 1986 to 21 February 1987, and from 5 December 1987 to 24 February 1988. We observed one forage for a coot on 17 May 1989. Breakdown of waterfowl prey by species is shown in Table B4.6-10; coots and eared grebes are the most numerous. Unlike fish prey at this breeding area, the eagles took far more live waterfowl than carrion.

Reservoir Forage Perches. Reservoir forage perches were notable for the large proportion of vegetation used. Of 67 identified forage perches, 55 were vegetation, primarily snags; some were identified as mesquite snags (n = 16), but most were simply referred to as snags (n = 31). Other vegetation used for foraging perches included two live shrubs, four low stumps or sticks, one large cottonwood, and one live mesquite. Twelve perches were on the ground: six cut banks, two cliff tops, and one cliff ledge, while three attacks started from shore.

Forages for fish covered perch to strike point distances of 5–350 m when the eagle apparently saw its prey from the perch; the average distance was 76 m (n = 34). Attacks in which the eagles appeared to

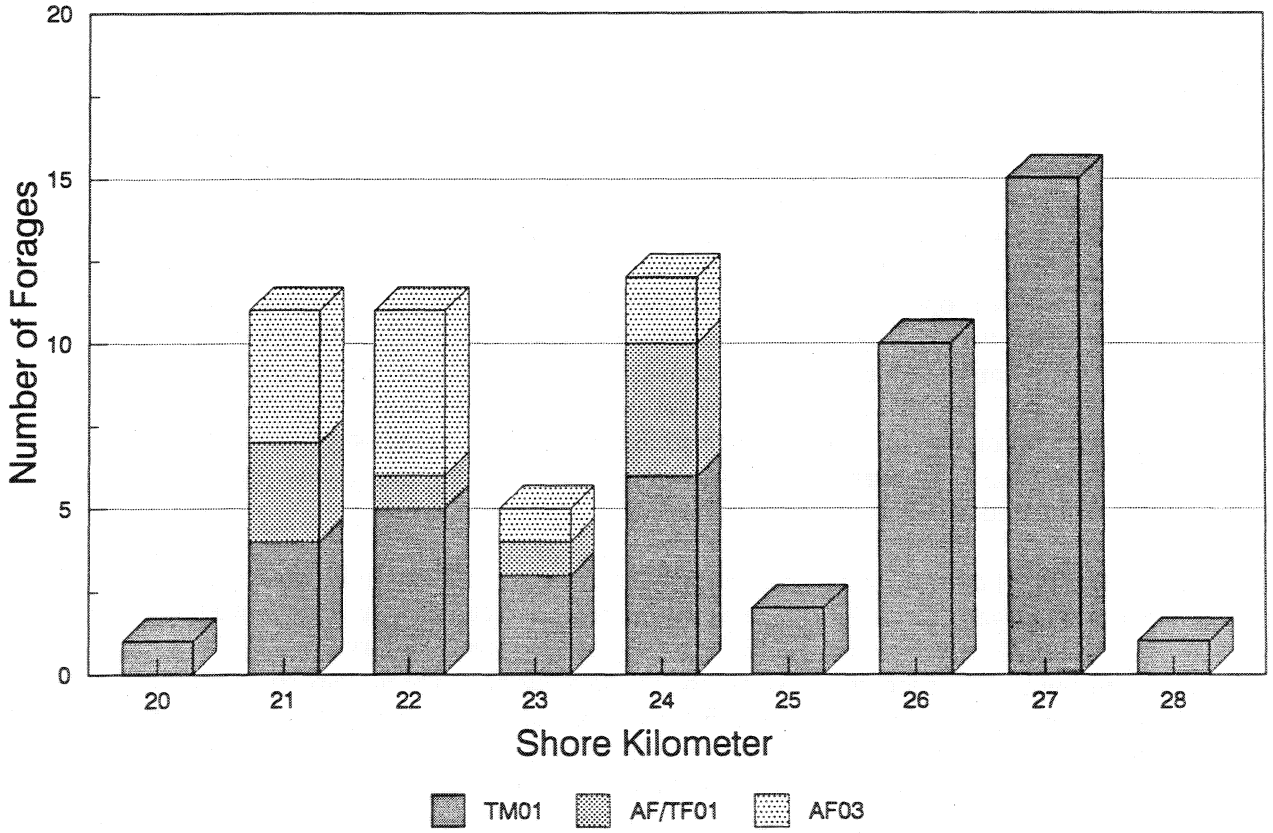


Figure B4.6-12. Foraging frequencies of three adult bald eagles in the upstream portion of Roosevelt Reservoir (Zone 901), Pinal territory. The data are presented by shore kilometer (SKm), starting at Schoolhouse Point (SKm 20). The river mouth is in SKm 25, and SKm 26–28 are on the north shore of the reservoir. See B4.6-5 for SKm locations.

locate their prey while in flight covered between 100 and 800 m on eight occasions, and over 1000 m for ten forages. Perch to strike point distances in waterfowl forages were typically long, although one recorded distance was only 10 m. Four were from 100–150 m, two between 300–350 m, one 800 m, and two over 1000 m.

Table B4.6-10. Observed forages for waterfowl, Roosevelt Reservoir, Pinal territory, 1987–1989.

Species	Total	Live	Carrion	Piracies	Unknown
Coot	10	3	0	2	5
Eared Grebe	5	1	2	0	2
Western Grebe	2	2	0	0	0
Cormorant	1	0	0	0	1
Green-winged Teal	1	1	0	0	0
Ruddy Duck	1	1	0	0	0
Shoveler	1	1	0	0	0
Unidentified Waterfowl	1	1	0	0	0
Total	22	10	2	2	8

B4.6.3 Prey Studies

During our fisheries investigations in the Pinal Breeding area we attempted to identify: (1) the relative abundance of potential prey fish in the Salt River and Roosevelt Reservoir; (2) availability of prey fish in the Salt River above and below the Roosevelt Diversion Dam; (3) whether the diversion dam acts as a fish barrier; (4) availability and causes of carrion in the reservoir.

B4.6.3.1 Relative Abundance (Salt River). The majority of information on the relative abundance of potential prey fish inhabiting the Salt River in the Pinal Breeding area upstream of the diversion dam was collected by J. Hanson (USFWS biologist) in 1981 and 1988 (see Section E2.1). In electrofishing surveys, catfish were by far the most abundant species accounting for almost 60 percent of total prey fish collected. Green sunfish (15%), carp (15%), and roundtail chub (11%) made up the remainder of potential prey fish in the river. Suckers were rarely collected and comprised less than one percent of the 1739 prey fish collected by Hanson in 1981 and 1988.

In March 1988, an electrofishing survey was conducted by SWCA Consultants in the Salt River above and below the Roosevelt Diversion Dam to determine if differences in species composition existed in the two reaches (SWCA report to Salt River Project). Below the dam, electrofishing catches were dominated by common carp (47%), channel catfish (32%), bigmouth buffalo (11%), and largemouth bass (6%). Flathead catfish, green sunfish, smallmouth bass, fathead minnows, and red shiners comprised less than 4 percent of the total abundance. Above the dam, fish populations were dominated by fathead minnows (45%), green sunfish (31%), red shiner (10%), and common carp (8%). Channel catfish, yellow

bullhead, flathead catfish, and razorback sucker accounted for the remaining 6%. Based on this survey, it appears that potential prey fish for eagles are considerably more abundant below the diversion dam.

B4.6.3.2 Relative Abundance (Roosevelt Reservoir). A total of 6,203 potential prey fish were collected in Roosevelt Reservoir during electrofishing and netting surveys by the Arizona Game and Fish Department in 1984 and 1985 (Warnecke 1988). Bluegills (46%) and largemouth bass (30%) were the most abundant prey fish collected in the reservoir during these surveys. Black crappie (8%), carp (7%), green sunfish (4%) and catfish (3%) were also collected in relatively large numbers. Small numbers of smallmouth bass, buffalo fish spp. and Sonora sucker comprised the remainder of prey-sized fish in the reservoir. The abundance of black crappie and buffalo fish, which utilize the pelagic zone of the reservoir, was probably under-represented in the AGF surveys due to greater sampling effort along the shallow margins of the reservoir and the greater effectiveness of electrofishing in these areas.

B4.6.3.3 Snorkeling Surveys. We conducted snorkeling surveys in the Salt River from the Highway 88 Bridge to Roosevelt Reservoir on 15 May 1989 to assess relative fish abundance. We concentrated our surveys on fish greater than 20 cm TL to identify potential eagle prey fish (the surveys were not intended to characterize overall fish abundance or species composition). Areas chosen for snorkeling consisted primarily of run habitat interspersed by an occasional riffle. We avoided areas with deep pools where visibility was poor. One biologist performed these surveys between 0930–1440 hr using snorkeling gear and an underwater slate. While floating downstream, the biologist recorded the number and size of fish observed in each habitat in four areas, including one between the diversion dam and the Highway 88 Bridge (Km 112.1–112.3), and three areas between the diversion dam and Roosevelt Reservoir (Km 109.7–110.8, Km 108.3–106.7, Km 104.0–104.5).

We did not observe any fish greater than 20 cm TL in the 300 m snorkeled upstream of the diversion dam (Km 112.1–112.3). In contrast, we saw numerous potential prey fish in the three areas snorkeled between the diversion dam and the reservoir. In 1.1 km of river just downstream of the diversion dam (Km 109.7–110.8), we observed 22 carp, 4 largemouth bass and 4 catfish ranging from 30–40 cm TL. In 1.6 Km of river near Meddler Point (Km 106.7–108.3), we identified 25 carp and 2 flathead catfish between 30–40 cm TL. In a 0.5 Km section near Red Cliffs (Km 104.0–104.5), we observed 21 carp and 1 largemouth bass ranging in size from 30–40 cm TL. In all the areas surveyed, we only observed fish in run habitat.

B4.6.3.4 Fixed Point Surveys. We also conducted fixed-point visual surveys of shallow water areas (< 0.6 m deep) of the river in May 1989 to appraise fish availability. We conducted these from elevated observation points (i.e., cliffs) adjacent to shallow water areas using binoculars (10 × 50) and polarized sunglasses. Height of the observation points ranged from 10–30 m above the water surface. Fish availability was calculated by averaging fish observed during 30-minute intervals.

Table B4.6-11 provides a summary of fish availability estimates for the Salt River upstream of Roosevelt Reservoir determined from our May 1989 visual surveys. All fish identified during these surveys were carp. We did not observe any courtship or spawning activity by the carp during the surveys. We generally observed higher numbers of potential prey fish downstream of the diversion dam than upstream. However, in surveys conducted two weeks apart at the same location downstream of the diversion dam (Km 105.6), we found revealed considerable differences in mean number of fish observed (10.4 versus 1.0). Interestingly, we observed the highest number of fish in the river near the inflow of the reservoir which coincided with the foraging pattern of the eagles. Most of the carp in the river below the diversion dam may have been the recent migrants of a spawning run from the reservoir (see below).

Table B4.6-11. Mean number of fish observed during fixed point visual surveys in the Salt River (Km 101.1–116.2) in May 1989.

Date	Location Description	Location (km)	Survey Time	Survey Interval	Total Number Surveys	Mean Number of Fish Observed	Minimum Number of Fish Observed	Maximum Number of Fish Observed
Downstream of Diversion Dam								
5/16/89	Cougar Point	101.1	0900–1700 hr.	30 min.	12	0.58	0	3
5/27/89	Cougar Point	101.2	1400–1730 hr.	30 min.	7	30.29	2	63
5/29/89	Cougar Point	101.2	630–800 hr.	30 min.	3	18.00	6	27
5/15/89	Meddler Point	105.6	1300–1730 hr.	30 min.	8	10.38	4	13
5/28/89	Meddler Point	105.6	1330–1700 hr.	30 min.	6	1.00	0	3
Upstream of Diversion Dam								
5/28/89	River near Pinal Creek	112.8	0700–1300 hr.	1 hr.	6	1.00	0	2
5/17/89	River near Pinal Creek	113.4	0730–1330 hr.	30 min.	11	1.36	0	9
5/17/89	White Cliffs	114.1	0830–1230 hr.	30 min.	5	1.60	1	4
5/30/89	White Cliffs	114.6	0700–1800 hr.	30 min.	14	0.00	0	0
5/30/89	Upstream of White Cliffs	116.2	0700–1700 hr.	1 hr.	10	3.10	0	7

B4.6.3.5 Netting Surveys. We used floating gill nets to collect potential prey fish in the river upstream of Roosevelt Reservoir in April and May 1989. We sampled upstream and downstream of the diversion dam to determine if differences in species composition or relative abundance existed. As discussed in the introduction to this section, the river above the diversion dam passes through a narrow canyon area resulting in the formation of many deep runs and pools, whereas below the diversion dam the river widens into the Tonto Basin, resulting in the formation of many shallow riffles and runs. As a result, our netting surveys above the diversion dam where limited by access and availability of shallow water habitat, whereas many suitable areas to sample could be found downstream of the diversion dam. These habitat differences resulted in differences in sampling intensity in the two river reaches.

We also sampled at the base of the diversion dam as well as the irrigation canal originating on the north end of the dam. Fish in the Salt River downstream of the diversion dam may enter the irrigation canal by swimming along the base of the dam and passing through a drainage pipe. We used floating gill nets to sample at the base of the diversion dam and throw nets to sample fish in the irrigation canal.

Results of our netting surveys, summarized in Table B4.6-12, indicate that large numbers of carp were present in shallow water in April and May 1989 at the base of the diversion dam and in the irrigation canal. The area at the base of the diversion dam appeared highly suitable as foraging habitat for eagles owing to the low flows (probably not as suitable in high flows). Carp and catfish were also available in the river between the diversion dam and the reservoir particularly in shallow river habitat near the reservoir confluence. In contrast, we failed to catch any fish in shallow water upstream of the diversion dam. We are not suggesting that potential prey fish were not present in shallow water upstream of the diversion dam, clearly our visual surveys do not support this conclusion. However, the abundance of potential prey fish appears to be considerably higher downstream of the diversion dam.

We caught 121 fish in nets placed in the Salt River in April and May 1989. Carp comprised 96 percent of the sample; catfish (4%) and largemouth bass (1%) made up the remainder. The size distribution of carp collected in the river is illustrated in Figure B4.6-13. Carp ranged in size from 306 mm to 578 mm TL with the majority of fish collected between 380 mm and 480 mm TL. Almost equal numbers of male and female carp were collected (62 males and 54 females). All the male carp (n = 62) collected released milt when examined, but only 7 female carp released eggs. The majority of remaining female carp (n = 45) contained mature eggs in their ovaries; two females examined were spawned out. Water temperature in the river in the last week in April through the end of May were within the preferred spawning temperatures of carp, ranging from 14–22°C in April (mean 18.2°C, n = 20) and 16–28° in May (mean 21.4 C, n = 47).

B4.6.3.6 Diversion Dam. We believe the relatively high number of carp caught at the diversion dam in 1989 is the result of a spawning migration of fish from Roosevelt Reservoir into the Salt River in the spring. Discussions with local fisherman and J. Warnecke (AGF) indicate that spawning migrations of carp, channel catfish and flathead catfish out of the reservoir in the spring are common occurrences. The magnitude of the runs appears to be related to flow into the reservoir. Local catfish anglers told us that when flows are high in the spring, large numbers of catfish migrate into the river. However, when spring flows are low, as in 1989, fewer fish migrate. We did observe substantially higher fishing intensity on the river during 1987 and 1988 when April and May flows averaged 2207 cfs and 1496 cfs respectively, compared to 1989 when April and May flows averaged only 405 cfs. We believe that considerable less carrion was produced by anglers in 1989 compared to 1987 and 1988. This may explain why the eagles appeared to forage less in the river in 1989 than in previous years.

Table B4.6-12. Summary of fish collected and their reproductive status during netting surveys in the Salt River in April and May 1989 (Km 100.5–114.0).

Location (Km)	Date	Capture Method	Time	Survey Length (m)	Species	Number Collected	Reproductive Status
Meddler Point - Reservoir							
106.7 (Left braid)	4/26/89	Float Gill Net	1330	124	Carp	4	RSS-4
106.7 (Right braid)	4/26/89	Float Gill Net	1405	171	Carp	3	RSS-1, EG-2
106.7 (Left channel)	4/27/89	Float Gill Net	800	124	Carp	3	RSS-3
106.7 (Right channel)	4/27/89	Float Gill Net	840	171	Carp	3	RSS-3
102.5	5/29/89	Float Gill Net	915	199	Carp	3	RSS-3
101.5	5/29/89	Float Gill Net	1035	165	Carp Largemouth bass Channel catfish	5 1 1	RSS-4, SPO-1 (f)
100.9	5/29/89	Float Gill Net	1235	196	Carp Channel catfish	18 1	SPO-1(f), RSS-7, RSE-3, EG-7
100.6	5/29/89	Float Gill Net	p.m.	268	Carp Channel catfish	1 1	RSS
100.5	5/29/89	Float Gill Net	1540	165	Carp Channel catfish	1 1	RSS SPO
Total				1,583		46	
Diversion Dam Area							
110.80	4/26/89	Float Gill Net	1540		Carp	4	RSS-3, EG-1
110.80	4/26/89	Float Gill Net	1545		Carp	13	RSS-7, EG-5, RSE-1
110.80	4/27/89	Float Gill Net	1021		Carp	16	RSS-12, EG-4
Diversion canal	5/15/89	Throw Net	820		Carp	2	EG-2
110.80	5/15/89	Float Gill Net	1640		Carp	8	EG-3, RSS-3, RSE-3
Diversion canal	5/15/89	Throw Net	1700		Carp	10	EG-6, RSS-4
Total						53	

Table B4.6-12. Continued

Location (Km)	Date	Capture Method	Time	Survey Length (m)	Species	Number Collected	Reproductive Status
Upstream of Diversion Dam							
114.0	5/17/89	Float Gill Net	1400	91	None		
113.75	5/17/89	Float Gill Net	1445	91	None		
113.0	5/17/89	Float Gill Net	1540	75	None		
112.65	5/17/89	Float Gill Net	1559	52	None		
Total				310		0	

EG = Eggs abundant in ovary; RSE = Released eggs; RSS = Released milt; SPO = Spawned out

In 1989, we tried to determine if the diversion dam acted as an effective barrier to migrating fish. During 15–30 May, we conducted several surveys at the base of the diversion dam to observe the number of fish attempting to jump over the dam during 30 minute observation periods. Of the 2062 attempts by carp (>30 cm TL) to jump over the dam, none was successful. We also observed 268 failed attempts by fish less 15 cm TL to jump over the dam (species unknown). Based on these observations, we concluded that the dam was an effective fish barrier in 1989, concentrating fish at the base of the dam and stimulating some fish to swim into the irrigation canal to seek out spawning habitat.

B4.6.3.7 Summary—Fish Availability in Salt River. Catfish and carp were the most abundant prey fish in the Salt River within the Pinal Breeding area during our study. These species appeared to be more available to eagles in the reach between the diversion dam and the reservoir than upstream of the diversion dam. The latter concentrates fish that make spawning runs out of the reservoir. The magnitude of these runs are most likely influenced by the amount of flow entering the reservoir. During high flow years, large numbers of carp and catfish are apparently attracted to the river which subsequently draws large number of anglers. These anglers produce carrion which may substantially supplement the eagles' diet.

Interestingly, when flows into the reservoir were low in May 1989, the eagles seemed to focus mainly on the reservoir. A May die-off of catfish in the inflow area provided a significant source of food for the foraging male eagle. We do not know the exact cause of the catfish die-off, but toxins released from ingested blue-green algae is a possibility. The reservoir was substantially lower in 1989 than in previous years which may have contributed to conditions producing the fish kill.

B4.6.3.8 Carrion. In addition to the May carrion surveys described in Section B4.6.2 in which we found catfish and carp, we also recorded carrion on Roosevelt Reservoir in other months. In nine additional surveys during 1987 and 1988 conducted by boat in Campaign Bay and along the north shore of the reservoir (2 in December, 1 in January, 3 in February, 1 in June, 1 in August, and 1 in October)

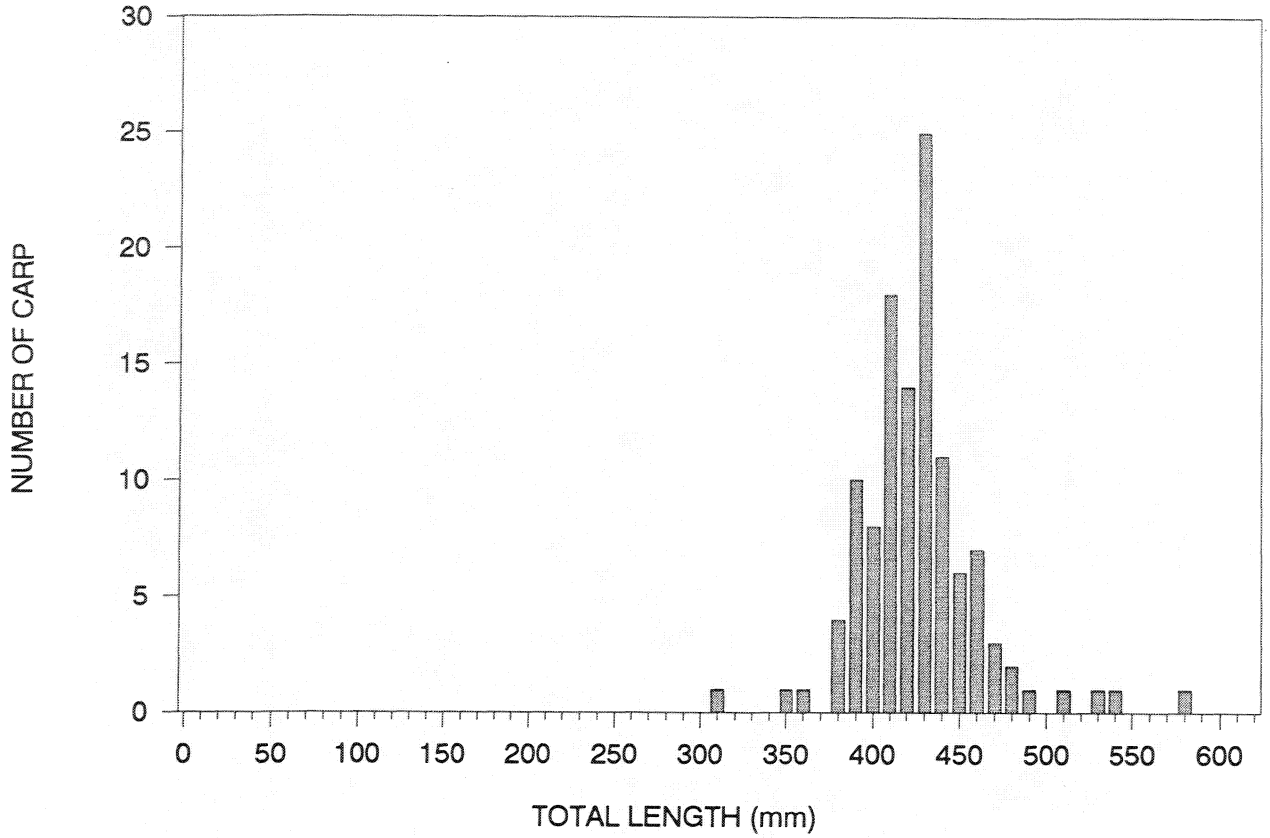


Figure B4.6-13. Size distribution of carp caught in netting surveys in the Salt River (Km 100–114) in May and June, 1991.

we counted five channel catfish, four carp, three flathead catfish, one western grebe, and one striped skunk, for an average of 1.5 items per survey.

To view the extent of carrion produced by anglers in the vicinity of the diversion dam at Km 110, we walked on shore from the diversion dam downstream for 400 m on both sides of the river on 31 May, 1989. We found 15 whole carp, five carp heads, one whole channel catfish, eight channel catfish heads, one bluegill, and the dried skeletal remains of other carp and catfish. One of the carp had recently been fed upon by an eagle.

B4.6.3.9 Waterbirds. Table B4.6-13 gives the results of waterfowl surveys at the Pinal/Pinto breeding area (asterisks indicate species observed as bald eagle prey at Pinal/Pinto). The largest number of waterfowl were present in January and February, and the most common species in those months were eared grebes, American coots, and Canada geese. Numbers of individuals decreased from January to February and again from February to March, yet remained fairly steady in March and May. The drop in numbers marked the departure of wintering waterfowl, and the more consistent numbers, the presence of summering birds.

The proportion of western grebes rose dramatically from January through March but none were seen in May. Eared grebes made up over one third of the waterfowl on the reservoir in January but less than

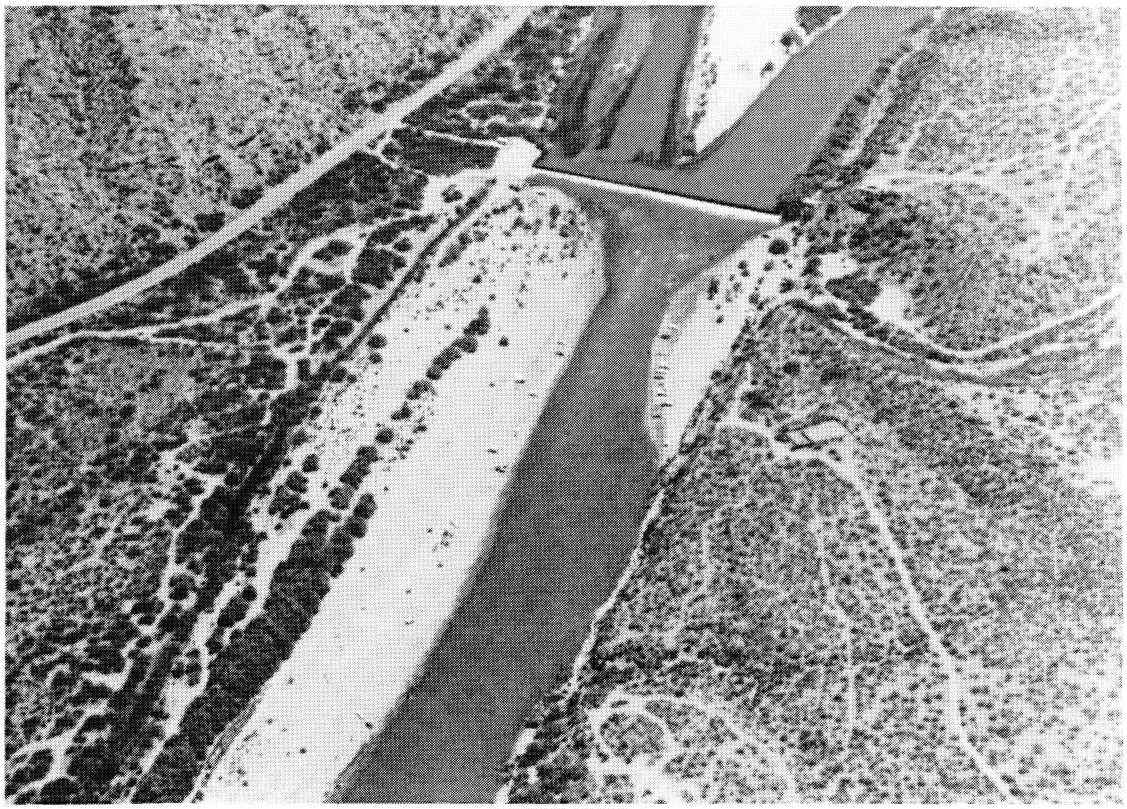


Plate B34. The Roosevelt Diversion Dam, on the Salt River upstream of Roosevelt Reservoir, was once used to divert river flow for irrigation and the construction of Theodore Roosevelt Dam. The diversion dam has acted as a fish barrier since the creation of Roosevelt Reservoir, preventing spawning runs of carp and other exotic fishes from entering the upper Salt River. The area is now popular for catfishing. Note the many vehicles along the shore, March 1988 (photo by D. Driscoll).

three percent in February, being absent in March and May. The numbers of Canada geese dropped 15 percent from January to February; geese were not present in March and May. Coots consistently made up about one third of the waterfowl population on the reservoir during January through March, then dropped to only seven percent in May.

B4.6.4 Human Impacts

The Pinal and Pinto eagles were subject a fair amount of public use because the foraging area includes the upper end of the Salt Arm of Roosevelt Reservoir, a popular area for many recreational activities. Vehicle access is easy, particularly to the reservoir's south shore, with improved or paved roads and boat ramps. Nestwatchers in 1987 reported a variety of types of public use, but remarked that there were very few if any visible reactions by the eagles. Nest watchers in 1989 and 1990 reported no public use disturbances, probably because the Pinal nest is located some distance from the reservoir. However, while tracking foraging eagles, BioSystems recorded flushing of eagles by the public, mainly on the reservoir.

The public use data in Table B4.6-14 were collected by BioSystems wherever an incident occurred within 100 m of an eagle. We recorded a total of 32 incidents around Campaign Bay (56%) and School House

Table B4.6-13. Waterbirds observed in surveys at Pinal breeding area (1987–1989). Asterisks indicate species found in prey remains in Pinal/Pinto areas.

Species	Avg. No. Individuals per Survey	Percent Species per Month			
		January	February	March	May
Western Grebe*	58 (n = 461)	6.7	33.3	56.8	—
Eared Grebe*	190 (n = 1,516)	35.1	2.8	—	—
Pied-billed Grebe	< 1 (n = 3)	0.1	—	—	—
Double-crested Cormorant	3 (n = 26)	0.3	0.4	—	25.6
Canada Goose	91 (n = 725)	16.7	1.7	—	—
Mallard	1 (n = 6)	—	1.3	—	—
Northern Pintail	41 (n = 330)	7.7	—	—	—
American Wigeon	6 (n = 50)	—	10.9	—	—
Green-winged Teal*	8 (n = 63)	—	13.7	—	—
Redhead	< 1 (n = 2)	—	0.4	—	—
Bufflehead	1 (n = 4)	< 0.1	0.4	—	—
Common Merganser	2 (n = 18)	0.4	0.2	—	—
Great Blue Heron	4 (n = 33)	—	3.7	5.4	32.6
Green-backed Heron	<1 (n = 3)	—	—	—	7.0
White-faced Ibis	1 (n = 7)	—	—	—	16.3
American Coot*	196 (n = 1,568)	32.9	31.1	35.1	7.0
Other Waterbirds	<1 (n = 3)	—	—	—	7.0
Gull sp.	<1 (n = 3)	—	—	2.7	4.7
		n = 4,282 (three surveys)	n = 460 (two surveys)	n = 37 (one survey)	n = 43 (two surveys)

Table B4.6-14. Summary of public use incidents and eagle responses at Pinal territory in 1987, 1988, and 1989.

Type Public Use	No. Public Use Incidents	Percent of Total Incidents	Duration (min)	Percent Duration	Response to Public User		
					N	W	F
Fishing:							
not using motor	2	6.3	82	20.9	2	–	–
using motor	22	68.6	109	27.7	3	3	16
Picnicking	1	3.1	1	0.3	–	–	1
Boating:							
non-motorized	2	6.3	131	33.3	2	–	–
using motor	3	9.4	7	1.8	–	–	3
Shooting	2	6.3	63	16.0	2	–	–
Total	32	100%	393	100%	9	3	20

N = No response; W = Watching; F = Flush.

Point Recreation Area (31%). Of the four remaining incidents, three occurred near the nest in 1987, and one took place in Km 94. Four flushing incidents not included in the table took place at distances greater than 100 m. Three occurred in Campaign Bay and were caused by an angler, a low flying plane, and a gunshot by a duck hunter. The remaining incident took place near the nest at the mouth of Pinal Creek and was caused by a low flying military jet. In all but two flushing incidents for which we have data on perch height, the eagle was perched less than ten meters in elevation above the public user (n = 21). For the remaining two incidents, the eagle was perched between 11 and 30 m high. One human-related event resulted in a bald eagle mortality when an eaglet died from becoming entangled in monofilament (see Sections C3.3 and D4.22). There was considerable monofilament in evidence on the reservoir and river.

In connection with our home range studies of the Pinal and Pinto adults, we tried to obtain a picture of bald eagle use of the Salt arm of Roosevelt Reservoir to aid in understanding the effects of increasing human use and planned shoreline developments on bald eagles. Figures B4.6-5 and B4.6-8 (above) show the distribution adults along the shoreline, and Table B4.6-15 lists our observations of these and other perched bald eagles in the area by zone. In interpreting the table, the reader should be aware that counts of non-telemetered birds are not indicative of real distributions since the sightings depended on observer location; hence, there was probably far more use by non-telemetered eagles of the area downstream of Schoolhouse Point than the data suggest.

Table B4.6-15. Observed perching events for telemetered and untelemetered birds on the Salt Arm of Lake Roosevelt from 9 January 1987 to 14 April 1988. See Figure B4.6-6 for zone map.

		Number of Observations				
Zone		AF01*	AF03*	TM01*	Others*	Others+
901	Campaign Bay (except Red Cliffs)	18	67	52	11	29
901	Red Cliffs	12	25	15	4	6
909	Schoolhouse Pt. to Grapevine Pt.	10	11	9	14	12
915	Grapevine Pt. to Salome Cove	0	0	0	6	5
925	Salome Bay	0	7	0	1	23

* Telemetered birds.

\+ Untelemetered birds. Counts of untelemetered birds indicates only where we happened to see them during our monitoring of telemetered eagles or while attempting to capture eagles for tag placement.

For example, while monitoring our trapping sets in Salome Bay during 13 days in February 1988, we observed a number of bald eagles using the bay. We differentiated among nine individuals there, including an adult female, an adult male, the Pinto female (AF03), a near-adult female (NF01), a near-adult male (NM01), a third near-adult, and three subadults (all in the cove at the same time). Other

subadults may have used Salome Bay during this period, but their lack of distinguishable characteristics resulted in only those seen together being counted. Eagles usually entered the bay at first light from Salome Creek, although the adult male roosted in a Fremont cottonwood at the creek confluence on three occasions. NF01 roosted in a canyon north of Armer Gulch the night following capture. Eagles usually soared over the confluence area, then perched or continued out to the reservoir. The birds entered and departed the bay throughout the day. We monitored the bay on 3 weekend days (Saturday or Sunday) and 10 weekdays. Eagles used the bay on all 10 weekdays, but none were observed in the area on weekends.

Salome Bay, a popular fishing area, sustained boat traffic every day. The eagles perched on live cottonwoods, on mesquite snags in the shallows, on shore, and on the ground on a ridge on the west side of the bay. The birds did not appear disturbed by the presence of boats on the water, but flushed on the only two occasions when people were observed beaching their boat and walking on shore. Most anglers remained in the north half of the bay, which is also where the eagles spent most of their time. Boat traffic was not systematically censused, although we noticed a dramatic increase on weekends, coinciding with bass and crappie tournaments, skiing, and leisure boating. Two incidental counts on Saturdays yielded the following: 37 boats on 27 February and 55 boats on 5 March, 33 of which were located in the north half of the bay (all boats present in bay at the same time).

In addition to increased boat traffic, the weekend also brought campers to the northern shore of the bay via a road which departs the A-Cross Road and terminates adjacent to eagle perch trees on Salome Bay. On the three monitored weekend days and another incidental Saturday, people camped below these perch trees. We attribute the absence of bald eagles in Salome Bay on weekends to increased boat traffic or campers near perch trees, or both.

B4.6.5 Discussion

The foraging ecology of the Pinal/Pinto eagles bears similarity to that observed at the Horseshoe bald eagle breeding area where a free-flowing river enters a reservoir. Carrion fish composed the majority of prey taken on the reservoir, with carrion fish (75%) of all species outnumbering live fish (25%) Like Horseshoe, the area of inflow (Zone 901) is favored probably because carrion collected there after floating downriver. We also observed that the prevailing wind appeared to blow carrion fish into the shallows of Campaign Bay or the north shore near the inflow. Channel catfish were the most frequently observed prey, both overall and in Zone 901, and were primarily taken as carrion.

In addition to natural mortality, carrion fish may be available to eagles on the reservoir because of a high fish kill by the large number of bass anglers. Fishing boats are almost constantly present on the reservoir, and even catch-and-release fishing may result in enough fish mortality to significantly increase eagle foraging opportunities. Anglers may also discard "undesirable" fish such as carp, adding these to the potential carrion prey on the reservoir.

Eagles consistently used one perch on Campaign Bay, a drowned live cottonwood in the bay itself at approximately SKm 22.5. This tree, which was essentially a snag during the colder months, provided a view of much of Campaign Bay. It was used as a foraging and loafing perch by the Pinal, Pinto, and by a number of immature eagles which frequented the reservoir.

Our records show that the eagles used the reservoir and the river section nearest the inflow mainly in winter and late spring, but to what extent they foraged there in March and the first half of April is less

Plate B35. Salome Creek flowing into Salome Bay on Roosevelt Reservoir, March, 1988. The inflow area (north half) of the bay is frequented by bald eagles and fishermen (photo by D. Driscoll).

clear because (1) we did not have an observer of prey deliveries or a full tracking team deployed during March and part of April; (2) we did not tag the male, and (3) habitat selection by the Pinal female differed in 1987 and 1988 because of the arrival of the Pinto female. The visitation data suggest, however, that the river sections were more significant to the Pinal pair than is apparent in the distribution of observed forages.

In previous years, nest watchers reported that the Pinal eagles commonly brought food to the nest from an upstream direction, and concluded from these observations that the birds were foraging and otherwise spending a disproportionate amount of time upstream from the nest. We believe that some of these deliveries from upstream might have been an artifact of the female's mode of approach to the nest when arriving from downstream. On several occasions we noticed that when AF01 returned to the nest from downstream (with or without food) she took a circuitous route. Initially she would begin soaring over the shoreline, gaining altitude and gradually moving inland; then when she had attained an elevation of several hundred meters, she would level off and travel along the bajada toward and beyond Black Mesa or Klondike Butte. Ultimately she would turn west and approach the nest from upstream. One possible advantage of this route of travel is to exploit the thermals and terrain-induced updrafts.

Are there sufficient food resources in the Pinal/Pinto area to support two productive pairs of eagles? Thus far, the matter has not been tested, since the Pinto female has failed to hatch eggs. One favorable point is that, despite the Pinal female's shift in home range in response to AF03's intrusion, the Pinal pair

raised one young in 1989. However, the Pinto female's appearance did not affect the foraging range of the Pinal male, the main provider to the Pinal nest, who still had access to the reservoir and the river section nearest the reservoir. The answer to the question of two successful pairs probably awaits the arrival of a new mate for the Pinto female, since it is unlikely that both females can reproduce with the Pinal male as the sole provider.

B4.6.5.1 Water Project Impacts. It is unlikely that construction work on Roosevelt Dam itself will affect the Pinal eagles, since the dam is approximately 22 air km from the current nest area, and the eagles forage at the other end of the reservoir.

However, the Meddler Point area of the river upstream of the reservoir is proposed as the borrow area for dam fill. Under the 1983 Fish and Wildlife Service Biological Opinion, contractors will be required to excavate only during the non-breeding season, and to recontour the area to restore fish habitat. The Meddler Point area is important because (1) it is within the range of the Pinal eagles; 92) it is the site of 21 percent of observed river forages (n = 14); and (3) it is not far from the area where the Pinto female attempted to nest. Her choice of the general area suggests its suitability as nesting habitat, and in the future it may function either as home to a second nesting pair or as an alternate nesting site for the Pinal pair. As explained above, our data probably underestimate the importance of Meddler Point (and certain other river sections) because direct observation of this reach were more difficult than the reservoir or the Red Cliffs area.

Plate B36. Craig Himmelwright tracking the Pinal female (AF01), January 1987 (photo by D. Driscoll).

Construction activity at Meddler Point might temporarily affect eagle foraging on the river and reservoir if this activity affects the spawning runs (and reduces carrion production) of carp and flathead catfish in the river. Increased turbidity associated with the excavation of borrow material might also temporarily reduce eagle access to prey fish in the river. We suggest that the recommendations of the Fish and Wildlife Service Biological Opinion be followed to reduce the possibility of adverse effects.

Long-term effects on eagles arising from the proposed increase in reservoir levels include those on nesting and perching trees. The cottonwood grove in the Pinto breeding area contains two nests. The most recent Bureau of Reclamation biological assessment of dam impacts on eagles on Roosevelt reservoir states that increased water levels will probably kill the cottonwoods in the grove (U.S. Bureau of Reclamation 1989b). The report further states that, although eagles may continue to nest in the dead trees, these trees will eventually disintegrate and become unsuitable for nesting. Live trees are presumably superior to dead trees for nesting since the foliage may moderate temperatures in and around the nest.

Perch trees can tolerate elevated water levels to a certain extent. According to a report by the Fish and Wildlife Service (1980), Fremont cottonwoods are capable of 100 percent survival after 100-103 days of partial submersion. In that study, there was 75 percent survival after 100-103 days of partial submersion the second year, but no survival after total submersion during the growing season. Goodding willow is apparently capable of 100 percent survival after 60 days of total submersion during the growing season (U.S. Fish and Wildlife Service (*op. cit.*).

The "drowned cottonwood," in Campaign Bay which eagles regularly used for perching and foraging is currently alive, even though its base is inundated during much of the year. Perhaps some of the cottonwoods upstream may survive if they are only partially and temporarily inundated. If, instead, the death and total disintegration of trees in the area occurs as predicted over the long term, there will be less opportunity for the eagles to forage from perches. It might be possible to offset the effect (if any) of the loss of perches (and perhaps even nest trees) by providing suitable artificial replacements (see Section A6), but we cannot speculate on their acceptance by the eagles.

Given the reliance of the eagles on carrion in the inflow area, we doubt that rising water levels will have a major impact on foraging opportunities for eagles. Although water levels at Campaign Bay will be deeper during portions of the year, much of the prey taken there is carrion, and water depth is not a factor in forages for floating, dead fish. However, live fish are also taken there, and observers noted the presence of live fish at the edge of the Bay. When water levels in the reservoir are raised, new shallow areas will form in upstream areas.

The periodic increases and decreases in reservoir area, which now occur and will effect an even greater area with the proposed construction, will likely have no adverse affect on eagles. The Horseshoe breeding area, in a similar habitat and flow regime setting in which the reservoir is lacustrine in some years and riverine in others, has exhibited no adverse response in nesting success to such changes (except when tree nests are inundated by flooding).

B4.7 CLIFF BREEDING AREA

The Cliff breeding area, about 65 km northeast of Phoenix, is situated on a regulated river reach of the Verde River (Km 65) about halfway between Horseshoe Dam (Km 73) and Bartlett Reservoir (ca. Km 60)(Figure B4.7.1). The fish community within the Cliff territory is considerably different from those in other regulated reaches of the lower Salt and Verde rivers (e.g. Bartlett and Blue Point). Several factors may be responsible for this difference, including water temperatures, turbidity, and the seasonal influx of spawning fish from Bartlett reservoir. River temperatures at Cliff are warmer during the nesting season than reaches fed by other reservoirs. This is because Horseshoe is relatively small, more shallow, often riverine, and is itself fed by free-flowing river. Stream temperatures may strongly influence fish species composition and spawning cycles. Being the farthest upstream reservoir on the river, Horseshoe is also more turbid than Bartlett and Saguaro reservoirs which leads to higher turbidity in water discharges from the dam. Turbidity is also known to influence fish species composition. A third reason for the difference in the fish community is that the river section in the Cliff breeding area, being just upstream of Bartlett Reservoir, probably receives reservoir fish migrating out of the reservoir, particularly carp and catfish, that may "swamp" the riverine species. Fish entering the reach when Horseshoe Reservoir is draining may also contribute to the dominance of carp and catfish. In regulated reaches with cool, clear hypolimnetic releases (e.g. Bartlett and Blue Point), and without the influence of large downstream reservoirs, suckers dominate the fish community.

The eagles at Cliff have the opportunity, based on distance, of foraging on two different reservoirs and a regulated river. Like Pinal/Pinto and Horseshoe the Cliff eagles are within foraging range of area where the river enters a reservoir. However, Cliff differs from these territories in that the river reach entering the reservoir is regulated (and relatively short) rather than free-flowing.

The terrain surrounding the Cliff territory is fairly open, particularly upstream toward Horseshoe Reservoir. Here the Verde River supports a single line of cottonwoods and a large mesquite bosque which is used as a campground. The river is braided in this section, with several shallow areas offering fording by vehicle. The are numerous roads in the bosques, and much recreation downstream to the point where large promontory cliffs on the west bank near the USGS gaging station limit vehicle travel along the river. However, four-wheel drive vehicles may ford the river at this point and travel down the east bank just across the river from the nest. The nest cliff itself is a large promontory containing a pinnacle which has supported a somewhat meager nest since 1986. The land closes in downstream as the river approaches Bartlett Reservoir, and there are few trees. In this section, the river supports some emergent vegetation along scattered cutbanks and small cliffs.

Cliff is within the Lower Sonoran Life Zone (C. H. Merriam 1890,1898; in Lowe 1964), and surrounding habitat is of the Sonoran Desertscrub Biome, containing species of the Paloverde-Cacti-Mixed Scrub Series and the Creosotebush-Crucifixion-thorn Series (Brown and Lowe 1980, Brown 1982). The riparian habitat is a mixture of the Sonoran Riparian Deciduous Forest and Woodlands Biome, the Sonoran Riparian Scrubland Biome, and the Sonoran Interior Strands Biome. There are Fremont cottonwoods, Goodding willows, mesquite spp., and tamarisk in the riparian area. See Section D2 for a more comprehensive description of habitats surrounding Arizona bald eagle breeding areas.

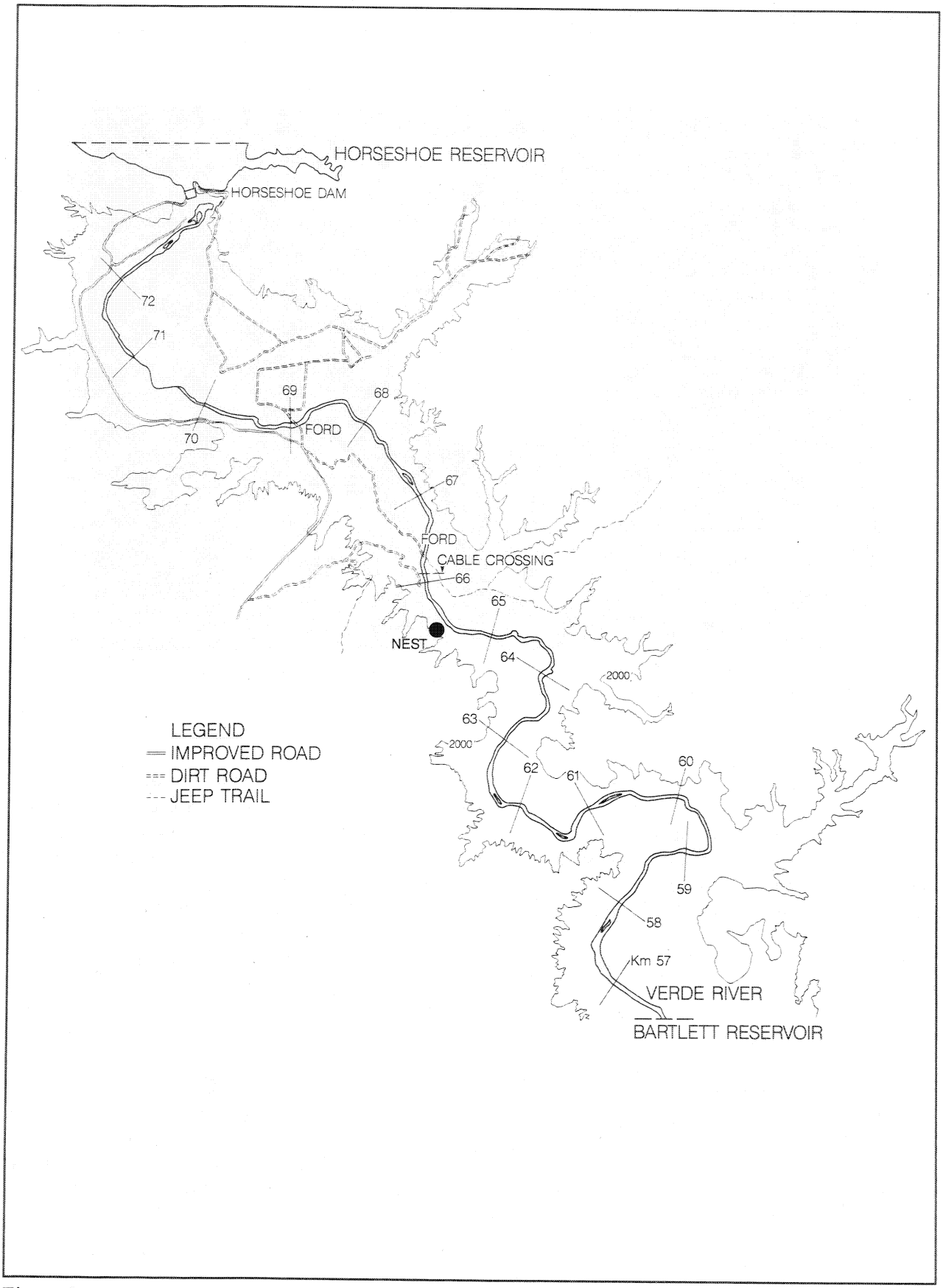


Figure B4.7-1. The Cliff bald eagle breeding area.

Plate B37. Unhatched egg in Cliff nest, May 1989. Note that the nest consists of only a few sticks and some crushed vegetation on top of a pinnacle (photo by D. Driscoll).

Because the nest failed in 1989 when we studied the pair, our data on the Cliff breeding area is less extensive than those obtained at the other sites where eagles were telemetered. Since there were no young to feed, the eagles' foraging range was restricted, there were no prey deliveries to observe, and the number of forage observations was small. The description of our findings given below is nevertheless valuable, particularly those on prey selection (obtained mainly through an analysis of remains), and is used to strengthen our overall perception of the foraging ecology of the Arizona population.

There are chronic human disturbance problems at Cliff. In this section, we report the incidents we observed and refer the reader to management recommendations in Section D4.9.

History of Reproduction

The Cliff breeding area was discovered in 1984, and the eagles have laid at least 10 eggs, but overall they have shown low productivity. The eggs failed to hatch in 1986. Two young died in the nest in 1984 and one in 1989. The pair apparently did not lay eggs in 1987 and 1990, but successfully fledged two eaglets in 1985 (Grubb 1986a) and two in 1988. In the seven years of its known existence, the Cliff territory has been successful in only two years, failed three years, and apparently did not lay eggs in two years. See Section D4.9 for more details on annual productivity and mortality at Cliff.

Verde River (Cliff Territory)

Mean monthly flows and the range of mean daily flows in a month in the Verde River downstream of Horseshoe Reservoir from November 1986–May 1989 are illustrates in Figure B4.7-2. Mean annual flow in 1987 was lower than in 1988 (455 cfs and 622 cfs, respectively). Mean monthly flows in 1987 ranged from 100 cfs in December to 1038 cfs in March; in 1988, they ranged from 350 cfs in October to 1158 cfs in February. Mean monthly flows during the first 6 months of 1989 ranged from only 61 cfs (June) to 273 cfs (February).

Figure B4.7-3 compares mean monthly flows in the Verde River below Horseshoe Dam (Cliff breeding area) with the river section below Bartlett Dam (Bartlett breeding area). In general, flows appear similar in the two regulated reaches and therefore cannot explain why suckers dominate the fish community at Bartlett breeding area while carp and catfish are the main species at Cliff. Figure B4.7-4 shows that water temperatures are consistently higher in the reach downstream of Horseshoe Dam (Cliff breeding area) than the reach downstream of Bartlett Dam (Bartlett breeding area). We hypothesized in Section E2 that carp may have a competitive advantage over suckers as water temperature increases. Therefore, differences in water temperatures between the two reaches may account for the observed differences in fish communities. Turbidity is also greater in the river downstream of Horseshoe Dam and may act with water temperature to favor carp in the Cliff breeding area.

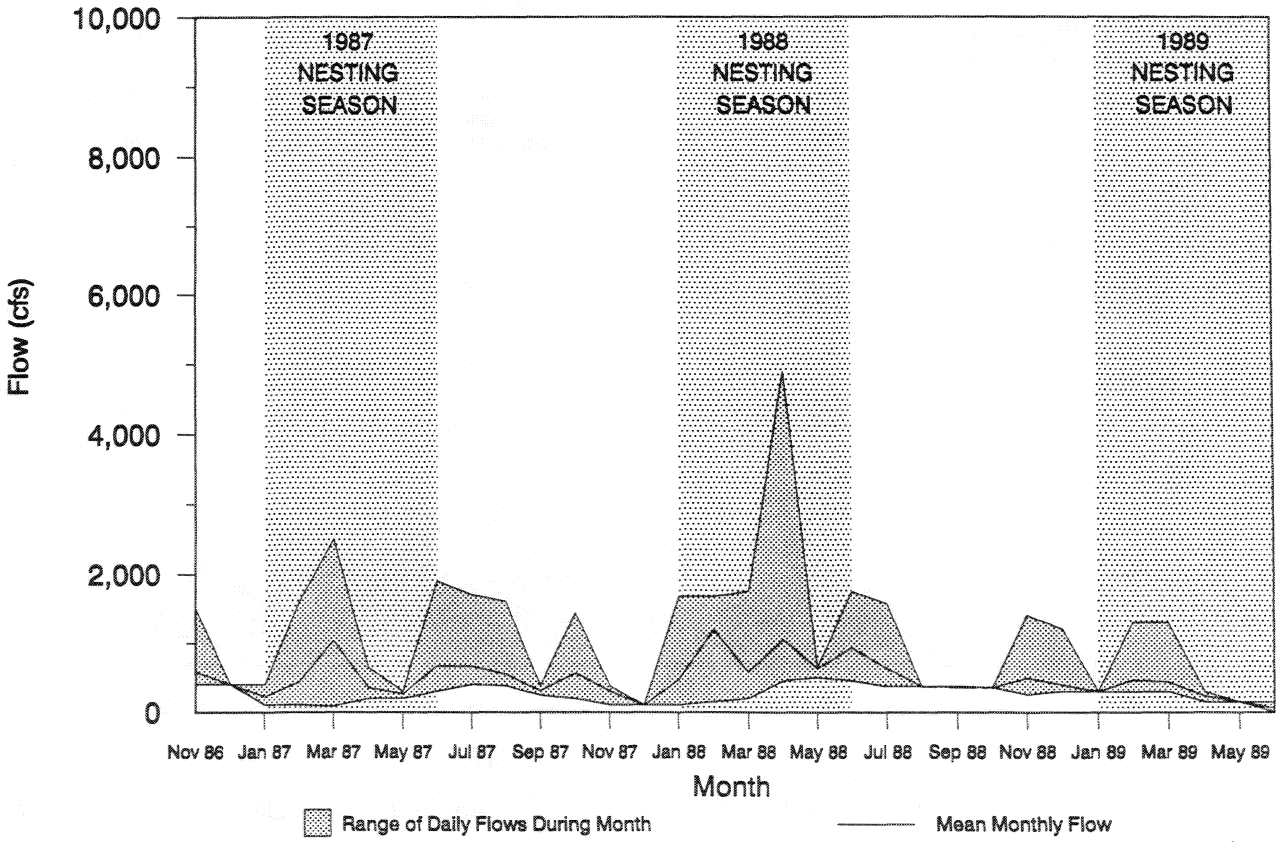


Figure B4.7-2. Mean monthly flows and range of daily flow in the Verde River below Horseshoe Reservoir during November 1986–May 1989.

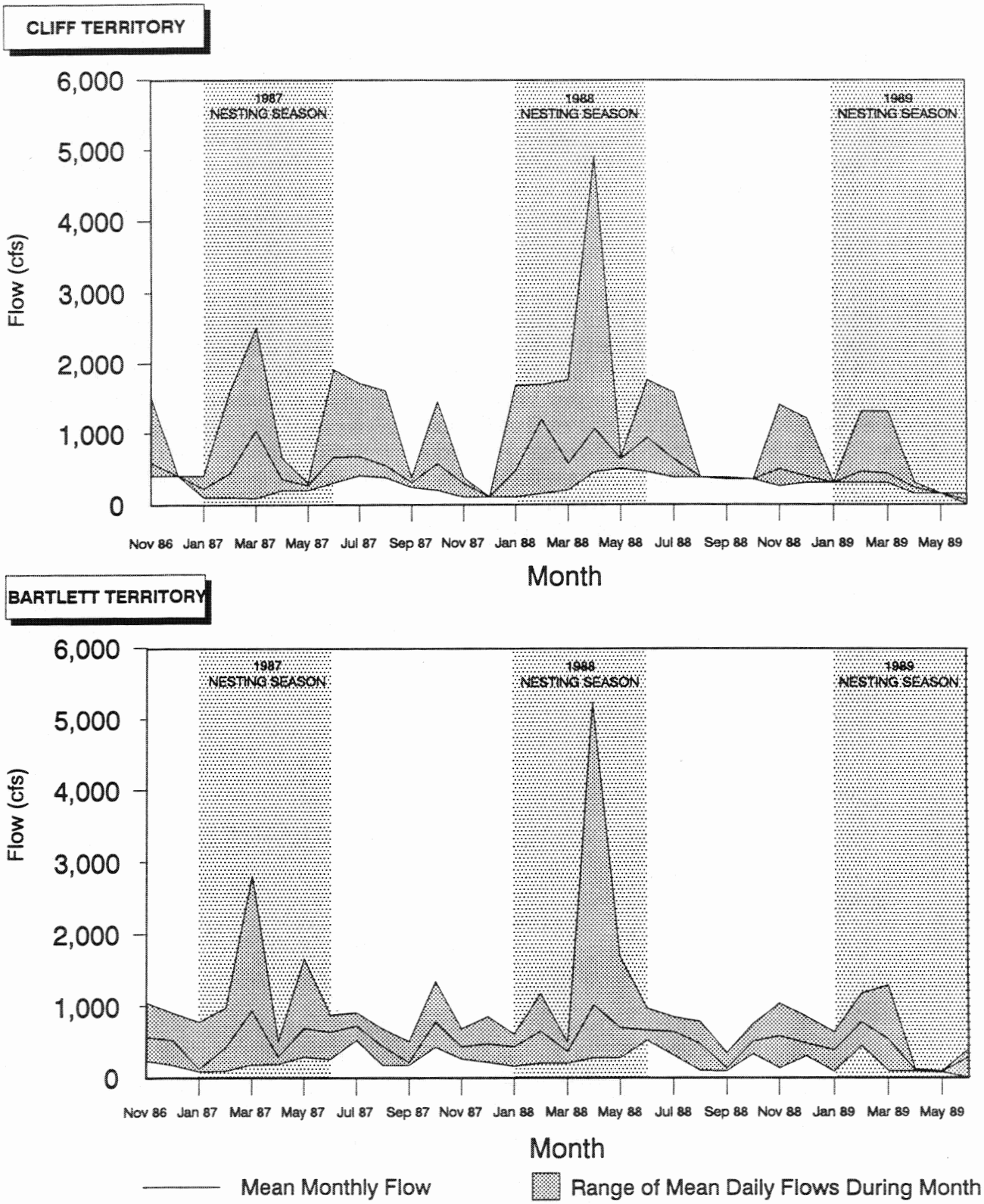


Figure B4.7-3. Comparison of mean monthly flows and range of daily flows in the Verde River below Horseshoe Dam (Cliff territory) and below Bartlett Dam (Bartlett territory) from November 1986 to May 1989.

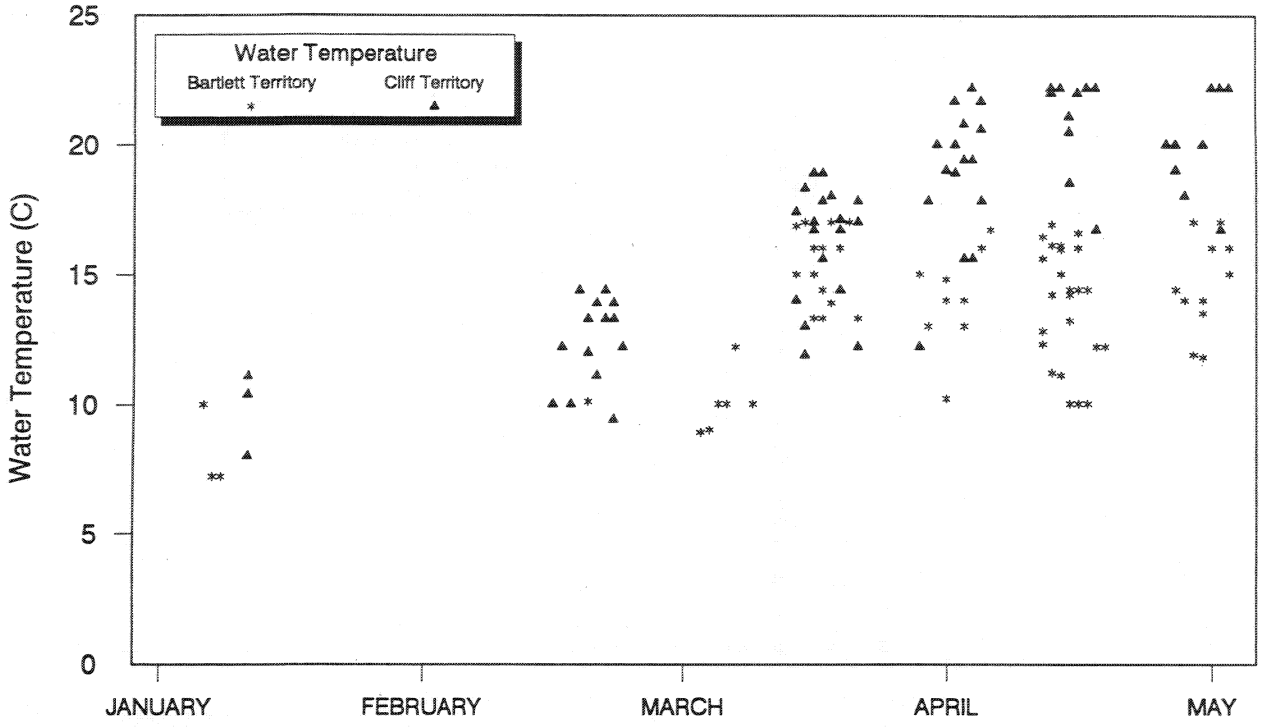


Figure B4.7-4. Daily water temperatures in the Verde River within the Bartlett and Cliff territories between 1 January and 1 May 1989.

B4.7.1 Home Range

We captured and telemetered the adult male AM06 at Cliff breeding area on 8 June 1988. Two radio trackers, recording his movements from 15 February to 15 May 1989, found he had a much smaller home range than any of the other eagles that we studied probably because the pair failed to produce young. During the 1989 breeding season, we located him along a 13-km stretch of the Verde River from Km 60 to Km 73 (Figure B4.7-5). We never observed AM06 using Horseshoe Reservoir despite its being 8 river Km and only about five airline km upstream of the nest. However, BioSystems trackers on Horseshoe Reservoir during spring 1988 (when both Horseshoe adults were telemetered) made occasional sightings of non-telemetered adults near the dam; the Cliff pair had young in 1988.

In previous studies, most known foraging at Cliff was observed in the river below the nests (Km 65–66) and in a pool bounded by promontory cliffs at Km 64.1, although the eagles were observed flying to other areas and returning with prey (Dodds 1984, Martin 1984, Camara and Motzkin 1985, Cooper 1985, Williams 1985, Nahstoll and Prescott 1987, Dixon and Maack 1988, Kuder and Sinor 1989, Mehling and Kershaw 1990). In addition to the nest area, foraging was observed on two occasions near KA Ranch (ca. Km 68)(Camara and Motzkin 1985, Mehling and Kershaw 1990).

Camara and Motzkin (1985) and Cooper (1985) observed a seasonal trend in foraging range. Prior to hatching, the eagles captured prey below the nest cliff but also brought prey back from distant locations. From 12 March (hatch date) to 5 May 1985 the eagles foraged almost exclusively below the nest. During this period, carp were observed spawning below the nest cliff. After 5 May foraging was less localized,

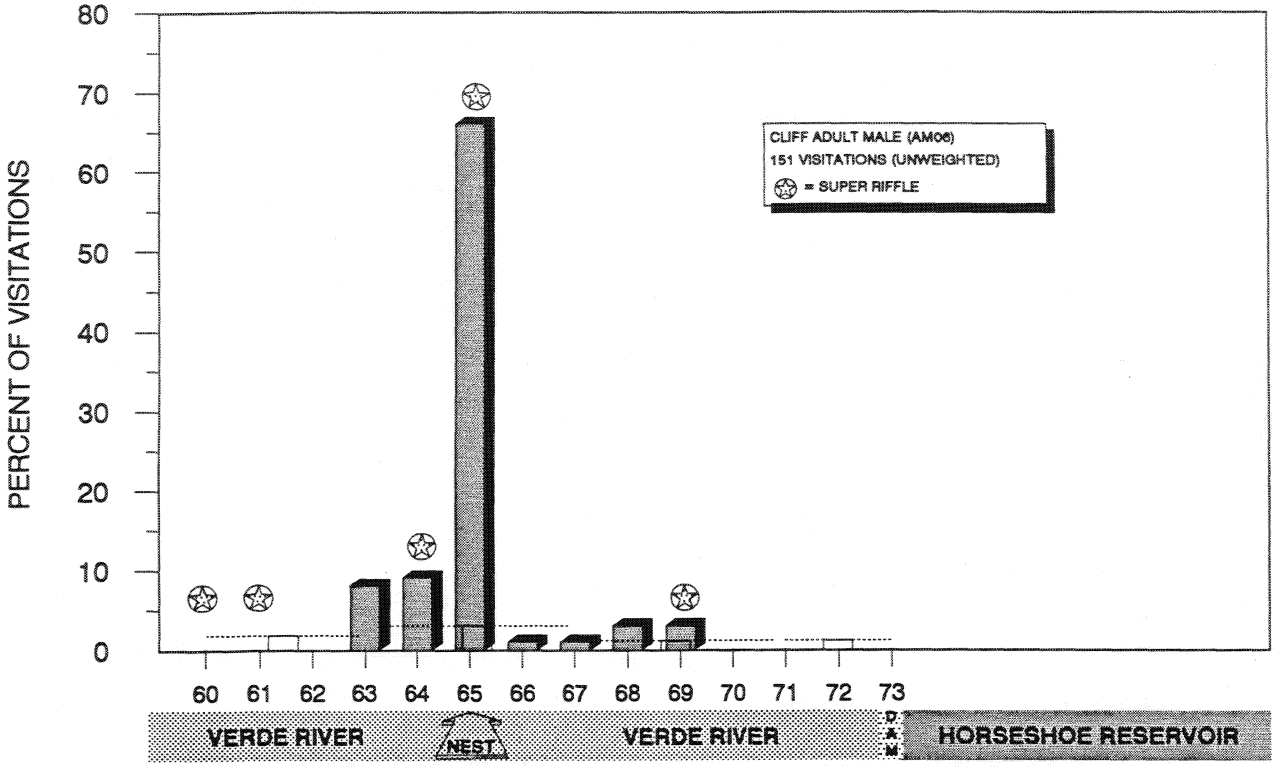


Figure B4.7-5. Home range of the telemetered Cliff adult male (AM06) during the 1989 breeding season. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from those bars indicate zones of eagle occupancy for the imprecise locations. These visitation scores are not weighted according to foraging rates in the nest vicinity because there were no young in 1989.

and prey was taken upstream and downstream of the nest. Carp were available in such numbers that the eagles would wade into the water and hop on a fish (Camara and Motzkin 1985, Cooper 1985, Williams 1985). Kuder and Sinor (1989) also observed a carp spawn below the nest cliff. It appears that carp are available throughout the year below the nest cliff; we have observed carp wallowing in the shallows with their backs out of the water from March to October at Km 65–66. We observed the Cliff adults wading in backwaters near the nest and foraging on shad, simply by picking the fish up in their beaks.

In the present study, two-thirds of AM06's total visitations were in the vicinity of the nest located at Km 65.4, a frequency comparable to those of eagles feeding young, but we cannot say whether AM06 favored the area because the nest was there or because it was a fairly large cliff with a super-riffle below it. The next most frequented area was downstream in Km 63 and Km 64 (there was a super-riffle in Km 64).

AM06's seasonal pattern of home range use was like other eagles we studied in that he ranged most widely during the early period (Figure B4.7-6). During February 1989, he used all portions of his home range from Km 60 through Km 73. During this time, about a quarter of his visitations were to a braided section of river from Km 67 through Km 70, an area he avoided after February. Another important perching and foraging area was a 2-km section of river just downstream of the nest.

Plate B38. The Cliff male (AM06), captured 8 June 1988, was banded as a nestling in 1979 at the Redmond breeding area. This 12-year-old male was still breeding at Cliff during the 1991 season (see Section D4.9 for details)(photo by D. Driscoll).

In March, AM06 utilized only half the area he had used in February, all of his observed visitations being downstream of Km 67, and he continued to use the smaller area until the end of the study in mid-May. The percentage of visitations to Km 63 and Km 64 remained relatively constant (between 15 and 22%) throughout the breeding season; however, visitations in the nest area fluctuated between 50 percent in February to 80 percent of all visitations in May.

Several possible reasons might explain the seasonal shift in home range, including changes in prey availability (a carp spawn) and increases in human disturbance in upstream sections after February. If the pair had young to feed, the home range of AM06 would have probably been larger and the pattern of habitat use different.

B4.7.2 Foraging Studies

B4.7.2.1 Prey Selection. We were not able to identify prey deliveries at the Cliff nest site due to nesting failure in 1989. Therefore, our discussion of prey selection at the Cliff territory is based on: (1) prey remains collected at the nest in 1986, 1988, and 1989 (Table B4.7-1); (2) prey remains collected

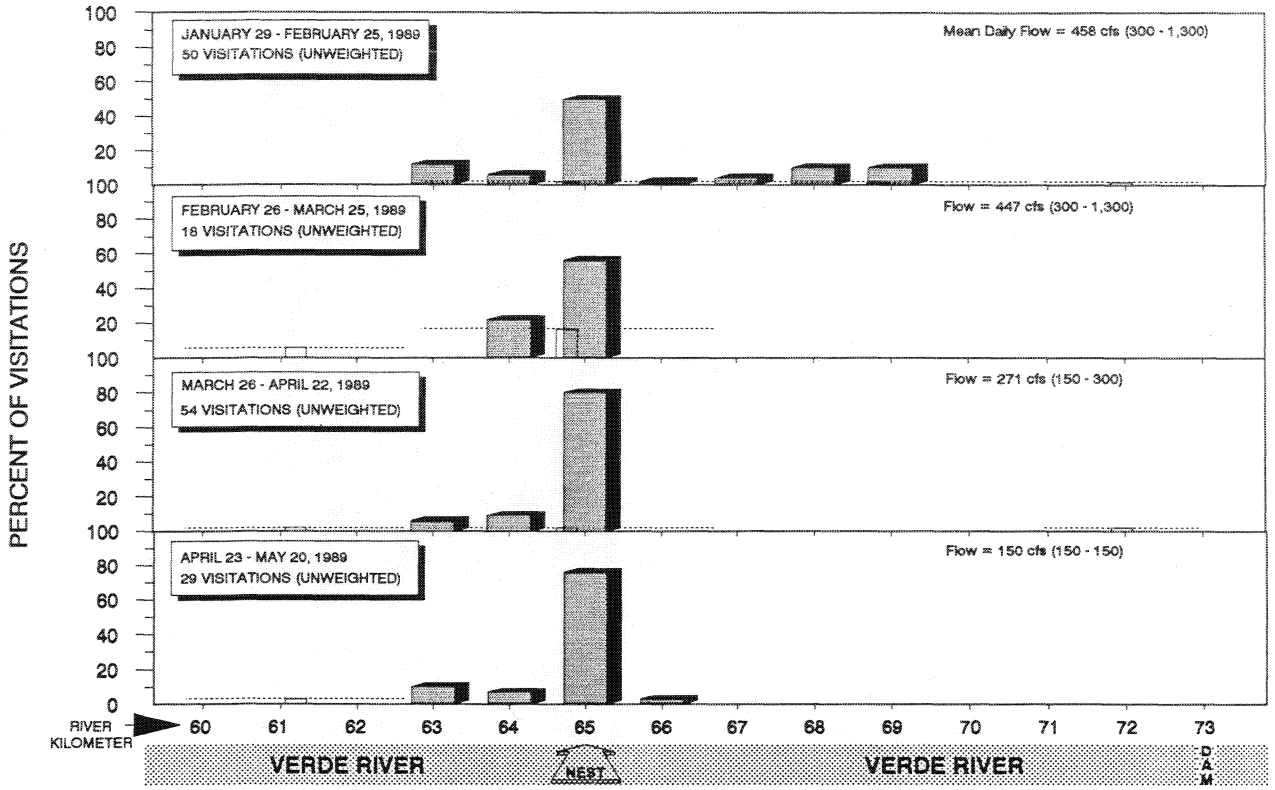


Figure B4.7-6. Seasonal changes in the distribution of visitations (%) by the telemetered Cliff adult male (AM06) during 25 February to 20 May 1989. Open bars indicate cases when trackers could not precisely locate the eagle, and the dotted lines extending laterally from these bars indicate zones of eagle occupancy for the imprecise locations.

from territory perches and following foraging events (Table B4.7-2); and, (3) observed forages (see below). Carp were the most important prey species for the Cliff eagles based on prey remains collected at the nest (45.9% of estimated biomass) and prey remains collected from territory perches (86.2% biomass). From the small number of observed forages, we also recorded a preponderance of carp (see below). Other important fish species identified in the prey remains included largemouth bass (12.9% biomass), flathead catfish (11.1%), crappie (8.4%), and channel catfish (7.3%). One possible sucker was identified following a forage by the Cliff male early in the 1989 breeding season (see below). We also documented some use of birds, including a Gambel's quail, and mammals, including two cottontails.

In the light of the fisheries discussion above, the dominance of carp in the Cliff diet, along with a virtual lack of suckers, was expected. The Blue Point and Bartlett pairs, which also utilized regulated rivers, preyed mainly on suckers, the dominant prey fishes in reaches fed by cool rather than warm water dam releases which favor carp. The presence of crappie in the remains collected in the nest may indicate some use of the reservoirs by the Cliff eagles; crappie typically favor lacustrine habitats (Moyle 1976).

B4.7.2.2 Observed Forages. We observed only 22 forages at the Cliff territory, two in 1987 and 20 in 1989. Nineteen of the 22 observed forages were for fish, two were for unknown prey (probably fish, due to forage location), and one was for a coot. We observed forages for fish from Km 64.3 to Km 69.9; however, most were concentrated near the nest in Segment 65, where we noted 16 forages. Fourteen of these 16 were in Km 65.4–65.6, very near the nest location at Km 65.4.

Eight of 19 identified forage perches were on cliffs. Of these, five were cliff ledges and three were cliff tops. Vegetation along the river was also used; six forages were made from large cottonwoods, three from snags, and one from a low branch. One forage originated from the nest. Perch to strike point distances were almost always short. Fourteen recorded distances were less than 100m, three were 100 m, and one was 400 m. There were 14 successful forages in the 22 attempts.

Table B4.7-1. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Cliff bald eagle nest (12 July 1986, 24 April 1988, 8 July 1988, and 16 May 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Carp	14	31.1	412	(211-608)	12,309	45.9
Channel Catfish	8	17.8	310	(229-372)	1,950	7.3
Largemouth Bass	6	13.3	347	(291-405)	3,471	12.9
Crappie sp.	5	11.1	306	(269-348)	2,244	8.4
Flathead Catfish	4	8.9	412	(352-510)	2,965	11.1
Blackbass sp.	3	6.7	344	(334-367)	1,540	5.7
Subtotal	40	88.9			24,479	91.3
Bird Species						
Unid. Waterfowl	1	2.2			811	3.0
Gambel's Quail	1	2.2			166	0.6
Unid. Passerine	1	2.2			56	0.2
Subtotal	3	6.7			1,033	3.9
Cottontail sp.	2	4.4			1,300	4.8
TOTAL	**45**	**100.0**			**26,812**	**100.0**

In forages for fish or unknown prey in the river, runs were the most common habitat (n = 5). Four forages occurred in pre-riffles and two in post-riffles, with five simply noted as river, generally the center of the channel. Three carrion fish were taken on shore. Of the sixteen forages noted in the nest area (Km 65.4–65.6), six occurred below the nest in Km 65.4, five of these occurred in runs and one in a pool.

Table B4.7-2. Number, length (mm in fish), and estimated biomass (grams) of prey identified from remains collected from perches and following foraging events in the Cliff bald eagle territory (1989).

Species	No.	Percent	Mean Length	(range)	Biomass	Percent
Carp	8	80.0	416	(276-483)	6,452	86.2
Channel catfish	1	10.0	356	(356)	345	4.6
Largemouth bass	1	10.0	370	(370)	689	9.2
Total	10	100.0			7,486	100.0

We identified the prey in 12 of the 19 forages for fish. Eight carp were taken, along with two shad, one largemouth bass, and one probable sucker. We observed the forages for carp from 17 February to 27 April, 1989. Six of the carp taken were live, one was carrion, and the status of one was undetermined. Habitat was evenly divided between runs (n = 2), pre-riffles (n = 2), and post-riffles (n = 2), with one simply noted as "river channel." Both shad were taken as carrion on shore on 8 January. The male made an unsuccessful forage on 11 January in a section of river where the observer noted "numerous shad" floating dead in the water. The forage attempt for the coot (unsuccessful) occurred in the nest area on 10 February, 1987.

B4.7.3 Prey Populations

Data on the fish community in the Verde River between Horseshoe and Bartlett reservoirs are scarce. Comprehensive surveys have not been conducted, however, J. Warnecke (AGF) told us that carp, catfish and smallmouth bass are the most common prey-sized fish in the reach; suckers are rare.

We collect 22 potential prey fish in the area using gill nets in April and May 1989. Although our surveys were not extensive, the majority of fish collected were carp (77%), and all the fish collected are also common in Bartlett and Horseshoe reservoirs (see Table B4.7-3). We did not collect any suckers in the river in the Cliff breeding area despite using the same collection techniques that yielded hundreds of suckers in other territories (i.e., Bartlett, Blue Point, and Ladders).

Table B4.7-3. Summary of potential prey fish collected in floating gill nets and overnight gill net sets in the Verde River between Horseshoe Reservoir and Bartlett Reservoir in March and April, 1989.

Location (km)	Date	Capture Method	Length Surveyed (m)	Start Time	End Time	Species Collected	Total Length (mm)	Weight (gm)	Reproductive Status
69.05	4/15/89	Floating Gill Net	140	845	906	Carp	331	458	RSS
						Carp	440	1,025	RSS
						Carp	479	1,260	RSS
						Carp	536	2,580	RSS
						Carp	342	475	SPO
						Carp	492	1,340	RSE
						Carp	350	488	SPO (F)
69.1	4/15/89	Floating Gill Net	89	1000	1008	Largemouth Bass	240	172	NRS
						Largemouth Bass	102	11	NRS
						Bluegill	122	28	NRS
67.6	4/15/89	Floating Gill Net	93	1050	1056	Carp	514	1,740	EG
66.6	4/15/89	Floating Gill Net	89	1250	1313	Carp	384	715	SPO
67.5	4/15/89	Floating Gill Net	174	1117	1124	None			
66.4	3/14/89	Gill Net	—	1830	545	None			
69.03	3/17/89	Gill Net	—	1930	550	Largemouth Bass	334	530	RG
						Carp	342	510	RG
						Carp	515	1500	EG
64.5	4/03/89	Gill Net	—	1600	630	None			
61.8	4/04/89	Gill Net	—	920	1010	None			
62.0	4/04/89	Gill Net	—	1050	1215	None			
69.2	4/05/89	Gill Net	—	800	1005	Carp	458	1,400	SPO
69.1	4/05/89	Gill Net	—	1325	1445	Carp	415	890	RSS
						Carp	445	1,150	RSE
						Carp	519	1,750	RSS
						Green Sunfish	133	45	RSS
66.4	3/15/89	Gill Net	—	1920	620	None			
69.0	3/17/89	Gill Net	—	1930	615	Largemouth Bass	334	530	RG
						Carp	342	510	RG
						Carp	515	1,500	EG

NRS = No gametes released; **RG** = Reabsorbed gonads; **RSE** = Released eggs; **RSS** = Released sperm; **SPO** = Spawned out.

We also conducted roving visual surveys along the river (Km 61–69) on 15–17 March, 2–6 April and 15 April 1989 to assess fish availability. During these surveys, one biologist walked along the edge of the river and surveyed the river visually using polarized sunglasses and binoculars (10 × 50). When possible, the biologist climbed cliffs or trees along the river to get a better view. Fish activity (i.e., feeding or spawning) was noted during these surveys. Carp were by far the most abundant potential prey fish observed, followed by catfish. We observed carp spawning in the river on numerous occasion in April; temperatures in the river in April were 15–22°C.

The fishery in the Cliff breeding area is similar to that in the reach just upstream of Roosevelt Reservoir (Pinal breeding area) in (1) species composition (i.e., carp and catfish dominate) and (2) that a fish barrier in both territories would act to concentrate carp and catfish making spawning runs out of a reservoir (diversion dam at Pinal/Pinto, Horseshoe Dam at Cliff). In Section B4.6.4 we discussed how the Roosevelt diversion dam concentrates carp and catfish making spawning runs out of Roosevelt Reservoir, drawing anglers to the river. Similarly, in the Cliff breeding area, we observed anglers concentrated on the river from the base of Horseshoe Dam downstream 5 Km. The majority of anglers in both territories were fishing almost exclusively for catfish. In both the Pinal/Pinto and Cliff breeding areas, we suspect that carrion produced by the anglers (i.e., unwanted carp and remains of filleted catfish) may provide forage for the eagles in some years. Interestingly, we observe substantially lower fishing activity at the base of Stewart Mountain Dam and Bartlett Dam compared to at the base of Horseshoe Dam and the Roosevelt Diversion Dam. The main difference at these sites is that no reservoirs are located downstream of Stewart Mountain Dam or Bartlett Dam to provide a source of catfish. Cold water releases from these dams are not conducive to the establishment of large riverine populations of catfish downstream.

Results of four waterbird surveys conducted at the Cliff breeding area are given in Table B4.7-4.

B4.7.4 Human Impacts

In our opinion, the Cliff pair is among the most vulnerable to public disturbance of any pair in Arizona because: (1) the top of the cliff is accessible and attractive to hikers; (2) the cliff is relatively small; (3) people visiting the area from below pass very near the cliff; (4) the current nest is on a pinnacle where no shade is available; and, (5) there is considerable public use activity in the territory. On warm days, eggs or young of adults flushed from the pinnacle nest would probably soon be in distress from ambient, conductive, and reflective heat.

The Cliff territory is accessible by an improved dirt road on the west side of the reservoir and by multiple jeep trails, including some that come from the north end of Bartlett Reservoir. The Forest Service enacted a closure on 7 February 1985, restricting entry from 15 November–15 July. The order was revised in 1987, changing the dates of effect to 1 December–30 June. The closure extends from about Km 62.6 to Km 66.3 and includes areas on either side of the river.

B4.7.4.1 Public Users. We recorded ten public use incidents at Cliff territory during the 1989 breeding season, only one of which was within 100 m of an eagle. The low number of records is due to early failure of the nest. The single incident within 100 m was caused by a four-wheel drive vehicle fording the river which prompted the eagle to flush from the shore. The remaining public use records consisted of the following: (1) two by people outside of a vehicle; (2) two by airplanes; (3) two by helicopters;

Table B4.7-4. Water birds observed in surveys at Cliff breeding area (1989).

Species	Avg. No. Individuals per Survey	% Species/Month		
		Feb	March	April
Double-crested Cormorant	0.3 (n = 1)	—	—	16.7
Pintail	4.25 (n = 17)	25.4	—	—
Redhead	4.8 (n = 19)	13.4	83.3	—
Ring-necked Duck	4.5 (n = 18)	26.9	—	—
Bufflehead	5.8 (n = 23)	34.3	—	—
Great Blue Heron	1.8 (n = 7)	—	16.7	83.3
		n = 67 (one survey)	n = 12 (one survey)	n = 6 (two surveys)

(4) one by an all-terrain cycle; (5) one by anglers on foot; and, (6) one by gunshot. One of the airplanes and both helicopter events caused an eagle to flush. These observations seem to indicate that these eagles have an aversion to aircraft and public users in general, suggesting negative experiences with them.

Nest watchers from 1984, 1985, and 1989 reported high amounts of public use. In 1984, nest watchers, Dodds and Martin suggested a closure to cut down on disturbances in the nest area. After the closure was established in 1985, nest watchers reported having problems keeping people out of the nest area. Williams (1985) described several violations of the closure, including fishing on the cobble bar downstream from the ford, and shooting fish and cliff swallows also from the cobble bar. Kuder and Sinor (1989) placed their camp on the west edge of the closure from Thursdays through Sundays in order to prevent recreationists from entering the closure, but commented that most of the people they talked to knew about the closure but had never seen it enforced and were ready to enter again. Kuder and Sinor said there was at least one gunshot in the area every weekend and sometimes during the week during the 1989 breeding season. Camera and Motzkin (1985) suggested enlarging the upper end of the closure and creating a 200–300 m buffer zone around the edge in which recreational activities other than shooting would be allowed.

B4.7.4.2 Effects of Dam Repair. Safety of Dams (SOD) modifications will be required at Horseshoe Dam (see B4.3), but construction activity and alterations to Horseshoe Dam itself are unlikely to affect the Cliff eagles, since the nest is well downstream. However, because the Cliff pair did not have young in the year of study, the importance of the dam area as a foraging site remains uncertain.

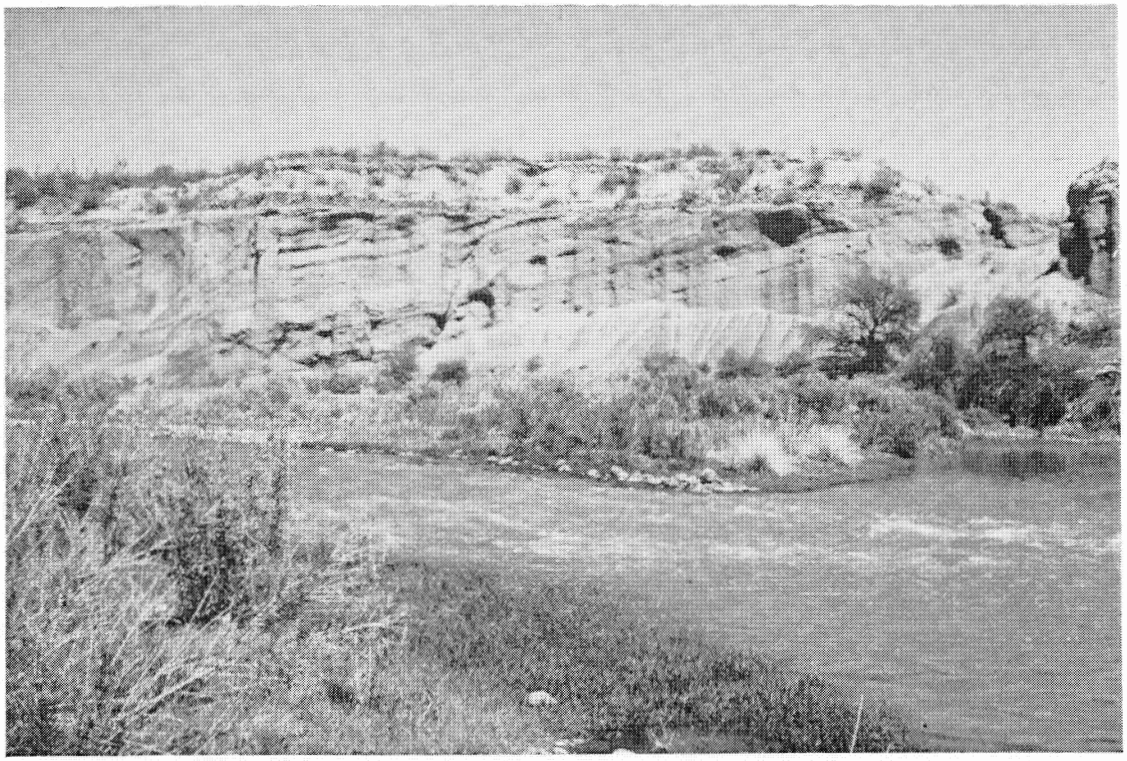


Plate 39. Regulated Verde River at the proposed location for Cliff Dam, April 1990. The river along these cliffs was used for foraging by the Cliff eagles (photo by D. Driscoll).

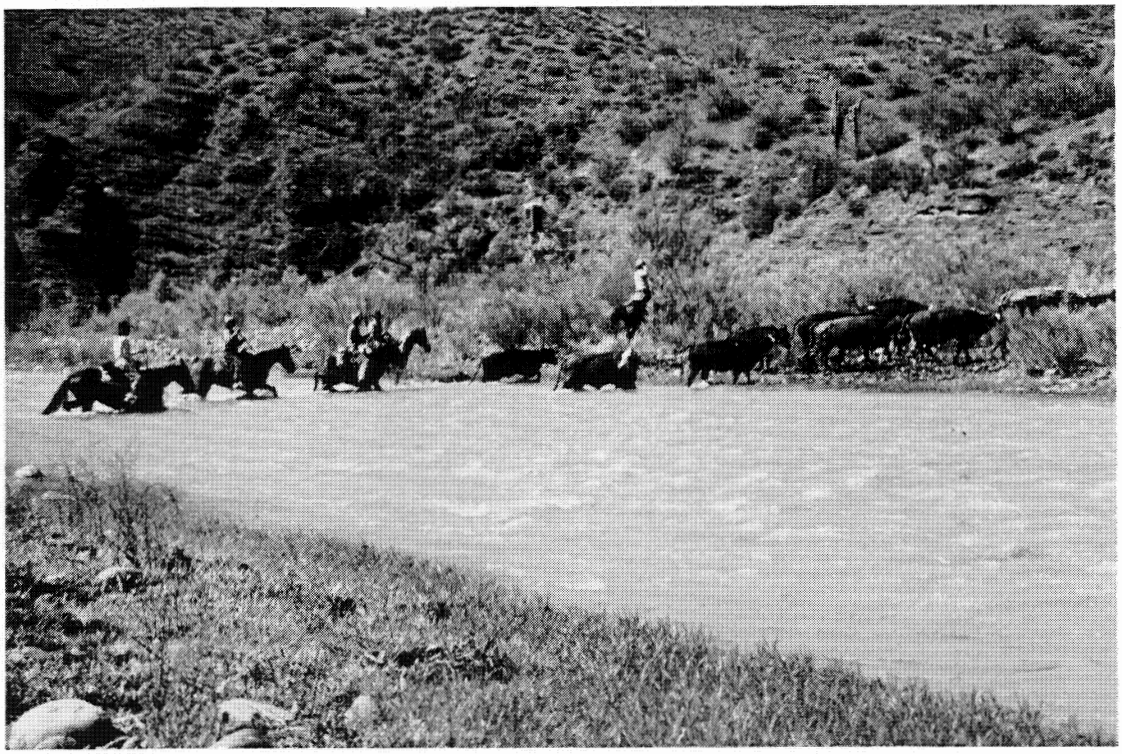


Plate 40. Cowboys leading cattle across the regulated Verde River at Cliff, April 1990 (photo by D. Driscoll).

Indirect effects on foraging opportunities should also be minimal, since reservoir elevations, release rates, and release elevations are not expected to change (U.S. Fish and Wildlife Service 1989). Peak elevations would be restricted in the spring, but no fish kill is predicted (U.S. Bureau of Reclamation 1990). However, the borrow area for construction is downstream of the dam and might temporarily affect the eagles either by disturbance or by increasing turbidity.

B4.7.5 Discussion

Because the Cliff pair was unsuccessful in the year of study and thus had relatively low food requirements, they probably did not demonstrate normal foraging ranges and patterns. Our results, therefore, are not directly comparable to those obtained at breeding areas where eagles raised young.

The habitat setting of the Cliff bald eagle nesting area is similar to that of Bartlett and Blue Point in containing a regulated river section not far downstream of a dam from which there is a hypolimnetic release. However, the diet of the cliff eagles is much different than those of Bartlett and Blue Point where the birds took significant numbers of suckers and relatively few carp. We found no suckers in the Cliff nest prey remains or in forage observations, while carp made up nearly half the diet. As we have said, this difference was likely a result of the much warmer river temperatures at Cliff which favor carp over suckers, and possibly because of spawning runs of carp and catfish out of Bartlett reservoir. In the Cliff territory, the reservoir above the dam apparently does not maintain a cool hypolimnion.

B4.7.6 Management Recommendations

We suspect that disturbance and possibly exposure to the elements have frequently exacted their toll during incubation and hatching at the Cliff breeding area. We speculate that negative experiences with these factors may in some years influence hormone titers during the egg-laying period, resulting in failure to lay. Perhaps the creation of an additional artificial nest structure on the cliff face might benefit these birds. Such a structure should be situated so as to provide a clear view of the river in both directions, rather than being placed in a recessed area. The eagles would be more likely to accept a location where intruders (eagles and people) could be detected at distance.

Other management guidelines for the Cliff breeding area are discussed in detail in Section D4.9 and mainly involve suggestions as to how the considerable rate of human disturbance to the pair might be reduced.

B5 PREY SELECTION THROUGHOUT THE ARIZONA BREEDING POPULATION

In this section we discuss prey species composition based on prey remains analysis for each of the Arizona bald eagle territories throughout the state where collections of prey items occurred. In addition to collections made at the nest, we include prey tables for items collected under perches and following foraging/feeding events at priority sites. We did not collect prey remains at Pleasant, Devil's Post, Ash, and Mule Hoof, since eggs apparently were not laid at these nest sites during our study. Although the Pinto female laid egg(s) in 1989, we were unable to climb the nest, as it was located on the end of thin, secondary tree limbs. However, we did collect prey remains below perches and following forage events of the Pinto female; then we combined these data with those of the Pinal/Pinto territory because the eagles used the same perches and foraging habitat.

We also summarize our findings of prey selection based on nest observation during intensive studies at priority territories (Sections B4.1–B4.6). A comparison between prey remains analysis and direct observation of prey deliveries to the nest will follow this discussion (see also Section A3.1.1); we used both methods to determine the diet of eagles at priority sites.

Prey tables contain data on both number and biomass of each species taken by bald eagles. Numbers of each species are important because each represents a single foraging or nest delivery event. Large numbers of a single species obviously indicate that species is commonly available in the territory. However, because of size differences of fish between and within species, and interspecific size differences among bird and mammal species, we also compare the eagle diets in terms of weight or biomass. This, being the amount of edible flesh available to the eagles, truly indicates the importance of each species. For example, at a nest we studied in California, we might find two Sacramento suckers (20% numerically) and eight tule perch (80%), but in terms of eagle food, these would yield 1700 grams of sucker (73%) and only 640 grams of perch (27%).

Prey lists have appeared in all previous studies of Arizona bald eagles, and the total number of prey species identified has accrued with each investigation. As diversity estimates increased, the percentage of each species' contribution decreased. In these studies, species representation was usually ranked according to numerical abundance, rather than biomass.

Duane Rubink's (USFWS) Study, 1972–1975. During the research of Duane Rubink (USFWS) in 1972–1975, prey remains were collected below nest trees, from fallen nests, below perches, and by visual examination of cliff nests. Although only a limited number of samples were obtained (seven collections from six breeding areas), Rubink and Podborny (1976) identified 63 individuals of seven species. They found channel catfish the most abundant prey (68.2% numerically), followed by carp (14.3%), American coots (4.8%), and suckers (3.2%) (Table B5.0-1). When prey types were grouped, fish represented 87.3 percent of the prey remains, birds 6.4 percent, mammals 3.2 percent, and herptiles 3.2 percent.

Tom Hildebrandt's (ASU) Research, 1977–1978. During 1977–1978, Tom Hildebrandt (ASU) obtained food habits data by collecting prey remains in and below nests that were climbed to band young, and by observing prey deliveries to the nest. In addition, Hildebrandt (1981) reported on prey remains collected

Table B5.0-1. Prey species observed taken by bald eagles or collected near nests at Arizona breeding areas, during the research of Duane Rubink (USFWS), 1972–1975.

		N	Percent	Rank
Fish		**55**	**87.3**	
Carp		9	14.3	2
Channel Catfish		43	68.2	1
Sucker sp.		2	3.2	4
Unidentified Fish		1	1.6	—
Birds		**4**	**6.4**	
Wading Birds	American Coot	3	4.8	3
Other Birds	Unidentified Bird	1	1.6	—
Mammals		**2**	**3.2**	
Cottontail Rabbit		1	1.6	—
Ground Squirrel		1	1.6	—
Herptiles		**2**	**3.2**	
Spiny Softshell Turtle		1	1.6	—
Unidentified Snake		1	1.6	—
Total	**7 species**	**63**	**100.1**	

below the Fort McDowell nest in 1976 by Norris Dodd (ASU). Hildebrandt (1981) and Hildebrandt and Ohmart (1978) reported 192 individuals of 20 species, and again found channel catfish the most abundant prey (40.1% numerically), and carp second in abundance (21.4%). Desert suckers ranked third (12.5%), followed by cottontail rabbits (4.7%), Sonora suckers (4.2%), blacktailed jackrabbits (3.1%), and great blue herons (2.6%) (Table B5.2-2).

When prey types were grouped, fish represented 82.3 percent of the prey remains, mammals 9.9 percent, birds 7.8 percent; no herptiles were found. Among the 220 prey items Hildebrandt observed in prey deliveries to the nest, 45.0 percent were fish, 8.2 percent mammals, 5.9 percent birds, and 40.9 percent were unidentified. If the unidentified prey are removed from the sample, 130 known prey deliveries resulted in 76.2 percent fish, 13.8 percent mammals, and 10.0 percent birds, roughly comparable to the prey remains analysis (Hildebrandt 1981).

Table B5.0-2. Prey species observed taken by bald eagles or collected from nests at Arizona breeding areas, during the research of Tom Hildebrandt, under Dr. Robert Ohmart (ASU), 1976–1978.*

		N	Percent	Rank
Fish		**158**	**82.3**	
Carp		41	21.4	2
Buffalo sp.		1	0.5	—
Channel Catfish		77	40.1	1
Flathead Catfish		2	1.0	—
Bullhead (Catfish)		1	0.5	—
Largemouth Bass		2	1.0	—
Smallmouth Bass		1	0.5	—
Desert Sucker		24	12.5	3
Sonora Sucker		8	4.2	5
Black Crappie		1	0.5	—
Birds		**15**	**7.8**	
Waterfowl	Unidentified Waterfowl	2	1.0	—
Wading Birds	Great Blue Heron	5	2.6	7
Passerines	Thrasher sp.	1	0.5	—
	European Starling	1	0.5	—
	Scrub Jay	1	0.5	—
Other Birds	Dove sp.	2	1.0	—
	Unidentified Caprimulgidae	1	0.5	—
	Gambel's Quail	2	1.0	—
Mammals		**19**	**9.9**	
Cottontail Rabbit		9	4.7	4
Blacktail Jackrabbit		6	3.1	6
Neotoma sp. (wood rat)		2	1.0	—
Unidentified Small Mammal		2	1.0	—
Total	**20 species**	**192**	**100.0**	

* 1976 samples collected below Fort McDowell nest by Norris Dodd, ASU.

Opercula were measured from known-size carp collected on the Salt and Verde rivers, and used to develop a regression relating operculum length to standard length of the fish. The estimated mean standard length for 46 carp found in prey remains was 398 mm, ranging from 234–549 mm. Size estimations were not made for other species.

Hildebrandt and Ohmart (1978) noted that "Mammalian prey, primarily desert cottontails, were important to eagles during periods of high and/or turbid water when fish were less accessible." They explained that the draining of Bartlett Reservoir (during the nesting season) produced high, turbid flows in the regulated Verde River, and a shift in food habits, with greater reliance on mammalian and avian prey, was detected.

Dennis Haywood and Robert Ohmart's (ASU) Research, 1979–1982. During 1979–1982 Haywood and Ohmart (1980, 1981, 1982, 1983) collected prey remains in nests and observed prey deliveries and forage events. They identified 484 individuals of 30 species. Channel catfish was the most abundant prey (37.2%), Sonora suckers ranked second (13.2%), and carp third (12.2%). These were followed by American coots (5.6%), flathead catfish (4.6%), desert suckers (4.3%), cottontail rabbits (3.5%), and blacktail jackrabbits (2.9%) (Table B5.2-3).

When prey types were grouped, fish represented 76.5 percent of the prey remains, mammals 12.0 percent, birds 11.0 percent, and herptiles 0.6 percent. Haywood and Ohmart utilized ABENWP nestwatchers to obtain visual data on 733 prey deliveries to the nest, 73.2 percent of which were fish, 5.0 percent mammals, 1.4 percent birds, and 16.5 percent unidentified (Haywood and Ohmart 1983). The percentage of fish in the diet is comparable to that found in prey remains; however, less mammals and birds were observed in the visual data, and herptiles were absent.

Opercula lengths were measured from 45 known-size carp, 38 Sonora suckers, and 37 desert suckers collected from the Salt, Verde, and Gila rivers, and in Phoenix area canals. Similarly, channel catfish pectoral spine diameters were measured from 157 collected fish (Haywood and Ohmart 1983). These measurements were used to develop a regression relating operculum length to standard length and biomass of these fish species.

The estimated mean standard length for 141 channel catfish found in prey remains from 1979–1982 was 253 mm, ranging from 128–476 mm. Biomass estimations were not made for catfish. Of 73 carp (46 from Hildebrandt 1981) found in prey remains from 1977–1982, the mean standard length was 313 mm, ranging from 151–437 mm, with a mean weight of 636 grams, varying from 106–1,432 grams. The mean standard length of 23 Sonora suckers found in prey remains from 1979–1982 was 288 mm, ranging from 166–415 mm, with a mean weight of 293 grams. Of eight desert suckers found in prey remains from 1979–1982, the mean standard length was 212 mm, ranging from 163–314 mm, with a mean weight of 348 grams (Haywood and Ohmart 1983).

Haywood and Ohmart (1986) argued that although fish were represented in a much higher percentage in prey remains than mammals (76.5% versus 11.9%), mammals provided 28.1 percent of the total biomass, compared to 57.6 percent supplied by fish. Birds and herptiles (11.0 and 0.6% of the prey remains, respectively) contributed 14.1 and 0.2 percent of the total biomass, respectively. The caloric contribution of mammals, specifically blacktail jackrabbits, led Haywood and Ohmart (1986) to state "... that mammalian prey is essential to satisfy the energy demands of bald eagles breeding in Arizona."

Teryl Grubb's (USFS) Research, 1983–1985. During 1983–1985, Teryl Grubb (USFS) identified 42 species from prey remains and observed deliveries to the nest (Table B5.0-4). No prey remains were

Table B5.0-3. Prey species observed taken by bald eagles or collected from nests at Arizona breeding areas during the research of Dr. Robert Ohmart (ASU), 1979–1982.

		N	Percent	Rank
Fish		**370**	**76.5**	
Carp		59	12.2	3
Channel Catfish		180	37.2	1
Flathead Catfish		22	4.6	5
Bullhead (Catfish)		8	1.7	10
Yellow Bass		5	1.0	—
Bass sp.		6	1.2	—
Desert Sucker		21	4.3	6
Sonora Sucker		64	13.2	2
Black Crappie		1	0.2	—
White Crappie		1	0.2	—
Unidentified Fish		3	0.6	—
Birds		**53**	**11.0**	
Waterfowl	Unidentified Waterfowl	1	0.2	—
Wading Birds	American Coot	27	5.6	4
	Great Blue Heron	5	1.0	—
	Great Egret	1	0.2	—
Passerines	Northern (Bullock's) Oriole	1	0.2	—
	Blue Grosbeak	1	0.2	—
	Great-tailed Grackle	1	0.2	—
Other Birds	Gila Woodpecker	2	0.4	—
	Mourning Dove	4	0.8	—
	Red-naped Sapsucker	1	0.2	—
	Northern (Gilded) Flicker	2	0.4	—
	Gambel's Quail	1	0.2	—
	Common Poorwill	1	0.2	—
	Unidentified Bird	5	1.0	—
Mammals		**58**	**12.0**	
Cottontail Rabbit		17	3.5	7
Blacktail Jackrabbit		14	2.9	8
Neotoma sp. (Wood Rat)		4	0.8	—
Rock Squirrel		3	0.6	—
Harris' Ground Squirrel		1	0.2	—
Yuma Antelope Ground Squirrel		1	0.2	—
Pocket Gopher		1	0.2	—
Peromyscus sp. (Mouse)		3	0.6	—
Perognathus sp. (Pocket Mouse)		1	0.2	—
Unidentified Mammal		13	2.7	9
Herptiles		**3**	**0.6**	
Unidentified Snake		2	0.4	—
Unidentified Lizard		1	0.2	—
Total	**30 species**	**484**	**100.1**	

Table B5.0-4. Forty-two prey species observed taken by bald eagles or collected from nests at Arizona breeding areas (n = 1471 individuals), during the research of Teryl Grubb (USFS), 1983–1985.*

Fish (n = 1,118, 76%)		**Mammals (n = 263, 17.9%)**
Carp**		Cottontail Rabbit
Channel Catfish**		Blacktail Jackrabbit
Flathead Catfish		*Neotoma* sp. (Wood Rat)
Smallmouth Bass		Rock Squirrel
Yellow Bass		*Peromyscus* sp. (mouse)
Bass sp.		Unidentified Rodent
Sunfish sp.		Ringtail
Desert Sucker*		Striped Skunk
Sonora Sucker*		Beaver
Unidentified Fish		Muskrat
		Collared Peccary (Javelina)
		Hereford Cow
Birds (n = 59, 4.0%)		Unidentified Mammal
Waterfowl	Mallard	
	Green-winged Teal	
	Cinnamon Teal	**Herptiles (n = 31, 2.1%)**
	Common Merganser	Sonoran Mud Turtle
	Unidentified Waterfowl	Spiny Softshell Turtle
Wading Birds	American Coot	Racer
Passerines	Northern Mockingbird	Unidentified Snake
	Violet-green Swallow	Unidentified Lizard
	Cactus Wren	Unidentified Frog
	Grackle sp.	
	Blackbird sp.	
	Jay sp.	**Other**
Other Birds	Gila Woodpecker	Crayfish
	Mourning Dove	
	White-winged Dove	
	Greater Roadrunner	
	Northern Flicker	
	Gambel's Quail	
	Whip-poor-will	
	Wild (Merriam's) Turkey	
	Unidentified Bird	

* No data available on number or percent of prey species.
** Most common prey types.

collected in 1983 (Grubb *et al.* 1983), and although prey remains were collected from nests in 1984 and 1985, no quantified data are available (Grubb 1984, Grubb 1986a). Most prey data reported for 1983–1985 were obtained from observations of eagle prey deliveries to the nest by ABENWP personnel (Grubb 1986a). Grubb (1986a) noted that the most common prey types identified were catfish, carp, and suckers. Crayfish were present in prey remains collected, but these may have been present in the stomachs of delivered fish.

Of 1,471 observed prey deliveries, 76.0 percent were fish, 17.9 percent mammals, 4.0 percent birds, and 2.1 percent herptiles (Grubb 1986a). The most common fish sizes were estimated to be 6–12 inches (57%) and 12–18 inches (26%) by observers watching the nest (Grubb 1986a).

B5.1 BIOSYSTEMS PREY REMAINS ANALYSIS

In our discussions of prey composition along several drainages, we grouped bald eagle territories on the basis of their occurrence in the various habitat types, including free-flowing river, regulated river, reservoir, and combinations of these habitats. For a graphic display of geographic and habitat variation in prey selection among the Arizona eagles, we refer the reader back to Figure A3.1-4.

B5.1.1 Big Sandy, Bill Williams, Gila River Drainages

The number, mean lengths of fish, range of fish lengths, and estimated biomass of prey species identified from prey remains collected in the Chino, Alamo, Ive's Wash, and Coolidge bald eagle nests are presented in Tables B5.1-1, B5.1-2, B5.1-3, and B5.1-4, respectively. The four sites were the only territories not on the Salt or Verde systems where remains were collected. The Chino pair nested along the unregulated Big Sandy River near Alamo Reservoir. The remaining three pairs nest adjacent to a reservoir—Alamo Reservoir, San Carlos Reservoir (Coolidge)—and a regulated river—Bill Williams River, Gila River (Coolidge)—away from the Salt and Verde system. We collected no remains from the inactive site near Pleasant Reservoir on the Agua Fria River.

The majority of prey items and biomass were fish at all four sites; channel catfish contributed the bulk of the fish biomass in each territory. Largemouth bass (including black bass sp.) were also important at each of the nesting sites. Bird and mammal species occurred in different proportions at each site; however, the use of American coots, teal, grebes, and rabbits were shared by most pairs in this group.

We identified remains of 33 individual prey animals from two collections in 1986 and 1987 at the Chino nesting territory (Table B5.1-1). Channel catfish and bass accounted for 35.4 and 21.1 percent, respectively, of the biomass recorded at Chino. Other fish biomass contributions included: carp (5.9%), crappie (5.9%), and Tilapia (7.7%). We identified two jackrabbits in the remains that represented 20.0 percent of the total biomass.

From seven prey collections (1986–1989) at the Alamo bald eagle territory (Table B5.1-2), we identified the greatest diversity of prey species in this grouping. Channel catfish (48.0%), bass (18.2%), and carp (8.0%) comprised the majority of the fish biomass (76.6% of total biomass). In all, we identified 219 individual fish or 83.3 percent of 263 total prey items. Other fish collected in small numbers at Alamo were Tilapia, bullhead, sucker sp., and golden shiner. Birds represented 14.0 percent of the estimated biomass; American coot and green-winged teal were most common. Mammals, including four cottontails and two jackrabbits, accounted for 9.3 percent of the biomass.

Table B5.1-1. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected from below and from fallen nest debris of the Chino bald eagle nest (30 September 1986, 15 May 1987).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	16	48.5	388	(301–466)	7,468	35.4
Largemouth Bass	7	21.2	368	(309–458)	4,135	19.6
Carp	2	6.1	388	(359–418)	1,245	5.9
Crappie sp.	2	6.1	337	(321–353)	1,234	5.9
Tilapia sp.	2	6.1	358	(340–375)	1,628	7.7
Black Bass sp.	1	3.0	309	(309)	343	1.6
Subtotal	30	90.9			16,053	76.1
Other Species						
Jackrabbit sp.	2	6.1			4,228	20.0
Unid. Waterfowl	1	3.0			811	3.8
Subtotal	3	9.1			5,039	23.8
Total	**33**	**100.0**			**21,092**	**99.9**

At Ive's Wash, we recovered remains of 192 individual prey animals from five collections in 1987, 1988, and 1989 (Table B5.1-3). Again, channel catfish (60.7%) and black bass (21.0%) made up the majority of the calculated biomass. We also found the remains of five carp, two crappie, one bullhead, and one striped bass. The striped bass was possibly taken from the Bill Williams River during a spawning run out of Havasu Reservoir located about 40 airline km west of the territory. Birds, including four American coot and three cinnamon teal, contributed 9.3 percent of the biomass at Ive's Wash. Mammals were less significant with a 5.4 percent biomass contribution.

Fish species were less important to the diet of the Coolidge bald eagles than any other territory in this group. We calculated that fish represented 40.8 percent of available biomass from five collections made between 1986–1988. Channel catfish (12.2%), carp (11.1%), and black bass (10.9%) each contributed about equally to estimated biomass. Of 43 total individual prey items, birds (n = 12) supplied 22.0

Table B5.1-2. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in and below the Alamo bald eagle nest (17 June 1986, 15 May 1987, 1 April 1988, 23 April 1988, 27 June 1988, 25 March 1989, 15 May 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	142	54.0	381	(253–593)	65,822	48.0
Largemouth Bass	46	17.5	330	(195–467)	20,687	15.1
Carp	15	5.7	399	(276–498)	11,033	8.0
Black Bass sp.	8	3.0	329	(223–466)	4,197	3.1
Tilapia sp.	3	1.1	350	(282–432)	2,516	1.8
Bullhead sp.	2	0.8	273	(247–298)	452	0.3
Golden Shiner	1	0.4	120	(120)	30	trace
Sucker sp.	1	0.4	350	(350)	404	0.3
Unid. Ictaluridae	1	0.4	211	(211)	72	0.1
Subtotal	219	83.3			105,213	76.6
Bird Species						
American Coot	9	3.4			5,778	4.2
Green-winged Teal	5	1.9			1,705	1.2
Grebe sp.	3	1.1			2,214	1.6
Unid. Waterfowl	3	1.1			2,433	1.8
Ruddy Duck	2	0.8			1,090	0.8
Eared Grebe	1	0.4			297	0.2
Great Blue Heron	1	0.4			2,390	1.7
Unid. Ardeidae	1	0.4			1,048	0.8
White-faced Ibis	1	0.4			622	0.5
Anas sp.	1	0.4			683	0.5
Unid. Anatidae	1	0.4			662	0.5
Western Screech Owl	1	0.4			169	0.1
Western Meadowlark	1	0.4			98	0.1
Unidentified Passerine	1	0.4			56	trace
Subtotal	31	11.8			19,245	14.0

Table B5.1-2. (Continued)

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Mammal Species						
Cottontail sp.	4	1.5			2,600	1.9
Jackrabbit sp.	2	0.8			4,228	3.1
Unid. Rodent	2	0.8			100	0.1
Unid. Lagomorph	1	0.4			927	0.7
Rock Squirrel	1	0.4			817	0.6
Neotoma sp.	1	0.4			281	0.2
Muskrat	1	0.4			1,171	0.9
Striped Skunk	1	0.4			2,688	2.0
Subtotal	13	4.9			12,812	9.3
Total	**263**	**100.0**			**137,270**	**99.9**

percent and mammals (n = 12) 37.2 percent of the total biomass. American coot and eared grebes were common bird prey; rabbits and ground squirrels contributed the majority of mammal biomass at Coolidge.

B5.1.2 Regulated Verde River and Reservoir

The Cliff and Bartlett bald eagle territories occur along regulated portions of the Verde River near large reservoirs. The diets at the Bartlett and Cliff sites differed markedly (Tables B5.1-5 and B5.1-6, respectively). Desert and Sonora sucker dominated the prey items identified in the Bartlett territory. Prey species composition at Cliff resembled that of the territories discussed above: carp, black bass, and channel catfish.

Sonora and desert suckers, combined (including sucker sp.), accounted for 32 of 45 prey individuals identified in the Bartlett territory (Table B5.1-5). These prey were identified from remains collected on rocks and under perches in the territory and following observed forages. We observed many of these items, including suckers, delivered to the nest (see Section B4.1). We made no nest collections because the Bartlett nest site was not accessible. Suckers accounted for over 55 percent of the recorded biomass at Bartlett. We also identified remains of four channel catfish, three bass, two each of carp and flathead catfish, a crappie, and one bluegill. Non-fish prey included one jackrabbit and one cottontail. Suckers were also the prominent prey species identified from nest observations (see Section B4.1). During 79 days of observation at the nest in 1988 and 1989, we recorded over 80 kg of fish delivered. Suckers accounted for 66 percent of the total biomass in deliveries.

Table B5.1-3. Number, length (mm for fish), and estimated biomass (grams) of prey identified from remains collected in the Ive's Wash nest (15 May 1987, 23 April 1988, 27 July 1988, 25 March 1989, 15 May 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	126	65.6	361	(214–545)	48,677	60.7
Largemouth Bass	36	18.8	336	(212–467)	16,638	20.8
Carp	5	2.6	241	(100–479)	1,530	1.9
Crappie sp.	2	1.0	245	(234–255)	438	0.5
Bullhead sp.	1	0.5	224	(244)	124	0.2
Black Bass sp.	1	0.5	260	(260)	200	0.2
Striped Bass	1	0.5	359	(359)	725	0.9
Subtotal	172	89.6			68,332	85.3
Bird Species						
American Coot	4	2.1			2,568	3.2
Cinnamon Teal	3	1.6			1,158	1.4
Anas sp.	3	1.6			2,049	2.6
Eared Grebe	2	1.0			594	0.7
Green-winged Teal	1	0.5			341	0.4
Unid. Waterfowl	1	0.5			811	1.0
Subtotal	14	7.3			7,521	9.3
Mammal Species						
Cottontail sp.	1	0.5			650	0.8
Rock Squirrel	1	0.5			817	1.0
Ground Squirrel sp.	1	0.5			181	0.2
Unid. Sciuridae	1	0.5			356	0.4
Unid. Rodent	1	0.5			50	0.1
Skunk sp.	1	0.5			2,240	2.8
Subtotal	6	3.1			4,294	5.4
Total	**192**	**100.0**			**80,147**	**100.0**

Table B5.1-4. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Coolidge bald eagle nest (11 June 1986, 17 April 1987, 9 October 1987, 27 April 1988, 24 June 1988).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	5	11.6	427	(374–506)	3,074	12.2
Carp	5	11.6	366	(275–450)	2,787	11.1
Largemouth Bass	4	9.3	320	(300–361)	1,556	6.2
Black Bass sp.	3	7.0	318	(269–367)	1,187	4.7
Unid. centrarchidae	2	4.7	312	(306–318)	707	2.8
Bullhead sp.	1	2.3	298	(298)	287	1.1
Crappie sp.	1	2.3	350	(350)	686	2.7
Subtotal	21	48.8			10,284	40.7
Bird Species						
American Coot	6	14.0			3,852	15.3
Eared Grebe	4	9.3			1,188	4.7
Gambel's Quail	1	2.3			166	0.7
Greater Roadrunner	1	2.3			376	1.5
Subtotal	12	27.9			5,582	22.1
Mammal Species						
Cottontail sp.	2	4.7			1,300	5.2
Ground Squirrel sp.	2	4.7			362	1.4
Jackrabbit sp.	1	2.3			2,114	8.4
Unid. Lagomorph	1	2.3			927	3.7
Rock Squirrel	1	2.3			817	3.2
Neotoma sp.	1	2.3			281	1.1
Deer	1	2.3			2,500	9.9
Unid. Mammal	1	2.3			1,072	4.2
Subtotal	10	23.3			9,373	37.1
TOTAL	**43**	**100.0**			**25,239**	**99.9**

Table B5.1-5. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected from Bartlett bald eagle territory perches and following foraging events during 1987–1989.

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Sonora Sucker	14	29.8	422	(296–498)	9,531	30.6
Sucker sp.	12	25.5	341	(255–384)	4,668	15.0
Desert Sucker	6	12.8	368	(336–406)	2,959	9.5
Channel Catfish	4	8.5	346	(312–379)	1,289	4.1
Carp	2	4.3	534	(467–600)	3,437	11.0
Flathead Catfish	2	4.3	557	(402–712)	4,369	14.0
Black Bass sp.	2	4.3	351	(330–371)	1,075	3.5
Crappie sp.	1	2.1	325	(325)	518	1.7
Bluegill	1	2.1	229	(229)	220	0.7
Largemouth Bass	1	2.1	290	(290)	313	1.0
Subtotal	45	95.7			28,379	91.1
Mammal Species						
Cottontail sp.	1	2.1			650	2.1
Jackrabbit sp.	1	2.1			2,114	6.8
Subtotal	2	4.3			2,764	8.9
TOTAL	**47**	**100.0**			**31,143**	**100.0**

We collected prey remains representing 45 prey individuals from the Cliff bald eagle nest site (Table B5.1-6). In addition, we identified 10 other prey items from perches and following foraging events within the territory (Table B5.1-7). Carp made up 46.0 percent of biomass from the nest and 86.2 percent of biomass identified in the territory. Fish comprised about 90 percent of both prey individuals and prey biomass collected in the nest. Other fish present in the nest included eight channel catfish, nine black bass, five crappie, and four flathead catfish. Small numbers of birds and mammals included a Gambel's quail and one cottontail.

Table B5.1-6. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Cliff bald eagle nest (12 July 1986, 24 April 1988, 8 July 1988, and 16 May 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Carp	14	31.1	412	(211–608)	12,309	45.9
Channel Catfish	8	17.8	310	(229–372)	1,950	7.3
Largemouth Bass	6	13.3	347	(291–405)	3,471	12.9
Crappie sp.	5	11.1	306	(269–348)	2,244	8.4
Flathead Catfish	4	8.9	412	(352–510)	2,965	11.1
Black Bass sp.	3	6.7	344	(334–367)	1,540	5.7
Subtotal	40	88.9			24,479	91.3
Bird Species						
Unid. Waterfowl	1	2.2			811	3.0
Gambel's Quail	1	2.2			166	0.6
Unid. Passerine	1	2.2			56	0.2
Subtotal	3	6.7			1,033	3.9
Mammal Species						
Cottontail sp.	2	4.4			1,300	4.8
Total	**45**	**100.0**			**26,812**	**100.0**

B5.1.3 Regulated Salt River and Reservoir

Both the Blue Point and Horse Mesa bald eagles occupy sites adjacent to large reservoirs along the regulated Salt River. We present the prey species identified from the Blue Point nest in Table B5.1-8, from the Blue Point territory perches in Table B5.1-9, and the prey of the Horse Mesa eagles in Table B5.1-10. The diets of eagles at these two sites showed some similarities; both took relatively high proportions of yellow bass, channel catfish, and American coot. The Blue Point eagles utilized many

Table B5.1-7. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected from perches and following foraging events in the Cliff bald eagle territory (1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Carp	8	80.0	416	(276–483)	6,452	86.2
Channel Catfish	1	10.0	356	(356)	345	4.6
Largemouth Bass	1	10.0	370	(370)	689	9.2
Total	**10**	**100.0**			**7,486**	**100.0**

more suckers than their neighbors at Horse Mesa where large carp contributed significantly to the biomass. Suckers appear to be more available to eagles nesting below the last dams on both the Verde (see Bartlett above and Ft. McDowell/Orme below) and Salt rivers, while carp apparently replace suckers in the diets of eagles nesting along regulated river separated by reservoirs (see Cliff above, Horse Mesa below).

The Blue Point eagles utilized a large diversity of fish species. Fish accounted for 60.4 percent of the biomass identified from the nest (Table B5.1-8) and 67.7 percent of prey remains identified from perches and following eagle foraging/feeding (Table B5.1-9). Numerically, fish accounted for 67 of 85 prey individuals from the nest and 27 of 33 individuals from the territory-wide collections. Channel catfish were most prevalent in the nest collection and represented 16.8 percent of the biomass. Suckers (9.6% of biomass), both desert and Sonora, were second in importance followed by yellow bass (9.1%), black bass (9.0%), and carp (6.8%). We also identified six bullheads, two carp, and one each of crappie, walleye, and yellow perch. Suckers represented 25.1 percent of biomass calculated from territory perch and feeding collections, followed by channel catfish (15.6%), yellow bass (10.6%), and carp (10.1%, 1 large individual). Birds and mammals contributed significantly to biomass in both collections; American coot, grebes, and rabbits were most common. In 1989, we recorded 40 days of prey deliveries to the Blue Point nest; suckers represented 28 percent of the total biomass delivered (see Section B4.2). Overall, fish contributed 83 percent of the delivered biomass. Yellow bass and black bass accounted for 21 and 20 percent of the biomass, respectively. Among non-fish prey, waterfowl were the most important (8% of biomass delivered).

We calculated that carp accounted for the most biomass (27.2%) from four collections made at the Horse Mesa nesting site (Table B5.1-10). Of 36 total individuals, we found 26 fish (72.2%). Other important fish included yellow bass (14.6% biomass), channel catfish (11.9%), and crappie sp. (9.8%). In addition, we identified three bullheads, one sucker, one bass, and one walleye. American coot were the most commonly taken bird. The skin of one chuckwalla was also found in the nest collection.

Table B5.1-8. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in and below (11/14/86) the Blue Point bald eagle nest (14 November 1986, 22 April 1987, 14 October 1987, 4 May 1988, 24 May 1988, and 27 March 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	21	24.7	333	(222–506)	7,017	16.8
Yellow Bass	13	15.3	268	(185–365)	3,786	9.1
Bullhead sp.	6	7.1	271	(235–282)	1,322	3.2
Largemouth Bass	5	5.9	289	(168–388)	1,750	4.2
Black Bass sp.	5	5.9	308	(225–454)	2,021	4.8
Desert Sucker	4	4.7	333	(304–358)	1,446	3.5
Sonora Sucker	4	4.7	396	(362–424)	2,224	5.3
Carp	2	2.4	488	(381–594)	2,859	6.8
Unid. Centrarchidae	2	2.4	273	(203–343)	553	1.3
Unid. Ictaluridae	1	1.2	372	(372)	394	0.9
Sucker sp.	1	1.2	330	(330)	343	0.8
Crappie sp.	1	1.2	300	(300)	419	1.0
Walleye	1	1.2	190	(190)	74	0.2
Yellow Perch	1	1.2	400	(400)	1,070	2.6
Subtotal	67	78.8			25,278	60.4
Bird Species						
American Coot	3	3.5			1,926	4.6
Eared Grebe	2	2.4			594	1.4
Great Blue Heron	2	2.4			3,810	9.1
Unid. Waterfowl	2	2.4			1,622	3.9
Mallard	1	1.2			1,082	2.6
Common Poorwill	1	1.2			52	0.1
Subtotal	11	12.9			9,086	21.7

Table B5.1-8. (Continued)

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Mammal Species						
Jackrabbit sp.	2	2.4			4,228	10.1
Cottontail sp.	2	2.4			1,300	3.1
Unid. Lagomorph	1	1.2			927	2.2
Ground Squirrel sp.	1	1.2			181	0.4
Rock Squirrel	1	1.2			817	2.0
Subtotal	7	8.2			7,453	17.8
Total	**85**	**99.9**			**41,817**	**99.9**

B5.1.4 Regulated Verde River

The Ft. McDowell and Orme territories occur along the regulated Verde River with no large reservoir in the vicinity. Suckers were the most common prey species and accounted for the greatest biomass in six collections representing 62 total individuals at the Ft. McDowell bald eagle nest (Table B5.1-11) and in five collections totaling 56 individuals from the Orme nesting site (Table B5.1-12). In addition, both bald eagle pairs also took some carp, channel catfish, and bass. Rabbits were important at both territories.

Most of the suckers sp. collected at the Ft. McDowell nest (Table B5.1-11) were represented by tail sections found in the nest. We noted that some had tubercles on the anal fin indicating a spawning condition. The Ft. McDowell eagles captured both Sonora and desert suckers. In all, suckers represented 66.0 percent of the biomass calculated for this territory. Other fish taken included carp (n = 2), bullhead (n = 2), channel catfish (n = 2), and bass (n = 1). This pair captured at least four cottontails; all mammals combined made up 18.2 percent of the total biomass. Three mourning doves and a sharp-shinned hawk were among the seven birds identified.

Sonora suckers (n = 17) were apparently taken more frequently than desert suckers (n = 6) at the Orme bald eagle territory (Table B5.1-12). Together, suckers accounted for 44.7 percent of the estimated biomass at the site. Seven small carp (mean length = 219 mm) were taken but comprised only 3.6 percent of the biomass. The Orme eagles also fed on two *Lepomis* sp., two unidentified centrarchids, and one bass. Birds and mammals numbered eight and ten, respectively, out of a total of 56 prey individuals identified from five collections. American coot, jackrabbits, squirrels, and cottontails were important non-fish prey.

Table B5.1-9. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected from the Blue Point bald eagle territory perches and following foraging events (1987, 1988).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Yellow Bass	8	24.2	251	(217–305)	1,733	10.6
Sucker sp.	7	21.2	346	(330–430)	2,815	17.2
Channel Catfish	7	21.2	349	(237–391)	2,547	15.6
Carp	1	3.0	535	(535)	1,651	10.1
Desert Sucker	1	3.0	312	(312)	291	1.8
Sonora Sucker	1	3.0	488	(488)	993	6.1
Black Bass sp.	1	3.0	380	(380)	630	3.9
Unid. Centrarchidae	1	3.0	325	(325)	409	2.5
Subtotal	27	81.8			11,069	67.7
Bird Species						
American Coot	3	9.1			1,926	11.8
Pied-billed Grebe	1	3.0			442	2.7
Unid. Waterfowl	1	3.0			811	5.0
Subtotal	5	15.2			3,179	19.4
Mammal Species						
Jackrabbit sp.	1	3.0			2,114	12.9
Total	**33**	**100.0**			**16,362**	**100.0**

B5.1.5 Free-flowing River into Reservoir

Channel catfish were the most important prey species represented by remains identified from the Pinal nest (Table B5.1-13) and from the Horseshoe bald eagle nest (Table B5.1-14) where the habitat setting is quite similar. The Pinal territory is located along the unregulated Salt River near Roosevelt Reservoir; Horseshoe lies along the unregulated Verde River at the head of Horseshoe Reservoir. Carp, crappie,

Table B5.1-10. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Horse Mesa bald eagle nest (3 July 1986, 10 April 1987, 29 April 1988, and 24 April 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Yellow Bass	7	19.4	284	(207–383)	2,594	14.6
Carp	4	11.1	454	(347–642)	4,831	27.2
Channel Catfish	4	11.1	384	(277–530)	2,120	11.9
Crappie sp.	4	11.1	300	(270–348)	1,744	9.8
Bullhead sp.	3	8.3	283	(241–321)	764	4.3
Sonora Sucker	1	2.8	424	(424)	667	3.8
Black Bass sp.	1	2.8	325	(325)	507	2.9
Unid. Centrachidae	1	2.8	269	(269)	296	1.7
Walleye	1	2.8	400	(400)	476	2.7
Subtotal	26	72.2			13,999	78.8
Bird Species						
American Coot	3	8.3			1926	10.8
Pied-billed Grebe	1	2.8			442	2.5
Grebe sp.	1	2.8			738	4.2
Northern Cardinal	1	2.8			45	0.3
Western Meadowlark	1	2.8			98	0.6
Unid. Passerine	1	2.8			56	0.3
Subtotal	8	22.2			3,305	18.6
Other Species						
Unid. Sciuridae	1	2.8			356	2.0
Chuckwalla	1	2.8			100	0.6
Subtotal	2	5.6			456	2.6
Total	**36**	**100.0**			**17,760**	**100.0**

Table B5.1-11. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in and below the Fort McDowell bald eagle nest (17 May 1986, 7 April 1987, 5 September 1987, 17 May 1988, 1 April 1989, 2 June 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Sucker sp.	32	51.6	349	(220–480)	13,741	52.2
Desert Sucker	4	6.5	323	(276–373)	1,351	5.1
Sonora Sucker	4	6.5	398	(324–430)	2,297	8.7
Carp	2	3.2	383	(338–427)	1,217	4.6
Bullhead sp.	2	3.2	232	(212–252)	280	1.1
Channel Catfish	2	3.2	313	(253–372)	518	2.0
Unid. Ictaluridae	1	1.6	349	(349)	458	1.7
Black Bass sp.	1	1.6	325	(325)	256	1.0
Subtotal	48	77.4			20,118	76.4
Bird Species						
Mourning Dove	3	4.8			357	1.4
Unid. Passerine	2	3.2			112	0.4
Sharp-shinned Hawk	1	1.6			139	0.5
Unid. Waterfowl	1	1.6			811	3.1
Subtotal	7	11.3			1,419	5.4
Mammal Species						
Cottontail sp.	4	6.5			2,600	9.9
Unid. Lagomorph	1	1.6			927	3.5
Ground Squirrel sp.	1	1.6			181	0.7
Unid. Mammal	1	1.6			1,072	4.1
Subtotal	7	11.3			4,780	18.2
Total	**62**	**100.0**			**26,317**	**100.0**

Table B5.1-12. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Orme bald eagle nest (3 April 1987, 5 September 1987, 21 April 1988, 21 June 1988, and 13 May 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Sonora Sucker	17	30.4	402	(314–504)	10,189	35.2
Carp	7	12.5	219	(59–337)	1,043	3.6
Desert Sucker	6	10.7	334	(290–394)	2,215	7.6
Channel Catfish	2	3.6	392	(372–411)	925	3.2
Lepomis sp.	2	3.6	175	(150–200)	166	0.6
Unid. Centrarchidae	2	3.6	194	(175–214)	187	0.6
Sucker sp.	1	1.8	384	(384)	527	1.8
Black Bass sp.	1	1.8	293	(293)	290	1.0
Subtotal	38	67.9			15,542	53.6
Bird Species						
American Coot	3	5.4			1,926	6.6
Anas sp.	1	1.8			683	2.4
Gambel's Quail	1	1.8			166	0.6
Western Meadowlark	1	1.8			98	0.3
Unid. Passerine	1	1.8			56	0.2
Unid. Bird	1	1.8			540	1.9
Subtotal	8	14.3			3,469	12.0
Mammal Species						
Jackrabbit sp.	3	5.4			6,342	21.9
Unid. Sciuridae	3	5.4			1,068	3.7
Cottontail sp.	2	3.6			1,300	4.5
Ground Squirrel sp.	1	1.8			181	0.6
Unid. Mammal	1	1.8			1,072	3.7
Subtotal	10	17.9			9,963	34.4
Total	**56**	**100.1**			**28,974**	**100.0**

Table B5.1-13. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Pinal bald eagle nest (18 October 1987, 26 April 1988, 30 April 1989, and 13 June 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	57	53.3	369	(237–561)	25,168	43.5
Carp	12	11.2	435	(316–511)	10,957	18.9
Crappie sp.	8	7.5	285	(245–348)	2,948	5.1
Black Bass sp.	8	7.5	328	(214–404)	3,628	6.3
Flathead Catfish	3	2.8	384	(333–472)	1,801	3.1
Sonora Sucker	2	1.9	359	(334–384)	845	1.5
Largemouth Bass	2	1.9	318	(256–379)	839	1.4
Razorback Sucker	1	0.9	591	(591)	1805	3.1
Subtotal	93	86.9			47,991	82.9
Bird Species						
American Coot	5	4.7			3,210	5.5
Eared Grebe	2	1.9			594	1.0
Grebe sp.	1	0.9			738	1.3
Gambel's Quail	1	0.9			166	0.3
Subtotal	9	8.4			4,708	8.1
Mammal Species						
Jackrabbit sp.	2	1.9			4,228	7.3
Cottontail sp.	1	0.9			650	1.1
Subtotal	3	2.8			4,878	8.4
Reptile Species						
Sonoran Mud Turtle	1	0.9	150	(150)	290	0.5
Unid. Lizard	1	0.9			17	trace
Subtotal	2	1.9			307	0.5
Total	**107**	**100.0**			**57,884**	**99.9**

Table B5.1-14. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Horseshoe Reservoir bald eagle nest (23 April 1987, 4 October 1987, 10 May 1988, 27 July 1988, 3 April 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	31	32.6	391	(285–522)	15,244	32.6
Crappie sp.	22	23.2	297	(246–343)	8,725	18.7
Carp	11	11.6	315	(222–450)	3,785	8.1
Largemouth Bass	8	8.4	361	(326–432)	5,292	11.3
Flathead Catfish	2	2.1	327	(320–333)	662	1.4
Black Bass sp.	2	2.1	333	(302–364)	666	1.4
Desert Sucker	1	1.1	359	(359)	448	1.0
Unid. Ictaluridae	1	1.1	482	(482)	855	1.8
Subtotal	78	82.1			35,677	76.4
Bird Species						
American Coot	5	5.3			3,210	6.9
Grebe sp.	2	2.1			1,476	3.2
Gambel's Quail	2	2.1			332	0.7
Great Blue Heron	1	1.1			2,390	5.1
Anas sp.	1	1.1			683	1.5
Unid. Waterfowl	1	1.1			811	1.7
Subtotal	12	12.6			8,902	19.1
Mammal Species						
Cottontail sp.	2	2.1			1,300	2.8
Unid. Sciuridae	2	2.1			712	1.5
Subtotal	4	4.2			2,012	4.3
Unid. Reptile	1	1.1			111	0.2
Total	**95**	**100.0**			**46,702**	**100.00**

bass and American coot also figure prominently in the diet of both bald eagle pairs. We identified very few suckers in the remains found at Pinal and Horseshoe. The species composition resembled that found for bald eagle pairs nesting adjacent to regulated river/large reservoir habitats off the Salt/Verde system (see Alamo, Ive's Wash, and Coolidge, above).

We identified 107 total prey individuals from the Pinal nest (Table B5.1-13), along with 169 prey items from perches and collections following eagle feeding/foraging throughout the territory (Table B5.1-15). Eighty-three percent of the calculated biomass from the nest was fish; birds and mammals each contributed about eight percent. In addition to channel catfish, carp, bass, and crappie, we also found three flathead catfish, two Sonora sucker, and one razorback sucker. We identified the razorback sucker from an apparently old cranium found in the Pinal nest on 13 June 1989 (identification confirmed by R. R. Miller, University of Michigan, Museum of Zoology, pers. comm.). Razorback suckers have been reintroduced to the Salt River in the Horseshoe Bend area by AGF IN 1981, 1983, 1984, 1985, and 1989 (Francisco Abarca, AGF.

American coot and eared grebes appeared in both nest and territory-wide prey collections. Birds contributed 23.4 percent of the biomass calculated from the latter sample of prey remains, most being taken during winter months. Fish species were responsible for 76.6 percent of the biomass found in the territory-wide collections. Channel catfish (n = 47) were most numerous; however, carp (n = 34) contributed the most biomass. Flathead catfish also contributed substantially to the biomass, as shown in Table B5.1-15. We identified one large buffalo fish sp. from a collection made below a mesquite perch on the shore opposite Schoolhouse Pt. on Roosevelt Reservoir. One largemouth bass, taken by an adult eagle in upper Roosevelt Reservoir (Km 105.5) on 23 March 1988, wore orange Floy tag #00361 attached by fisheries biologists in the vicinity of the diversion dam. Our observations at the Pinal nest in 1989 (see Section B4.6) reinforced the importance of catfish in this territory. Fifty-five percent of estimated biomass delivered to the nest was catfish. Overall, fish represented 97 percent of all nest deliveries for 27 days of observation. Crappie were second in importance (18% of nest delivery biomass), followed by carp (10%) and largemouth bass (9%).

Differences between prey species composition identified in the Horseshoe nest (Table B5.1-14) and Horseshoe perches (Table B5.1-16) were similar to those found for Pinal. Channel catfish contributed the most biomass (32.7%) in the nest collection; however, carp were more important (25.4% biomass) in the territory-wide collections. Crappie were conspicuous in both collections. Other fish identified in the nest included largemouth bass, flathead catfish, and desert sucker. Birds contributed 18.9 percent of the biomass identified from the nest; American coot and eared grebe were most numerous. During 25 days of nest observation in 1988, we determined that carp (34% of estimated biomass delivered) and crappie (32%) were most important to the nesting Horseshoe eagles (see Section B4.5). We recorded only 11 percent catfish in the actual nest deliveries.

B5.1.6 Free-flowing Verde River

Carp, channel catfish, flathead catfish, and Sonora suckers were the fish species shared most commonly by the bald eagle pairs nesting along the upper, unregulated reaches of the Verde River. Remains collected in the nests at Ladders (Table B5.1-17) and East Verde (Table B5.1-18) revealed carp to be most significant in terms of biomass, followed by channel catfish, suckers (probably all Sonora suckers), and flathead catfish. Both pairs took several birds and mammals; however, fish made up approximately eighty percent of the biomass at both sites. Small collections from the Table Mountain (Table B5.1-19) and Perkinsville (Table B5.1-20) nests suggested similar use of carp, catfish, and suckers.

Table B5.1-15. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected from the Pinal bald eagle territory perches and following foraging events during 1986–1989.

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	47	27.8	310	(119–654)	15,095	13.8
Carp	34	20.1	430	(234–610)	31,661	29.0
Black Bass sp.	12	7.1	328	(256–392)	5,460	5.0
Crappie sp.	9	5.3	310	(233–380)	4,497	4.1
Flathead Catfish	5	3.0	601	(238–1040)	19,702	18.0
Unid. Centrachidae	5	3.0	337	(318–389)	2,216	2.0
Largemouth Bass	4	2.4	364	(340–430)	2,378	2.2
Unid. Ictaluridae	2	1.2	260	(190–330)	328	0.3
Buffalo sp.	1	0.6	600	(600)	2,355	2.2
Lepomis sp.	1	0.6	158	(158)	69	0.1
Subtotal	120	71.0			83,761	76.6
Bird Species						
Eared Grebe	22	13.0			6,534	6.0
American Coot	15	8.9			9,630	8.8
Western Grebe	3	1.8			4,431	4.1
Grebe sp.	2	1.2			1,476	1.3
Green-winged Teal	2	1.2			682	0.6
Northern Shoveler	1	0.6			613	0.6
Anas sp.	1	0.6			683	0.6
Ruddy Duck	1	0.6			545	0.5
Unid. Waterfowl	1	0.6			811	0.7
Western Screech Owl	1	0.6			169	0.2
Subtotal	49	29.0			25,574	23.4
Total	**169**	**100.0**			**109,335**	**100.0**

Table B5.1-16. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected from the Horseshoe bald eagle territory perches and following foraging events (1987, 1988).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Crappie sp.	21	35.6	295	(230–380)	8,625	23.1
Carp	14	23.7	375	(200–550)	9,483	25.4
Channel Catfish	8	13.6	374	(252–470)	3,534	9.5
Flathead Catfish	4	6.8	599	(542–692)	9,078	24.3
Unid. Ictaluridae	2	3.4	385	(380–390)	874	2.3
Black Bass sp.	2	3.4	320	(309–330)	791	2.1
Unid. Centrarchidae	2	3.4	288	(250–325)	587	1.6
Largemouth Bass	1	1.7	339	(339)	492	1.3
Threadfin Shad	1	1.7	100	(100)	16	trace
Unid. Fish	1	1.7	353	(353)	655	1.8
Subtotal	56	94.9			34,135	91.6
Bird Species						
Eared Grebe	1	1.7			297	0.8
Grebe sp.	1	1.7			738	2.0
Subtotal	2	3.4			1,035	2.8
Mammal Species						
Jackrabbit sp.	1	1.7			2,114	5.7
Total	**59**	**100.0**			**37,284**	**100.1**

Table B5.1-17. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Ladders bald eagle nest (26 June 1986, 21 April 1987, 8 May 1987, 28 July 1988, 28 April 1989, and 23 June 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Carp	25	31.6	462	(141–610)	29,448	48.0
Channel Catfish	18	22.8	389	(214–498)	8,849	14.4
Flathead Catfish	7	8.9	375	(330–429)	3,528	5.8
Sonora Sucker	4	5.1	429	(413–443)	2,759	4.5
Sucker sp.	4	5.1	384	(300–412)	2,195	3.6
Unid. Centrarchidae	2	2.5	330	(330)	818	1.3
Subtotal	60	75.9			47,597	77.6
Bird Species						
Grebe sp.	2	2.5			1,476	2.4
Mourning Dove	2	2.5			238	0.4
Western Meadowlark	2	2.5			196	0.3
Wood Duck	1	1.3			658	1.1
Woodpecker sp.	1	1.3			48	0.1
American Robin	1	1.3			77	0.1
Unid. Passerine	1	1.3			56	0.1
Subtotal	10	12.7			2,749	4.5
Mammal Species						
Neotoma sp.	2	2.5			562	0.9
Ringtail	2	2.5			2,016	3.3
Jackrabbit sp.	1	1.3			2,114	3.4
Cottontail sp.	1	1.3			650	1.1
Coyote	1	1.3			2,043	3.3
Javelina	1	1.3			2,500	4.1
Unid. mammal	1	1.3			1,072	1.7
Subtotal	9	11.4			10,957	17.9
Total	**79**	**100.0**			**61,303**	**100.0**

Table B5.1-18. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the East Verde bald eagle nest (20 May 1986, 28 April 1987, 12 September 1987, 11 May 1988, 27 April 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Carp	28	29.5	471	(289–626)	34,083	46.8
Channel Catfish	27	28.4	418	(277–648)	17,324	23.8
Flathead Catfish	6	6.3	332	(270–396)	2,202	3.0
Sucker sp.	3	3.2	434	(434)	2,244	3.1
Black Bass sp.	3	3.2	335	(281–393)	886	1.2
Smallmouth Bass	2	2.1	364	(359–369)	719	1.0
Sonora Sucker	2	2.1	439	(414–464)	1,484	2.0
Subtotal	71	74.7			58,942	80.9
Bird Species						
Unid. Waterfowl	2	2.1			1,622	2.2
Gambel's Quail	1	1.1			166	0.2
Anas sp.	1	1.1			683	0.9
American Coot	1	1.1			642	0.9
Ladder-backed Woodpecker	1	1.1			30	trace
Unid. Bird	1	1.1			540	0.7
Subtotal	7	7.4			3,683	5.1
Mammal Species						
Unid. Mammal	2	2.1			2.144	2.9
Unid. Lagomorph	1	1.1			927	1.3
Ground Squirrel sp.	1	1.1			181	0.2
Chipmunk sp.	1	1.1			70	0.1
Ringtail	1	1.1			1,008	1.4
Skunk sp.	1	1.1			2,240	3.1
Cow (Calf)	1	1.1			2,500	3.4
Subtotal	8	8.4			9,070	12.5
Reptile Species						
Softshell Turtle	9	9.5	134	(75–175)	1,130	1.6
Total	**95**	**100.0**			**72,825**	**100.1**

Table B5.1-19. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Table Mountain bald eagle nest on 1 May 1989.

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Carp	1	33.3	381	(381)	575	29.3
Sucker sp.	1	33.3	434	(434)	748	38.1
Subtotal	2	66.7			1,323	67.3
Bird Species						
American coot	1	33.3			642	32.7
Total	**3**	**100.0**			**1,965**	**100.0**

We collected remains of at least 79 individual prey items from the Ladders nest sites (Table B5.1-17) and an additional 20 items from territory perches (Table B5.1-21). Important fish species based on biomass contributions from the nest included carp (48.0%), channel catfish (14.4%), suckers (8.1%), and flathead catfish (5.8%). Collectively, mammals made important contributions to biomass, comprising 17.9 percent of the total. The mammals taken included rabbits, ringtails, *Neotoma* sp., coyote, and javelina. Carp provided 57.1 percent of biomass calculated from territory-wide collections of remains; suckers made up the remaining 42.9 percent of the biomass figured from 20 total prey individuals. Suckers accounted for 45 percent of the biomass in prey deliveries from observations made at the Ladders nest during 63 days in 1988–1989 (see Section B4.3). The Ladders eagles delivered 97 percent fish, which included carp (33%) and catfish (17%).

Nest collections at the East Verde site yielded 95 total prey individuals (Table B5.1-18); we picked up remains of an additional 19 individuals from the territory (Table B5.1-22). Together, carp and channel catfish comprised over seventy percent of the estimated biomass in the nest remains. Suckers (5.1% biomass), flathead catfish (3.0%), and bass (2.2%, probably all smallmouth bass) were also taken. Mammals contributed 12.5 percent of the total biomass; the pair also captured nine soft-shelled turtles. From remains collected in the territory, we calculated that carp contributed over sixty percent of the biomass. From actual observation at the East Verde nest in 1987, we observed biomass deliveries in the following percentages for fish species: carp (49%), catfish (17%), sucker (14%) and black bass (8%). In total, fish comprised 92 percent of all biomass delivered at East Verde (see Section B4.4).

Table B5.1-20. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Perkinsville bald eagle nest on 21 June 1989.

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish species						
Sonora sucker	3	75.0	375	(354–394)	1,427	88.8
Unid. Ictaluridae	1	25.0	286	(286)	180	11.2
Total	**4**	**100.0**			**1,607**	**100.0**

We identified one carp, one sucker, and one American coot from remains found in the Table Mountain bald eagle nest on 1 May 1989 (Table B5.1-19). On 21 June 1989, we collected the remains of three Sonora suckers and one unidentified catfish from the bald eagle nest at Perkinsville (Table B5.1-20).

B5.1.7 Free-flowing Salt River

Channel catfish, sucker, and carp were the fish species shared by most of the bald eagle pairs nesting along the upper, unregulated Salt River. Although some of the collections were small, we noted that use of channel catfish was common throughout the reach, and that suckers appeared to replace carp in the

Table B5.1-21. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected from the Ladders bald eagle territory perches and following foraging events (1988, 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Carp	10	50.0	483	(385–560)	12,377	57.1
Sucker sp.	9	45.0	449	(355–690)	8,458	39.0
Sonora sucker	1	5.0	455	(455)	856	3.9
Total	**20**	**100.0**			**21,691**	**100.0**

diet of the pairs in the upper river. Results of prey remains analyses for the Redmond, Cibecue, Canyon, Cedar Basin, and Lone Pines nests appear in Tables B5.1-23, B5.1-24, B5.1-25, B5.1-26, and B5.1-27, respectively. Rabbits were also taken by most of these nesting pairs.

Table B5.1-22. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected from the East Verde bald eagle territory perches and following foraging events during 1987.

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Carp	12	63.2	418	(245–482)	9,774	60.4
Black bass sp.	5	26.3	379	(325–455)	3,386	20.9
Sonora sucker	1	5.3	425	(425)	728	4.5
Unid. Ictaluridae	1	5.3	610	(610)	2,302	14.2
Total	**19**	**100.1**			**16,190**	**100.0**

We found a total of 156 prey individuals from six collections in the Redmond bald eagle nest (Table B5.1-23). Fish represented 84.6 percent of both the number of individuals (n = 132) and the amount of biomass. Channel catfish and flathead catfish together comprised over fifty percent of the total biomass. Large catfish may have been taken as filleted carcasses left by fishermen (Driscoll 1985a). Twenty-eight carp represented 18.3 percent of biomass; 11 suckers (including Sonora, desert, and razorback suckers) accounted for 5.3 percent of the total biomass. Interestingly, the sucker bones at Redmond were mostly recovered in the 1986 collection and appeared old at that time. A few scales appeared in later collections. Other fish taken at Redmond included: crappie, bass, and buffalo. Certain of these fish may have been taken from Roosevelt Reservoir; the Redmond nest lies about eight air miles east of the upper end of the reservoir. Mammals added 22,204 grams of biomass to the diet or 11.6 percent of the total biomass. Species included jackrabbits, cottontails, hognose skunk, domestic sheep, ringtail, javelina, and squirrel.

From three collections at the Cibecue bald eagle nest site (Table B5.1-24), we found 31 prey individuals. Large Sonora sucker (mean length = 450 mm) contributed 16.9 percent to the total biomass. Other fish consumed were channel catfish, carp, and flathead catfish. In our biomass analysis, mammals were slightly more important than fish and represented 49.1 percent of estimate biomass. Apparently large carrion (including cow, deer, and javelina) was important along with rabbits, both jackrabbits and cottontails.

Table B5.1-23. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected from in and near (pinnacle cracks and wood rat den on nest pinnacle) the Redmond bald eagle nest (9 July 1986, 25 April 1987, 26 September 1987, 12 May 1988, 29 July 1988, and 13 April 1989).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	50	32.1	502	(150–727)	58,512	30.7
Flathead Catfish	34	21.8	488	(320–807)	46,167	24.2
Carp	28	17.9	475	(296–626)	34,924	18.3
Sonora Sucker	4	2.6	495	(435–563)	4,229	2.2
Sucker sp.	4	2.6	434	(391–478)	3,080	1.6
Crappie sp.	3	1.9	348	(348)	2,019	1.1
Buffalo sp.	2	1.3	665	(570–760)	6,914	3.6
Desert Sucker	2	1.3	443	(403–483)	1,764	0.9
Black Bass sp.	2	1.3	387	(382–392)	1,384	0.7
Razorback Sucker	1	0.6	514	(514)	1,212	0.6
Largemouth Bass	1	0.6	326	(326)	405	0.2
Unid. Centrarchidae	1	0.6	429	(429)	954	0.5
Subtotal	132	84.6			161,564	84.6
Bird Species						
Great Blue Heron	2	1.3			4,780	2.5
Gila Woodpecker	2	1.3			130	0.1
Grebe sp.	1	0.6			738	0.4
Mourning Dove	1	0.6			119	0.1
Greater Roadrunner	1	0.6			376	0.2
Unidentified Bird	1	0.6			540	0.3
Subtotal	8	5.1			6,683	3.5

Table B5.1-23. (Continued)

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Mammal Species						
Jackrabbit sp.	4	2.6			8,456	4.4
Cottontail sp.	2	1.3			1,300	0.7
Hognose Skunk	2	1.3			3,584	1.9
Domestic Sheep	2	1.3			5,000	2.6
Unid. Sciuridae	1	0.6			356	0.2
Ringtail	1	0.6			1,008	0.5
Javelina	1	0.6			2,500	1.3
Subtotal	13	8.3			22,204	11.6
Reptile Species						
Unidentified Reptile	2	1.3			222	0.1
Unidentified Snake	1	0.6			190	0.1
Subtotal	3	1.9			412	0.2
Total	**156**	**99.9**			**190,863**	**99.9**

A small collection from the Canyon site in 1986 (Table B5.1-25) revealed use of carp and sucker by that pair. From a 12 May 1988 collection at the Cedar Basin bald eagle nest, we found five channel catfish, one each sucker and black bass, and one cottontail (Table B5.1-26). A larger sample was available from the Lone Pine nesting site (Table B5.1-27). Channel catfish, sucker, and cow carrion were important prey items at Lone Pine. Remains of an elk from the Lone Pine site were identified at the University of Arizona Mammalogy Collection (Y. Petrosin, pers. comm.).

B5.1.8 Tonto Creek

Finally, we compared the diets of two eagle pairs nesting along Tonto Creek, a tributary of Roosevelt Reservoir and the Salt River. We collected the remains of 59 individual prey items from the "76" nesting site (Table B5.1-28). A smaller collection was made from the less successful Sheep nest; results are shown in Table B5.1-29. It is apparent that, at both Tonto Creek sites, mammals make up a significant portion of the diet. Jackrabbits, cottontails, and mammal carrion were consumed by both pairs. Suckers were taken at both sites; however, carp were the most important fish at the "76" nesting area.

Table B5.1-24. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in and near (nearby perch) the Cibecue bald eagle nest (19 June 1986, 24 April 1987, and 13 May 1987).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	8	25.8	363	(293–435)	3,061	10.6
Sonora Sucker	6	19.4	450	(392–499)	4,854	16.9
Carp	4	12.9	384	(257–460)	2,642	9.2
Flathead Catfish	1	3.2	563	(563)	1,830	6.4
Unid. Fish	1	3.2	446	(446)	770	2.7
Subtotal	20	64.5			13,157	45.8
Bird Species						
Unid. Anatidae	1	3.2			662	2.3
Unid. Waterfowl	1	3.2			811	2.8
Subtotal	2	6.5			1,473	5.1
Mammal Species						
Cottontail sp.	2	6.5			1,300	4.5
Unid. Sciuridae	2	6.5			712	2.5
Cow	2	6.5			5,000	17.4
Jackrabbit sp.	1	3.2			2,114	7.4
Deer	1	3.2			2,500	8.7
Javelina	1	3.2			2,500	8.7
Subtotal	9	29.0			14,126	49.1
Total	**31**	**100.0**			**28,756**	**100.0**

Table B5.1-25. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Canyon bald eagle nest on 23 July 1986.

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Carp	1	50.0	338	(338)	397	53.6
Sucker sp.	1	50.0	330	(330)	343	46.4
Total	**2**	**100.0**			**740**	**100.0**

Table B5.1-26. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in the Cedar Basin bald eagle nest on 12 May 1988.

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	5	62.5	520	(490–577)	5,431	82.3
Sucker sp.	1	12.5	330	(330)	343	5.2
Black Bass sp.	1	12.5	250	(250)	176	2.7
Subtotal	7	87.5			5,950	90.2
Mammal Species						
Cottontail sp.	1	12.5			650	9.8
Total	**8**	**100.0**			**6,600**	**100.0**

Table B5.1-27. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in and below (5/6/87) the Lone Pine bald eagle nest (1986, 6 May 1987, 12 May 1988).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Channel Catfish	8	40.0	451	(372–514)	5,808	30.1
Sucker sp.	3	15.0	400	(400)	1,776	9.5
Unid. Centrarchidae	2	10.0	400	(400)	952	5.1
Crappie sp.	1	5.0	348	(348)	637	3.4
Smallmouth Bass	1	5.0	400	(400)	476	2.5
Subtotal	15	75.0			9,649	51.5
Mammal Species						
Cow	2	10.0			5,000	26.7
Unid. Lagomorph	1	5.0			927	4.9
Elk	1	5.0			2,500	13.3
Subtotal	4	20.0			8,427	45.0
Bird Species						
Unid. Anatidae	1	5.0			662	3.5
Total	**20**	**100.0**			**18,738**	**100.0**

The "76" eagles preyed upon a variety of fish species, and fish (46.1%) slightly exceeded mammals (40.8%) in total biomass contribution (Table B5.1-28). In addition to carp and suckers (both Sonora and desert suckers were represented), we found bullheads, channel catfish, and black bass. Nine jackrabbits accounted for 26.3 percent of the total biomass at the "76" territory. Other mammals included cottontail (n = 3), javelina (n = 2), rock squirrel (n = 1), and striped skunk (n = 1). Birds were less important; two great blue herons added 4,780 g (6.6%) to the biomass.

Table B5.1-28. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected in and below the "76" bald eagle nest (28 May 1986, 4 April 1987, 3 May 1988, 14 May 1988, 25 May 1988, and 27 June 1988).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Carp	18	30.5	510	(402–706)	27,383	37.9
Sonora Sucker	6	10.2	370	(280–424)	2,863	4.0
Bullhead sp.	3	5.1	225	(156–277)	427	0.6
Desert Sucker	1	1.7	290	(290)	231	0.3
Sucker sp.	1	1.7	351	(351)	408	0.6
Channel Catfish	1	1.7	569	(569)	1,404	1.9
Unid. Ictaluridae	1	1.7	300	(300)	207	0.3
Black Bass sp.	1	1.7	325	(325)	401	0.6
Subtotal	32	54.2			33,324	46.1
Bird Species						
Anas sp.	2	3.4			1,366	1.9
Great Blue Heron	2	3.4			4,780	6.6
Grebe sp.	1	1.7			738	1.0
Teal sp.	1	1.7			364	0.5
Gambel's Quail	1	1.7			166	0.2
Common Raven	1	1.7			1,199	1.7
Western Meadowlark	1	1.7			98	0.1
Unid. Bird	1	1.7			540	0.7
Subtotal	10	16.9			9,251	12.8
Mammal Species						
Jackrabbit sp.	9	15.3			19,026	26.3
Cottontail sp.	3	5.1			1,950	2.7
Javelina	2	3.4			5,000	6.9
Rock Squirrel	1	1.7			817	1.1
Striped Skunk	1	1.7			2,688	3.7
Subtotal	16	27.1			29,481	40.8
Reptile Species						
Sonoran Mud Turtle	1	1.7	146	(146)	290	0.4
Total	**59**	**99.9**			**72,346**	**100.1**

Table B5.1-29. Number, length (fish in mm), and estimated biomass (grams) of prey identified from remains collected from in, below, and near (pilot perch) the Sheep bald eagle nest (4 April 1987, 20 April 1988).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Fish Species						
Sucker sp.	1	7.1	430	(430)	728	5.2
Bird Species						
Great Blue Heron	1	7.1			2,390	17.2
American Wigeon	1	7.1			756	5.5
Gull sp.	1	7.1			633	4.6
Mourning Dove	1	7.1			119	0.9
Gila Woodpecker	1	7.1			65	0.5
American Robin	1	7.1			77	0.6
Unid. Passerine	1	7.1			56	0.4
Subtotal	7	50.0			4,096	29.5
Mammal Species						
Cottontail sp.	1	7.1			650	4.7
Jackrabbit sp.	1	7.1			2,114	15.2
Unid. Lagomorph	1	7.1			927	6.7
Unid. Sciuridae	1	7.1			356	2.6
Javelina	1	7.1			2,500	18.0
Cow	1	7.1			2,500	18.0
Subtotal	6	42.9			9,047	65.2
Total	**14**	**100.0**			**13,871**	**99.9**

We found only one sucker in the remains collected at the Sheep bald eagle nest (Table B5.1-29). A second sucker was found among two prey items collected in the territory following a forage observation near the nest (Table B5.1-30). Also included in the table is one jackrabbit; we observed an adult eagle capture this prey item in the upland habitat approximately 300 m from the nest on 1 December 1987. Rabbits were also present in the nest remains; mammals accounted for 65.2 percent of the nest biomass. The Sheep eagles captured several birds; we found remains of great blue heron, American wigeon, gull sp., mourning dove, Gila woodpecker, and American robin in the nest.

Table B5.1-30. Number, length (fish), and estimated biomass (grams) of prey identified from remains collected from the Sheep bald eagle territory perches and following foraging events (1987, 1988).

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent
Sucker sp.	1	50.0	430	(430)	728	25.6
Jackrabbit sp.	1	50.0			2,114	74.4
Total	**2**	**100.0**			**2,842**	**100.0**

B5.1.9 Summary of Prey Remains Analyses

In all, we identified 1,847 prey individuals from a total of 2,601 prey remain items (bones, feather groups, etc.) representing 66 prey species at 23 bald eagle nesting territories (not including Pinto) in central Arizona (Table B5.1-31). Summarizing prey remains from all Arizona sites combined, we found that channel catfish were represented by both the greatest numbers (32.4%) and biomass (24.7%). Carp followed closely in biomass (21.1%), with suckers (8.2%), flathead catfish (7.6%), black bass (7.3%), and jackrabbits (5.5%) also being important. Crappie and American coot contributed 2.8 percent and 3.0 percent of the biomass, respectively. Overall, fish species contributed almost 80 percent of prey numbers and 75 percent of total biomass. Biomass ratings for fish were greater than those reported by Haywood and Ohmart (1986); we found less emphasis on mammals and birds, specifically coot, cottontails, and jackrabbits. We found greater utilization of centrarchids (i.e., bass, crappie), possibly because of the expanded number of nests (23 versus 11 nests for Haywood and Ohmart) and thus habitats examined. See Section B5.2 for further comparisons with previous Arizona studies.

Biomass percentages for each vertebrate class, as identified in the prey remains collected from Arizona bald eagle territories, are presented in Table B5.1-32. Fifteen of 23 territories recorded fish in percentages greater than the overall (mean) utilization of fish (73.8%). Territories apparently utilizing many birds and mammals included Coolidge (San Carlos Reservoir), Blue Point and Orme (lower Salt and Verde rivers), and Sheep and "76" (Tonto Creek). Sites with less than 70 percent fish biomass

Table B5.1-31. Summary of prey numbers, mean length (mm), and biomass (g) taken by Arizona bald eagles identified from prey remains collected by BioSystems under territory perches and in and below nests from 1986–1989. Important prey species ranked numerically for comparison to previous Arizona studies.

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent	Rank
Fish Species							
Channel Catfish	598	32.4	382	(119–727)	301,182	24.6	1
Carp	265	14.3	428	(59–706)	257,883	21.1	2
Largemouth Bass	122	6.6	336	(168–467)	58,645	4.8	3
Sucker sp.	83	4.5	372	(220–690)	43,549	3.6	4
Crappie sp.	80	4.3	301	(230–380)	34,734	2.8	5
Sonora Sucker	70	3.8	415	(280–563)	45,946	3.8	6
Flathead Catfish	68	3.7	467	(238–1040)	92,304	7.6	7
Black Bass sp.	63	3.4	330	(200–466)	29,024	2.4	8
Yellow Bass	28	1.5	267	(156–383)	8,113	0.7	13
Desert Sucker	25	1.4	347	(276–483)	10,705	0.9	14
Unid. Centrarchidae	20	1.1	315	(175–429)	7,679	0.6	15
Bullhead sp.	18	1.0	265	(156–321)	3,656	0.3	16
Unid. Ictaluridae	11	0.6	355	(190–610)	5,670	0.5	19
Tilapia sp.	5	0.3	353	(282–432)	4,144	0.3	
Buffalo sp.	3	0.2	643	(570–760)	9,269	0.8	
Smallmouth Bass	3	0.2	376	(359–400)	1,195	0.1	
Lepomis sp.	3	0.2	169	(150–200)	235	tr	
Razorback Sucker	2	0.1	553	(514–591)	3,017	0.2	
Walleye	2	0.1	295	(190–400)	550	tr	
Unid. Fish	2	0.1	400	(353–446)	1,425	0.1	
Threadfin Shad	1	0.1	100	(100)	16	tr	
Golden Shiner	1	0.1	120	(120)	30	tr	
Striped Bass	1	0.1	359	(359)	725	0.1	
Bluegill	1	0.1	229	(229)	220	tr	
Yellow Perch	1	0.1	400	(400)	1,070	0.1	
Subtotal	1,476	79.9			920,986	75.4	

Table B5.1-31. (Page 2 of 3)

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent	Rank
Bird Species							
American Coot	58	3.1			37,236	3.0	9
Eared Grebe	34	1.8			10,098	0.8	10
Unid. Waterfowl	15	0.8			12,165	1.0	17
Grebe sp.	14	0.8			10,332	0.8	18
Anas sp.	10	0.5			6,830	0.6	
Great Blue Heron	9	0.5			20,540	1.7	
Green-winged Teal	8	0.4			2,728	0.2	
Gambel's Quail	8	0.4			1,328	0.1	
Unid. Passerine	8	0.4			448	tr	
Mourning Dove	7	0.4			833	0.1	
Western Meadowlark	6	0.3			588	tr	
Unid. Bird	4	0.2			2,160	0.2	
Western Grebe	3	0.2			4,431	0.4	
Cinnamon Teal	3	0.2			1,158	0.1	
Unid. Anatidae	3	0.2			1,986	0.2	
Ruddy Duck	3	0.2			1,635	0.1	
Gila Woodpecker	3	0.2			195	tr	
Pied-billed Grebe	2	0.1			884	0.1	
Greater Roadrunner	2	0.1			752	0.1	
Western Screech Owl	2	0.1			338	tr	
American Robin	2	0.1			154	tr	
Unid. Aredeidae	1	0.1			1,048	0.1	
White-faced Ibis	1	0.1			622	0.1	
Wood Duck	1	0.1			658	0.1	
Mallard	1	0.1			1,082	0.1	
Teal sp.	1	0.1			364	tr	
Northern Shoveler	1	0.1			613	0.1	
American Wigeon	1	0.1			756	0.1	
Sharp-shinned Hawk	1	0.1			139	tr	
Gull sp.	1	0.1			633	0.1	
Common Poorwill	1	0.1			52	tr	
Ladder-backed Woodpecker	1	0.1			30	tr	
Unid. Woodpecker	1	0.1			48	tr	
Common Raven	1	0.1			1,199	0.1	
Northern Cardinal	1	0.1			45	tr	
Subtotal	218	11.8			124,108	10.2	

Table B5.1-31. (Page 3 of 3)

Species	No.	Percent	Mean Length	(Range)	Biomass	Percent	Rank
Mammal Species							
Jackrabbit sp.	32	1.7			67,648	5.5	11
Cottontail sp.	31	1.7			20,150	1.6	12
Unid. Sciuridae	11	0.6			3,916	0.3	20
Unid. Lagomorph	7	0.4			6,489	0.5	
Ground Squirrel sp.	7	0.4			1,267	0.1	
Javelina	6	0.3			15,000	1.2	
Unid. Mammal	6	0.3			6,432	0.5	
Rock Squirrel	5	0.3			4,085	0.3	
Domestic Cow	5	0.3			12,500	1.0	
Neotoma sp.	4	0.2			1,124	0.1	
Ringtail	4	0.2			4.032	0.3	
Unid. Rodent	3	0.2			150	tr	
Hognose Skunk	2	0.1			3,584	0.3	
Striped Skunk	2	0.1			5,376	0.4	
Skunk sp.	2	0.1			4,480	0.4	
Deer	2	0.1			5,000	0.4	
Domestic Sheep	2	0.1			5,000	0.4	
Chipmunk sp.	1	0.1			70	tr	
Muskrat	1	0.1			1,171	0.1	
Coyote	1	0.1			2,043	0.2	
Elk	1	0.1			2,500	0.2	
Calf	1	0.1			2,500	0.2	
Subtotal	136	7.4			174,517	14.3	
Reptile Species							
Soft-shelled Turtle	9	0.5	134	(75-175)	1,130	0.1	
Unid. Reptile	3	0.2			333	tr	
Sonoran Mud Turtle	2	0.1	148	(146-150)	580	tr	
Chuckwalla	1	0.1			100	tr	
Unid. Snake	1	0.1			190	tr	
Unid. Lizard	1	0.1			17	tr	
Subtotal	17	0.9			2,350	0.2	
Total	1,847	100.0			1,221,961	100.0	

Table B5.1-32. Biomass contributions (grams) of each vertebrate class to the diets of bald eagles nesting in Arizona based on prey remains analysis from nests (territory perches for Bartlett). Productivity shown as young fledged per nesting attempt for years represented by prey collections during 1986–1989 plus one year prior to first collection. Sites with collections of less than 10 individual prey items are not included in productivity analysis.

Young/ Nesting Attempt	Productivity	Territory	Collection	Biomass (grams) Fish	(%)	Bird	(%)	Mammal	(%)	Reptile	(%)	Total Biomass		Total No.
2 / 3	0.67	Chino	below nest	16,053	(76.1)	811	(3.8)	4,228	(20.0)	0	(0.0)	21,092	(99.9)	33
2 / 2	1.00	Alamo	in/below nest	105,213	(76.6)	19,245	(14.0)	12,812	(9.3)	0	(0.0)	137,270	(99.9)	263
3 / 3	1.00	Ive's Wash	in nest	68,332	(85.3)	7,521	(9.3)	4,294	(5.4)	0	(0.0)	80,147	(100.0)	192
5 / 4	1.25	Coolidge*	in nest	10,284	(40.8)	5,540	(22.0)	9,373	(37.2)	0	(0.0)	25,197	(100.0)	43
5 / 4	1.25	Bartlett	territory perches	28,379	(91.1)	0	(0.0)	2,764	(8.9)	0	(0.0)	31,143	(100.0)	47
4 / 4	1.00	Cliff	in nest	24,479	(91.4)	991	(3.7)	1,300	(4.9)	0	(0.0)	26,770	(100.0)	45
7 / 4	1.75	Blue Point*	in/below nest	25,278	(60.4)	9,086	(21.7)	7,453	(17.8)	0	(0.0)	41,817	(100.0)	85
5 / 5	1.00	Horse Mesa	in nest	13,999	(78.8)	3,305	(18.6)	356	(2.0)	100	(0.6)	17,760	(100.0)	36
8 / 5	1.60	Fort McDowell	in/below nest	20,118	(76.4)	1,419	(5.4)	4,780	(18.2)	0	(0.0)	26,317	(100.0)	62
3 / 2	1.50	Orme*	in nest	15,542	(53.7)	3,427	(11.8)	9,963	(34.4)	0	(0.0)	28,932	(99.9)	56
3 / 3	1.00	Pinal	in nest	47,991	(83.0)	4,666	(8.1)	4,878	(8.4)	307	(0.5)	57,842	(100.0)	107
6 / 4	1.50	Horseshoe	in nest	35,677	(76.5)	8,818	(18.9)	2,012	(4.3)	111	(0.2)	46,618	(99.9)	95
8 / 5	1.60	Ladders	in nest	47,597	(77.6)	2,749	(4.5)	10,957	(17.9)	0	(0.0)	61,303	(100.0)	79
7 / 5	1.40	East Verde	in nest	58,942	(81.0)	3,641	(5.0)	9,070	(12.5)	1,130	(1.6)	72,783	(100.0)	95
—	—	Table Mtn.	in nest	1,323	(67.3)	642	(32.7)	0	(0.0)	0	(0.0)	1,965	(100.0)	3
—	—	Perkinsville	in nest	1,607	(100.0)	0	(0.0)	0	(0.0)	0	(0.0)	1,607	(100.0)	4
6 / 5	1.20	Redmond	in/near nest	161,564	(84.6)	6,683	(3.5)	22,204	(11.6)	412	(0.2)	190,863	(99.9)	156
2 / 3	0.67	Cibecue*	in/near nest	13,157	(45.8)	1,473	(5.1)	14,126	(49.1)	0	(0.0)	28,756	(100.0)	31
—	—	Canyon	in nest	740	(100.0)	0	(0.0)	0	(0.0)	0	(0.0)	740	(100.0)	2
—	—	Cedar Basin	in nest	5,950	(90.2)	0	(0.0)	650	(9.8)	0	(0.0)	6,600	(100.0)	8
3 / 4	0.75	Lone Pine*	in/below nest	9,649	(51.5)	662	(3.5)	8,427	(45.0)	0	(0.0)	18,738	(100.0)	20
4 / 4	1.00	76*	in/below nest	33,324	(46.1)	9,209	(12.7)	29,481	(40.8)	290	(0.4)	72,304	(100.0)	59
0 / 3	0.00	Sheep*	in/below/near nest	728	(5.2)	4,096	(29.5)	9,047	(65.2)	0	(0.0)	13,871	(99.9)	14
83 / 72		**Total**	**23 territories**	**745,926**	**(73.8)**	**93,984**	**(9.3)**	**168,175**	**(16.6)**	**2,350**	**(0.2)**	**1,010,435**	**(99.9)**	—

Sites with <70% fish biomass = 24 young in 24 attempts = 1.00 young/nesting attempt.
Sites with >70% fish biomass = 59 young in 48 attempts = 1.23 young/nesting attempt.

* territories with < 70% fish biomass in diet

appeared to produce less young (1.00 young per nesting attempt) than those with greater than 70 percent fish biomass (1.23 young per nesting attempt). Grubb (1988a) reported similarly higher productivity for territories with greater than 70 percent fish identified in their diet; however, results were not significant.

We found no evidence of bald eagles taking trout in Arizona, despite our close examination of scales in nest lining collections at several sites, including Blue Point, Orme, and Ft. McDowell where we expected they might appear. Trout scales and small bones do appear in nest linings of bald eagle pairs elsewhere that utilize the species (PG&E 1988). An abundance of rainbow trout occurred in river reaches utilized by eagles in Northern California; however, eagles captured primarily Sacramento sucker and very few trout in these areas (BioSystems 1985). In past studies, the Blue Point, Fort McDowell, and Horse Mesa eagles were observed delivering trout to the nest (Canestorp *et al.* 1984, Collie *et al.* 1985, Collie and Knoll 1986, Collie and Knoll 1987, Driscoll and Buckley 1986), especially after AGF stocking operations on the lower Salt and Verde rivers.

Combining all prey remains and prey delivery data collected in Arizona from 1986-1990, we identified 72 different species utilized as prey (Table B5.1-33). Many of these were found in previous Arizona studies (see below); however, we found 34 previously unrecorded species from our data. Crayfish parts found in nests may have been from the stomach contents of prey fish.

B5.1.10 Re-evaluation of Prey Remains Analysis

To answer the question of whether or not our prey remains analysis correctly measured the diet of Arizona bald eagles, we compared biomass and percent biomass results of the prey remains analysis with our figures from actual nest delivery observations made at four priority sites. We also compared all prey deliveries recorded at the nests during our observation periods with two prey remains collections made from each nest (one during and one after the nesting cycle). Biomass comparisons for the Pinal, Blue Point, Ladders, Horseshoe, and East Verde bald eagle territories appear in Tables B5.1-34, B5.1-35, B5.1-36, B5.1-37, and B5.1-38, respectively.

Overall, most prey taxa were represented in both the prey remains and nest observation analyses. Because there were time gaps in the prey delivery observations (i.e., periods of the breeding season when no observations were made), the results of the two methods are not perfectly comparable. Thus, we found some species in the prey remains that we did not observe delivered to the nest (e.g., eared grebe, jackrabbit, Sonora sucker at Pinal; coot, quail, cottontail at Horseshoe). Conversely, we observed deliveries of some prey that did not appear in the prey remains (e.g., flathead catfish, eared grebe, rock squirrel at Blue Point).

We noted both similarities and discrepancies between percent biomass of important prey taxonomic groups when comparing the two methods. Percent biomass of all fish was greatest in the prey delivery observations for all sites (Tables B5.1-34 to B5.1-38), a fact which suggests that fish were under-represented in the prey remains analysis. Conversely, we found biomass of birds and mammals to be generally overestimated in the prey remains.

Proportions of fish species varied when comparing the two methods. Crappie were underestimated in the remains analysis at Pinal when compared with nest observations; however, carp were overestimated. Percent biomass for channel catfish in the remains analysis (45.4%) matched closely that observed at the Pinal nest (43.2%). Suckers, frequently observed as deliveries, were poorly represented in the remains at Blue Point. The biomass percentages of yellow bass at Blue Point demonstrated parity between the

Table B5.1-33. Prey species observed taken by bald eagles or collected from nests at Arizona breeding areas, during the research of BioSystems Analysis, Inc., 1986–1990.

FISH		
Cyprinidae	Carp	
	Golden shiner*	Alamo
Ictaluridae	Channel catfish	
	Flathead catfish	
	Bullhead (catfish)	
Centrarchidae	Largemouth bass	
	Smallmouth bass	
	Bass sp.	
	Yellow bass	
	Striped bass*	Ive's Wash
	Bluegill*	Bartlett
	Green sunfish*	Bartlett
	Lepomis sp. (sunfish)	
	Black crappie	
	Crappie sp.	
Percidae	Yellow perch*	Blue Point
	Walleye pike*	Blue Point, Horse Mesa
Catostomidae	Desert sucker	
	Sonora sucker	
	Razorback sucker*	Pinal, Redmond
	Sucker sp.	
	Buffalo sp.	
Clupeidae	Threadfin shad	Cliff, Horseshoe
Cichlidae	Tilapia sp.*	Alamo, Chino
BIRDS		
Waterfowl	Canada goose*, ***	Sheep
	Mallard	
	American wigeon*	
	Northern shoveler*	
	Wood duck*	Ladders
	Ruddy duck*	
	Anas sp. (surface-feeding ducks)	
	Green-winged teal	
	Cinnamon teal	
	Teal sp.	
Grebes	Western grebe*	
	Eared grebe*	
	Pied-billed grebe*	
	Grebe sp.	
BIRDS (continued)		
Wading Birds	American coot	
	Great blue heron	
	Unidentified Ardeidae (herons/bitterns)	
	White-faced ibis*	Alamo
Raptors	Sharp-shinned hawk*	Fort McDowell
	Western screech owl*	Alamo, Pinal
	Osprey*, ***	76
	Turkey vulture*, ***	Orme
Passerines	Western meadowlark*	
	Northern cardinal*	
	Common raven*	
	Cactus wren	
Other Birds	Gila woodpecker	
	Ladder-backed woodpecker*	
	Woodpecker sp.	
	Greater roadrunner	
	American robin*	
	Mourning dove	
	Northern (red-shafted) flicker***	
	Gambel's quail	
	Common poorwill	
	Gull sp.*	Sheep
MAMMALS		
Lagomorphs	Cottontail rabbit	
	Blacktail jackrabbit	
Rodents	Neotoma sp. (wood rat)	
Squirrels	Rock squirrel	
	Ground squirrel	
	Unidentified Sciuridae (squirrel)	
	Chipmunk sp.*	
Other Mammals		
	Ringtail	
	Striped skunk	
	Hognose skunk	
	Skunk sp.	
	Muskrat	Alamo

Table B5.1-33. (Continued)

MAMMALS (continued)			**HERPTILES**		
	Collared peccary (javelina)		Amphibians	Unidentified frog***	
	Deer sp.*	Cibecue, Coolidge, Redmond	Reptiles	Sonoran mud turtle	
				Spiny softshell turtle	
				Western diamondback rattlesnake*, ***	East Verde, Redmond
	Elk*	Lone Pine			
	Mountain lion*, ***	Redmond			
	Coyote*	Ladders		Unidentified snake	
	Hereford cow			Chuckwalla*	Horse Mesa
	Cow sp.			Unidentified lizard	
	Domestic sheep*	Redmond		Unidentified reptile	
			OTHER		
			Flies**		
			Crayfish		
Total	72 species				

* Indicates previously unknown prey species (n = 34), and breeding area where utilized if isolated to one or two sites.
** Captured and eaten by eagles while at nest.
*** Incidental observations, not included in prey analysis.

two methods. Suckers were also underestimated in the remains analyzed from the Ladders nest. Conversely, carp represented a far greater percentage of the biomass in the remains (65.0%) compared to observations at the nest (33.8%). Channel catfish appeared in almost equal percentages at Ladders in the two data sets. Biomass percentages for crappie at Horseshoe were almost equal for both methods; however, we observed a larger percentage of carp delivered to the nest than in what appeared in the remains. During nest delivery observations (all sites combined), we noted that over 60 percent of carp came to the nest without heads (i.e., the identifying bones, Table B5.1-39). At least 80 percent of all suckers, catfish and perciforms were delivered to the nests with the identifying bones (heads) intact. Channel catfish were responsible for a higher percentage of biomass in the remains analysis compared to Horseshoe nest observations.

We were also interested to see if our visual estimates of fish length during prey delivery observations agreed with those obtained from our analyses of prey remains (Table B5.1-40). We found that the mean fish lengths and ranges of lengths approximated each other in most instances.

An examination of pooled data for numbers of individuals (prey remains versus nest observations) at the three territories with extensive observations during the breeding season (Ladders, Blue Point, and East Verde) also reveals that fish numbers were underestimated in the prey remains analysis (Table B5.1-41). Moreover, an underestimation of suckers is strongly suggested by Chi-Square analysis (χ^2 = 13.4, df = 1, $p < 0.01$), while catfish were over-represented in the analysis of prey remains compared to

Table B5.1-34. Comparison of whole biomass (grams) results from methods based on prey remains analysis and prey delivery observations at the Pinal bald eagle nest. Prey remains were collected on 30 April and 13 June 1989. Nest observations occurred between 15 April and 1 June 1989.

	Remains			Observations		
Species	No.	Biomass	% Biomass	No.	Biomass	% Biomass
Fish Species						
Carp	7	7,171	(21.1)	3	5,328	(17.3)
Sonora Sucker	2	845	(2.5)	0	0	(0.0)
Razorback Sucker	1	1,805	(5.3)	0	0	(0.0)
Channel Catfish	31	15,410	(45.4)	22	11,925	(38.6)
Flathead Catfish	1	1,052	(3.1)	3	5,345	(17.3)
Crappie sp.	4	1,302	(3.8)	9	4,387	(14.2)
Largemouth Bass	0	0	(0.0)	5	2,037	(6.6)
Black Bass sp.	4	2,010	(5.9)	0	0	(0.0)
Unid. Fish	0	0	(0.0)	3	1,204	(3.9)
Subtotal	50	29,595	(87.2)	45	30,226	(97.9)
Bird Species						
American Coot	3	1,926	(5.7)	1	642	(2.1)
Eared Grebe	1	297	(0.9)	0	0	(0.0)
Subtotal	4	2,223	(6.6)	1	642	(2.1)
Mammal Species						
Jackrabbit sp.	1	2,114	(6.2)	0	0	(0.0)
Total	**54**	**33,932**	**(100.0)**	**46**	**30,868**	**(100.0)**

Table B5.1-35. Comparison of whole biomass (grams) results from methods based on prey remains analysis and prey delivery observations at the Blue Point bald eagle nest. Prey remains were collected on 5 and 24 May 1988. Nest observations occurred between 17 March and 17 May 1988.

Species	Remains			Observations		
	No.	Biomass	% Biomass	No.	Biomass	% Biomass
Fish Species						
Carp	0	0	(0.0)	2	1,367	(2.4)
Sucker sp.	1	343	(4.3)	42	15,531	(27.0)
Desert Sucker	1	290	(3.7)	0	0	(0.0)
Channel Catfish	2	435	(5.5)	14	3,980	(6.9)
Flathead Catfish	0	0	(0.0)	1	421	(0.7)
Bullhead sp.	1	301	(3.8)	0	0	(0.0)
Unid. Catfish	0	0	(0.0)	1	343	(0.6)
Yellow Bass	5	1,777	(22.5)	41	11,351	(19.7)
Largemouth Bass	2	727	(9.2)	22	9,934	(17.2)
Smallmouth Bass	0	0	(0.0)	2	330	(0.6)
Black Bass sp.	2	450	(5.7)	5	952	(1.7)
Unid. Centrarchidae	0	0	(0.0)	1	46	(0.1)
Walleye	0	0	(0.0)	1	230	(0.4)
Unid. Fish	0	0	(0.0)	6	1,096	(1.9)
Subtotal	14	4,323	(54.8)	138	45,581	(79.1)
Bird Species						
American Coot	1	642	(8.1)	6	3,852	(6.7)
Eared Grebe	0	0	(0.0)	1	297	(0.5)
Unid. Waterfowl	1	811	(10.3)	0	0	(0.0)
Subtotal	2	1,453	(18.4)	7	4,149	(7.2)
Other Species						
Jackrabbit sp.	1	2,114	(26.8)	2	4,228	(7.3)
Rock Squirrel	0	0	(0.0)	4	3,268	(5.7)
Unid. Prey	0	0	(0.0)	1	389	(0.7)
Subtotal	1	2,114	(26.8)	7	7,885	(13.7)
Total	**17**	**7,890**	**(100.0)**	**152**	**57,615**	**(100.0)**

Table B5.1-36. Comparison of whole biomass (grams) results from methods based on prey remains analysis and prey delivery observations at the Ladders bald eagle nest. Prey remains were collected on 28 April and 23 June 1989. Nest observations occurred between 15 March and 1 June 1989 (includes 16 supplemental suckers fed to the female).

	Remains			Observations		
Species	No.	Biomass	% Biomass	No.	Biomass	% Biomass
Fish Species						
Sucker sp.	1	645	(4.3)	69	41,614	(52.0)
Carp	7	9,669	(65.0)	24	27,110	(33.9)
Flathead Catfish	2	1,131	(7.6)	3	2,394	(3.0)
Channel Catfish	4	1,954	(13.1)	19	7,175	(9.0)
Unid. Centrarchidae	1	409	(2.7)	0	0	(0.0)
Unid. Fish	0	0	(0.0)	1	512	(0.6)
Subtotal	15	13,808	(92.8)	116	78,805	(98.4)
Bird Species						
Grebe sp.	1	738	(5.0)	0	0	(0.0)
Unid. Woodpecker	1	48	(0.3)	0	0	(0.0)
Subtotal	2	786	(5.3)	0	0	(0.0)
Mammal Species						
Neotoma sp.	1	281	(1.9)	0	0	(0.0)
Unid. Mammal	0	0	(0.0)	2	581	(0.7)
Deer	0	0	(0.0)	2	700	(0.9)
Total	**18**	**14,875**	**(100.0)**	**120**	**80,086**	**(100.0)**

Table B5.1-37. Comparison of whole biomass (grams) results from methods based on prey remains analysis and prey delivery observations at the Horseshoe bald eagle nest. Prey remains were collected on 10 May 1988 and 27 June 1988. Nest observations occurred between 27 April 1988 and 1 June 1988.

Species	Remains			Observations		
	No.	Biomass	% Biomass	No.	Biomass	% Biomass
Fish Species						
Carp	2	665	(3.4)	9	7,210	(41.1)
Flathead Catfish	1	310	(1.6)	2	337	(1.9)
Channel Catfish	12	6,385	(32.8)	4	1,186	(6.8)
Unknown Catfish	1	855	(4.4)	1	218	(1.2)
Crappie sp.	18	7,075	(36.4)	19	5,184	(29.6)
Largemouth Bass	2	895	(4.6)	5	999	(5.7)
Black Bass sp.	1	364	(1.9)	1	167	(1.0)
Unid. Fish	0	0	(0.0)	5	1,500	(8.6)
Subtotal	37	16,549	(85.1)	46	16,801	(95.9)
Bird Species						
American Coot	1	642	(3.3)	0	0	(0.0)
Gambel's Quail	2	332	(1.7)	0	0	(0.0)
Unid. Waterfowl	1	811	(4.2)	0	0	(0.0)
Subtotal	4	1785	9.2	0	0	(0.0)
Mammal Species						
Cottontail sp.	1	650	(3.3)	0	0	(0.0)
Unid. Sciuridae	1	356	(1.8)	0	0	(0.0)
Unknown Mammal	0	0	(0.0)	1	281	(1.6)
Subtotal	2	1,006	(5.2)	1	281	(1.6)
Other Species						
Unid. Reptile	1	111	(0.6)	0	0	(0.0)
Unid. Carrion	0	0	(0.0)	1	442	(2.5)
Subtotal	1	111	(0.6)	1	442	(2.5)
Total	**44**	**19,451**	**(100.1)**	**48**	**17,524**	**(100.0)**

Table B5.1-38. Comparison of whole biomass (grams) estimates and prey numbers based on prey remains analysis and prey delivery observations at the East Verde bald eagle nest. Prey remains were collected 28 April and 12 September 1987. Nest observations occurred between 7 March and 3 June 1987.

	Remains			Observations		
Species	No.	Biomass	% Biomass	No.	Biomass	% Biomass
Fish Species						
Sucker sp.	2	1,496	6.4	13	11,659	10.5
Sonora Sucker	2	1,484	6.4	0	0	0.0
Carp	6	7,713	33.1	35	58,196	52.3
Channel Catfish	14	7,049	30.2	4	1,450	1.3
Flathead Catfish	1	352	1.5	12	23,674	21.3
Unknown Catfish	0	0	0.0	2	838	0.8
Smallmouth Bass	1	374	1.6	9	2,593	2.3
Largemouth Bass	0	0	0.0	5	3,839	3.5
Black Bass sp.	1	452	1.9	0	0	0.0
Lepomis sp.	0	0	0.0	1	46	tr.
Unid. Centrarchidae	0	0	0.0	1	212	0.2
Unknown Fish	0	0	0.0	6	3,648	3.3
Subtotal	27	18,920	81.2	88	106,155	95.4
Other Species						
Soft-shelled Turtle	0	0	0.0	4	740	0.7
Unknown Turtle	0	0	0.0	1	350	0.3
Gambel's Quail	1	166	0.7	1	166	0.1
Unid. Bird	1	540	2.3	0	0	0.0
Unknown Lagomorph	1	927	4.0	0	0	0.0
Chipmunk sp.	1	70	0.3	0	0	0.0
Rock Squirrel	0	0	0.0	1	817	0.7
Ground Squirrel sp.	1	181	0.8	0	0	0.0
Neotoma sp.	0	0	0.0	2	562	0.5
Cow (Calf)	1	2,500	10.7	3	1,720	1.5
Unknown Mammal	0	0	0.0	2	370	0.3
Unknown Carrion	0	0	0.0	1	360	0.3
Subtotal	6	4384	18.8	15	5085	4.6
Total	**33**	**23,304**	**100.0**	**103**	**111,240**	**100.00**

Table B5.1-39. Condition of fish brought to the nest by adult bald eagles as determined by direct nest observations. Whole and anterior portions contained identifying bones; headless fish and posterior portion lacked these bones.

		Condition of Delivered Fish												
Species	Territory	Whole		Anterior Portion		Headless		Posterior Portion		Unknown		Total	
Sucker													
	Ladders	38	70%	3	6%	4	7%	8	15%	1	2%	54	100%
	East Verde	6	55%					5	45%			11	100%
	Blue Point	32	78%			7	17%	2	5%			41	100%
	Bartlett	113	83%	1	1%	15	11%	7	5%			136	100%
Subtotal		189	78%	4	2%	26	11%	22	9%	1	(tr)	242	100%
Catfish													
	Horseshoe	8	100%									8	100%
	Pinal	11	46%	5	21%	4	17%	4	17%			24	101%
	Ladders	23	96%					1	4%			24	100%
	East Verde	10	63%	4	25%			2	12%			16	100%
	Blue Point	13	87%			2	13%					15	100%
	Bartlett	15	79%	2	11%					2	11%	19	101%
Subtotal		80	75%	11	10%	6	6%	7	7%	2	2%	106	100%
Carp													
	Horseshoe	5	45%	1	9%	2	18%	3	27%			11	99%
	Pinal					2	67%	1	33%			3	100%
	Ladders	10	34%	7	24%	1	3%	11	38%			29	99%
	East Verde	4	12%			2	6%	26	76%	2	6%	34	100%
	Blue Point	1	50%					1	50%			2	100%
	Bartlett	1	50%	1	50%							2	100%
Subtotal		21	26%	9	11%	7	9%	42	52%	2	2%	81	100%
Perciformes													
	Horseshoe	26	90%			1	3%	2	7%			29	100%
	Pinal	10	77%			2	15%	1	8%			13	100%
	Ladders	1	50%					1	50%			2	100%
	East Verde	11	65%	2	12%			4	23%			17	100%
	Blue Point	68	94%			2	3%	1	1%	1	1%	72	99%
	Bartlett	43	91%			1	2%			3	6%	47	99%
Subtotal		159	88%	2	1%	6	3%	9	5%	4	2%	180	99%
Total		**449**	**74%**	**26**	**4%**	**45**	**7%**	**80**	**13%**	**9**	**1%**	**609**	**99%**

Table B5.1-40. Estimated length (cm, total length) of fish prey determined by nest observations at six bald eagle territories in Arizona. Lengths estimated from prey remains analysis (all collections per site) included for comparisons.

		Nest Observations			Prey Remains		
Territory	Species	Mean Length	(Range)	*n*	Mean Length	(Range)	*n*
Bartlett	Sucker	35	(18–51)	142		N/A	
	Channel Catfish	34	(23–53)	14		N/A	
	Largemouth Bass	30	(18–38)	11		N/A	
	Crappie	27	(20–38)	13		N/A	
	Lepomis sp.	16	(10–23)	12		N/A	
Blue Point	Sucker	33	(28–43)	40	36	(30–42)	8
	Channel Catfish	31	(18–46)	14	33	(22–51)	21
	Largemouth Bass	32	(20–41)	22	29	(17–39)	5
	Yellow Bass	27	(18–33)	41	27	(18–36)	13
Ladders	Sucker	37	(15–53)	57	43	(41–44)	4
	Carp	40	(33–56)	31	46	(14–61)	25
	Channel Catfish	33	(20–51)	21	39	(21–50)	18
	Flathead Catfish	44	(43–46)	3	37	(33–43)	7
East Verde	Sucker	44	(30–51)	10	43	(43)	3
	Carp	51	(25–76)	35	47	(29–63)	28
	Channel Catfish	34	(23–46)	4	42	(28–65)	27
	Flathead Catfish	50	(20–76)	12	33	(27–40)	6
	Largemouth Bass	38	(26–46)	5	33	(28–39)	3
	Smallmouth Bass	30	(20–38)	8	36	(36–37)	2
Horseshoe	Carp	40	(30–51)	9	31	(22–45)	11
	Channel Catfish	32	(20–43)	4	39	(28–52)	31
	Crappie	26	(20–30)	19	30	(25–34)	22
	Largemouth Bass	26	(23–28)	5	36	(33–43)	8
Pinal	Carp	54	(51–61)	3	44	(32–51)	12
	Channel Catfish	40	(23–51)	22	37	(24–56)	57
	Flathead Catfish	56	(51–59)	3	38	(33–47)	3
	Largemouth Bass	32	(23–36)	5	32	(26–38)	2
	Crappie	29	(20–46)	9	28	(24–35)	8

Table B5.1-41. Comparison of prey numbers as determined by nest prey remains analysis and observations of prey deliveries to the nest at three sites where nest observations occurred during a large part of the nesting period (Ladders, Blue Point, East Verde) and where prey remains collection was also possible.

Prey Group	No. in Remains		No. Observed		Conclusion
Fish Species					
Sucker	7	10.3%	124	33.2%	Under-represented in prey remains; $\chi^2=13.4289$, df=1, $p<0.01$
Carp	13	19.1%	61	16.4%	Not significant; $\chi^2=0.1478$, df=1
Catfish	24	35.3%	56	15.0%	Over-represented in prey remains; $\chi^2=14.5939$, df=1, $p<0.01$
Perciformes	12	17.6%	88	23.6%	Not significant; $\chi^2=0.8452$, df=1
Unknown Fish	0	0.0%	13	3.5%	Not significant; $\chi^2=1.3756$, df=1
Subtotal	56	82.4%	342	91.7%	Under-represented in prey remains; $\chi^2=4.6852$, df=1, $p<0.05$
Other Species					
Bird	6	8.8%	8	2.1%	Over-represented in prey remains; $\chi^2=6.3148$, df=1, $p<0.05$
Mammal	6	8.8%	18	4.8%	Not significant; $\chi^2=1.0930$, df=1
Turtle	0	0.0%	5	1.3%	Not significant; $\chi^2=0.1139$, df=1
Subtotal	12	17.6%	31	8.3%	
Total	**68**	**100.0%**	**373**	**100.00%**	

direct observations ($\chi^2 = 14.6$, df = 1, $p < 0.01$). From these analyses, we conclude that, in those territories where only prey remains are available, catfish are less important that indicated. On the other hand, carp and perciform numbers appeared in nearly equal proportions using the two methods. Birds were generally over-represented in the prey remains. Mammals also appeared more in the pooled sample of prey remains than expected from the observations; however, the differences were not significant by Chi-square.

Possible explanations for the disparity between methods predicting prey numbers and biomass include: (1) difference between observation days and the period represented by the remains; (2) softer-boned species leaving fewer remains (e.g., sucker); (3) the persistence of old prey remains (particularly large fish bones, and bird and mammal parts); (4) behavior of adults bringing in headless fish; (5) collections of remains below nest cliffs were often not possible; (6) adult nest cleaning behavior as observed at Bartlett (see below), Redmond (Driscoll 1985), Blue Point (Canestorp *et al.* 1984, Collie *et al.* 1985), Ladders (Poelker and Palmiotto 1985), Orme (Fawcett *et al.* 1990) and Horse Mesa (Driscoll and Buckley 1986) breeding areas; (7) removal of prey items by wood rats and other scavengers (Dodds 1985, and Sweitzer and Moller 1988 observed ravens stealing prey from Arizona eagle nests); and, (8) variation associated with season and age of the young (small young receive meat but not large bones, older young eat a larger portion of the bones and skin).

Driscoll and Buckley (1986) observed "house cleaning" on 11 occasions at the Horse Mesa breeding area in 1986. The Horse Mesa male and female were seen removing old prey items from the nest and embarking on short flights, dropping the remains over the reservoirs or canyons. In an extreme example of nest cleaning behavior, we noted that the Bartlett male would bring several suckers to the nest in the morning, but the following morning, he would often remove them from the nest and replace them with fresh fish. Adults also feed on filleted fish remains left by fishermen and deliver the filleted carcasses to the nest (Redmond Breeding Area, Driscoll 1985). Such behavior can result in overestimation of biomass, since most of the meat was already absent from the fish carcass.

Techniques described in this report for the visual identification of prey deliveries to the nest contributed an accurate accounting of daily food habits of priority bald eagle pairs. The technique failed in some cases to differentiate among species (i.e., Sonora versus desert suckers); however, it accurately represented family, genera and even species in most cases. The use of untrained observers, or identifications made from long distances, would likely result in a large number of unidentified prey and bias the prey selection data. Our observers were well trained in fish, bird, and mammal identification, had full views of the nest bowl, and blinds and observation points were close enough to make accurate identifications.

In summary, we feel that prey remains analyses are useful in determining important taxa for studies of bald eagle prey composition, but may not be reliable when evaluating the relative abundance or percent biomass contribution of taxonomic groups to the total dietary intake. Our prey remains analysis consistently under-represented the occurrence of fish in the eagle's diets. Direct nest observations revealed that fish are more important to Arizona bald eagles than prey remains analyses indicated. Moreover, prey remains analysis tends to underestimate some fish taxa (e.g., suckers) and overestimate others (e.g., catfish). These data agree with those of Mersmann (1989) as regards the tendency to overestimate catfish in prey remains analyses. We describe below an experiment that adds further weight to these conclusions.

B5.1.11 Feeding Trial with Captive Bald Eagle

To test prey identification techniques and further test accuracy of prey remains analysis in predicting size and occurrence of fish in a bald eagle's diet, we participated in a feeding experiment that utilized a captive eagle at the Phoenix Zoo. Fish of known species and length were fed to the captive bald eagle, then all remains of prey were collected following feeding (T. Gatz and M. Jakle, unpub. data). We identified the remains using the same methods described in this report for prey analysis of Arizona nest collections (see Section E8). The results of our analysis appear in Table B5.1-42 along with the number and size of fish species actually fed to the captive eagle.

We found evidence of 26 of the 45 fish fed to the eagle. We correctly identified at least one individual of all species in the feeding trial except for smallmouth bass and trout which were identified to the correct genus. Of five of the nine bluegill represented in the remains, we identified two to genus (*Lepomis*) only. We found three largemouth bass (represented by three right dentaries) and two black bass sp. (represented by a fourth right dentary and a pre-opercula of unique size). We offer no explanation for the occurrence of extra bass in the collection. Perhaps small bones from pre-experiment feedings had persisted in the cage gravel substrate.

While the remains analysis correctly identified the important taxa in the diet of the captive eagle, some species were poorly represented. Soft-boned fish such as trout and bluegill along with the smaller individuals (e.g., the 305-mm *Gila robusta*; all the smaller trout; the 216-mm, 228-mm, and 254-mm *Catostomus clarki*; and the 330-mm channel catfish) were under-represented in the analysis. Carp, which are large and hard-boned, were all identified from the remains. Eighty percent of catfish appeared in the remains collection; 60 percent of the somewhat softer-boned suckers were accounted for in the remains. These data strengthen our argument that particular fish taxa are underestimated in an analysis of prey remains.

B5.1.12 Evaluation of Biomass in Terms of Caloric Contribution

It is now appropriate to discuss the different caloric contributions of major prey classes, especially in light of the apparent increased importance of fish over other prey as demonstrated above. Stalmaster and Gessaman (1982) measured the wet energy content of dead, post-spawn chum salmon, black-tailed jackrabbit, and mallard duck (0.90, 1.22, and 1.96 Kcal/g, respectively) and found an inverse relationship between the daily consumption of these food items and their caloric content by captive bald eagles. We found that energy contents for fish were similar within a sample of eleven species (carp, hardhead, Sacramento squawfish, tui chub, Sacramento sucker, brown bullhead, channel catfish, black crappie, largemouth bass, and tule perch) from the Pit River in California (BioSystems 1985); the mean caloric content was 0.91 Kcal/g (range = 0.86 for carp and sucker, 1.00 for bullhead). We note that during a study of wintering bald eagles on the Skagit River, Washington, we measured only 0.63 Kcal/g in spawned-out chum salmon carrion (Hunt *et al.* 1981).

A diet of fish, therefore, would contain about one-quarter less calories per gram than a diet of mammals and less than one-half the calories of birds. Our biomass calculation for fish somewhat compensated for the lower energy content of fish since we subtracted the weight of bones plus five percent (representing unavailable flesh attached to bones, and so forth) from each fish in the biomass analysis. No corrections were calculated for bones or inaccessible flesh for either birds or mammals.

Because of the dominance of fish in the diet of nesting eagles at priority (nest observation) sites in Arizona, we conclude that despite their greater caloric content, mammals contribute a relatively minor portion of the energy required during the chick cycle and are probably important only during periods of high, turbid river flows or at territories with apparent deficiencies in fish populations (e.g., "76," Sheep).

Table B5.1-42. Comparison of numbers, total lengths (mm), and mean lengths of prey fish fed to captive bald eagle at the Phoenix Zoo with numbers, estimated lengths, and mean lengths of fish species identified from prey remains collected in zoo cage following feeding by captive eagle.

	Fed to Eagle			Identified in Remains		
Species	No.	Lengths	(Mean Length)	No.	Lengths	(Mean Length)
Salmo sp.	12	337 330 330 254 165 165 165 152 127 102 102 102	(194)	1	350	(350)
Roundtail Chub	2	330 305	(318)	1	336	(336)
Carp	4	406 393 381 368	(387)	4	418 385 385 289	(369)
Sonora Sucker	5	305 292 279 229 229	(267)	4	314 304 293 264	(294)
Desert Sucker	5	279 267 254 228 216	(249)	2	270 270	(270)

Table B5.1-42. (Continued)

Species	Fed to Eagle No.	Fed to Eagle Lengths	Fed to Eagle (Mean Length)	Identified in Remains No.	Identified in Remains Lengths	Identified in Remains (Mean Length)
Channel Catfish	5	394 387 381 368 330	(372)	4	459 435 380 364	(410)
Largemouth Bass	2	381 no data	(381)	3	396 291 256	(314)
Smallmouth Bass	1	178	(178)		214	
(*Micropterus* sp.)				2	416	(315)
Bluegill	9	178 165 165	(165)	3	196 188 158	(189)
(*Lepomis* sp.)		178 165 165 165 152 152		2	243 158	
Total	**45**			**26**		

However, because turbid periods are lengthy in some years, the availability of mammals may be essential to eagle productivity during such times. Mammals and mammal carrion may also be important in sustaining wandering juveniles and subadults (see Sections A4 and C5). Birds, particularly waterfowl, may play an important role during winter months, a time at which their greater caloric content may aid female bald eagles in amassing body fat for egg formation and incubation. Thus, in the larger view, healthy waterfowl and mammal populations are probably significant components of Arizona's rich landscape that supports bald eagles.

ECOLOGY OF BALD EAGLES IN ARIZONA

Part C

POPULATION ECOLOGY

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C1 INTRODUCTION

Little is known about an historical population of eagles that may have occurred in Arizona. Clearly, the landscape has changed significantly (see Section D2), and it may be that eagle numbers have also changed. Fewer large trees are available to serve as nesting sites, (see sections A2.2 and C2.2), waterways are diminished both in volume and extent, and the relative abundance and distribution of fish species are altered. Several of these changes resulted from the gradual warming and drying of the landscape during the past 12 or so millennia; the balance are related to the presence of humans within the past 400 years.

In addition to environmental and habitat changes, there is little doubt that the direct influence of humans in Arizona has affected two key parameters that regulate the size of bald eagle populations: fecundity and mortality. During the past 30 years, agricultural pesticides reduced bald eagle reproductive rates over large areas of North America (Wiemeyer 1984), and it is widely accepted that human disturbance during the nesting period frequently causes eggs or nests to fail (see sections A5.2, C3, and D4). Moreover, humans have introduced other mortality agents unknown to the bald eagles of pristine times; shooting, poisoning, electrocution, and wire strikes are but a few. Because Arizona's human population has enormously increased and is expected to continue to do so, it seems logical to assume that the rates of bald eagle survivorship, and probably fecundity, will respond to these changes.

On the other hand, it is fair to point out that human influences in Arizona have also benefitted bald eagles in some ways, and there is even the possibility that the net effects of humans on bald eagles here has been positive. Because early nesting reports are so few, we cannot say for certain that more bald eagles occurred in Arizona in ancient times. In this report, we demonstrate that reservoirs and regulated river sections support nesting and itinerant bald eagles. The increased diversity of gross aquatic habitats resulting from the addition of dams, reservoirs, and regulated reaches, and the introduction of exotic fishes, has increased the species available to eagles as prey.

We cannot discount the possibility that bald eagle fecundity and survivorship was impacted by mankind even before the arrival of the Europeans. While smaller in total population, native Americans were more evenly distributed along water courses in prehistorical times, perhaps actually increasing the potential for human/eagle interaction. Although the aboriginal people had no firearms, eaglets in tree nests would have been conspicuously available as food and for ceremonial use of body parts. Because of their size, efforts to trap adult eagles for food, as practiced by the Bella Coola Indians in the Pacific northwest (Smith 1929 cited in Stalmaster 1987), might also have been an efficient strategy in the hunter/gatherer economy of the southwestern native Americans.

In Part B, we discussed many aspects of the ecology of the breeding pairs of bald eagles in Arizona, most specifically those points relating to foraging and prey. In this section, we concentrate mainly on demographics, by first examining the specific factors influencing reproduction (Section C2), and then comparing productivity in Arizona to that of other bald eagle populations throughout North America (see Section A2 for overview). The details surrounding specific mortalities among each age class of eagles are presented in Section C3, and the possible impacts humans have had on eagles and their habitat is discussed in Section C4. In Section C5, we consider the nonbreeding population of native Arizona bald eagles, and, in doing so, we depart Arizona with the migrating juveniles and follow their summer travels northward as far as Manitoba and British Columbia, returning to Arizona habitats for fall, winter, and

spring. We present specific data on the movements of the non-breeding segment within Arizona, as revealed by telemetry. In Section C6, we estimate the minimum survivorship of Arizona nestlings to breeding age, through banding and telemetry data, and present the beginnings of a life-table for the Arizona bald eagle population. Much of the data presented in Part C is detailed, and we refer the reader to sections A2 and A5 for a general overview on these subjects, and to Part D for information on the history of specific pairs.

C2 REPRODUCTION

In this section, we examine the many factors affecting reproduction in Arizona bald eagles, and compare productivity elements with other populations in North America. We begin by introducing the 28 known Arizona bald eagle breeding areas in order of discovery by management agencies, as well as earlier records of the territory's existence. We then describe the nesting chronology of the population and the behavior of adults and young (and nestling development) during the breeding season. A discussion of nesting habitat follows, along with a description of egg characteristics, and a report of double-clutching by Arizona pairs. We then analyze productivity, summarizing the years of our study (1987–1990). We review the reproductive history of the Arizona population and compare the productivity of breeding areas. We also discuss the reasons for failure or success at individual nest sites, and population trends in reproduction.

Plate C1. Nestling bald eagle (4.5 weeks old) at the Redmond breeding area, April 1987 (photo by D. Driscoll).

The number of known bald eagle breeding areas in Arizona has increased from two in 1970 to 28 in 1990. Many newly discovered breeding areas were the result of increased nest search efforts, rather than new pairs moving into previously unoccupied but suitable breeding locations. Some "new" territories contained multiple nests that were very weathered and dilapidated, and contained old eggshell fragments, indicating they had been used in the past. In addition, interviews with local landowners and persons knowledgeable about bald eagles in Arizona indicate that some "new" nests had been occupied and producing young for years. These interviews, as well as known nests found in unoccupied territories,

indicate that bald eagles may have nested in higher regions, especially on the upper Verde River where currently existing nests in historical sites remain unoccupied. The locations of these nest sites are plotted in the Arizona Bald Eagle Nest Map Atlas (see Part F), and detailed discussions on each breeding area are provided in sections D4 and D5.

The two breeding areas known to management agencies prior to 1970 (Bartlett and Fort McDowell) are reported to have been occupied from "prior to the arrival of white men" (prior to 1900; Chief Haiawatha Hood, pers. comm.) to currently existing nests built in the 1940s and 1950s (see Table C2.0-1). Six "new" territories were found from 1970-1974; two of these did not have previous records of existence (Cibecue, Redmond), but two had been active since the 1920s and 1930s (Mule Hoof, Blue Point), one may have been occupied prior to 1918 (East Verde), and one (Ladders) had been active since 1962. Four breeding areas were found from 1975-1979, of which one contained nests existing prior to 1973 (one remnant of a nest on a pinnacle top likely present for many years prior) (Cedar Basin), and the remaining three (Horseshoe, Pinal, and Pleasant) had no records prior to discovery. See sections C2.5, D3, and D4 for details.

During 1980–1984, six "new" nest sites were located. Two of these territories had no previous records of occupancy (Sheep and Cliff) and may have been newly founded breeding areas. The Sheep eagles built the only known nest on top of an old buteo nest, and both Cliff adults carried USFWS bands. We captured one of these eagles and found it had been banded in 1979 at the Redmond breeding area, and would have been five years old when the breeding area was discovered in 1984 (see Section C6). Nests were reported in the White Mountains, possibly in vicinity of one of these breeding areas (Lone Pine) prior to 1937, but no historical records on the currently known nests exist. The three remaining territories existed prior to their discovery, one (Horse Mesa) has fledged young since the 1950s, another ("76") was active at least since the early 1970s, and Ash was occupied at least since 1982.

Ten breeding areas were found from 1985–1989. Three of these sites had no previous records of occupancy (Chino, Alamo, Ive's Wash), and Alamo was a new site formed by the Chino eagles in December 1986 (see sections D4.1 and D4.7). The remaining seven territories existed prior to discovery. Coolidge has occupancy records from 1976, and old eggshell fragments were collected from the recently found cliff nest. Canyon contains six nests, two of which appear very old and weathered, and one is merely a remnant of sticks on a pinnacle, likely present for many years. The Orme breeding area is located near the Salt and Verde River confluence. Although the site is near Phoenix, it has, according to local sources (Water Treatment Plant operators), fledged young since at least the early 1970s; these eagles eluded discovery until 1986. The Pinto eagles were reported feeding young in 1986, and eagles nested in the area prior to 1911. Table Mountain has been reported occupied at least since 1985, and adults and nests were found at Devil's Post in the early 1970s. The Perkinsville breeding area was at least occupied in the 1960s, with a nest present in 1973.

In addition to the 28 breeding areas above, four historical nest sites on the Salt and Verde rivers have evidence of past breeding. Rock Creek was occupied in the 1950s; Clay McCollough (AGF) photographed the adults at the nest. Breeding at Hell Point was reported to agency personnel in the early 1970s, and the source was told "bald eagles don't nest on cliffs." These nests are still present, and showed signs of occupancy in 1986. Nests are also present at Cold Water and Tower, and adults are annually sighted in the vicinity. Although no breeding records exist for Cold Water, the Tower site produced young in 1965, 1966, and 1968 (Floyd Thompson, USFWS, interviewed in Forbis 1984). There are also four locations on the Salt River (Theodore Roosevelt Dam, Canyon Reservoir, upper Cherry Creek, Gleason Flat) where adults are sighted year-round, yet no nests have been found. See sections D5 and D6 for more information on historical and possible nest sites.

Table C2.0-1. The status of bald eagle breeding areas in Arizona upon discovery, based on the presence and condition of nests, or historical records of occupancy and breeding.*

Year Discovered	Breeding Area	Status at Discovery	Comments
Prior to 1970			
1964	Bartlett	Existing	Nests built in or prior to 1940s; nest in saguaro cactus in 1937.
1968	Fort McDowell	Existing	Nests built prior to 1950s; breeding in early 1900s; nest in saguaro cactus in 1937.
1970–1974			
1971	Blue Point	Existing	Nest built in 1930; fledged young in 1932 and 1933.
1972	Ladders	Existing	Nest active since 1962
1973	Cibecue	Unknown	No records prior to 1973.
1973	East Verde	Unknown	Possible nest built prior to 1918; no records prior to 1973.
1974	Redmond	Unknown	No records prior to 1974.
1974	Mule Hoof	Existing	Nesting in 1920s and 1930s; at least one egg laid in 1935.
1975–1979			
1975	Horseshoe	Unknown	No records prior to 1975.
1978	Cedar Basin	Existing	Two nests found in 1973.
1978	Pinal	Unknown	No records prior to 1978; old eggshell fragments collected.
1979	Pleasant	Unknown	No records prior to 1979.
1980–1984			
1981	76	Existing	Breeding at least since 1970s.
1982	Sheep	Unknown	No records prior to 1982.
1982	Horse Mesa	Existing	Fledged young since 1950s.
1984	Ash	Existing	Occupied at least since 1982.
1984	Cliff	Unknown	No records prior to 1984.
1984	Lone Pine	Unknown	Nests in area prior to 1937.
1985–1989			
1985	Chino	Unknown	No records prior to 1985.
1985	Coolidge	Existing	Occupied at least since 1976; old eggshell fragments collected.
1986	Alamo	Unknown	No records prior to 1986; current nests built since 1986.
1986	Canyon	Existing	Six nests in breeding area; three nests old and bleached out; one very old, remnant nest.
1986	Orme	Existing	Fledged young at least since 1970s.
1987	Ive's Wash	Unknown	No records prior to 1987.
1987	Pinto	Existing	Breeding in 1986; breeding in area prior to 1911.
1987	Table Mountain	Existing	Occupied at least since 1985.
1988	Devil's Post	Existing	Occupied at least since the early 1970s.
1989	Perkinsville	Existing	Occupied at least since 1960s; nests found 1973.

* Historic nest sites with breeding activity along Salt and Verde Rivers: Rock Creek—Occupied in 1950s; Hell Point—Occupied in 1970s, nests still present; Cold Water—Adults in area, nest present; Tower—Adults in area, nests present, produced young in 1965, 1966, and 1968.

Areas with adults present year round, along Salt and Verde Rivers, but no nests located to date: Theodore Roosevelt Dam—Upper Apache Lake; Canyon Lake; Cherry Creek—East of Aztec Peak; Gleason Flat—Salt River.

Thus, of the 28 known bald eagle breeding areas in Arizona, 16 (57%) appear to have existed prior to discovery. The status of the remaining 12 territories when found is unknown: three may have existed previously (East Verde, Pinal, Lone Pine) while no information is available for the remaining nine before discovery. Of all 28 breeding areas, only three (11%) (Sheep, Cliff, and Alamo) showed evidence of being newly established. In addition, year-round observations of adults in areas where we have not found nests suggests that more breeding areas exist than are currently known. Therefore, it is difficult to estimate how much the recent rise in the number of known breeding areas is due to population expansion, and how many sites have been occupied in the past without our knowledge.

C2.1 NESTING CHRONOLOGY

The Arizona bald eagle breeding season, from egg laying to fledging, extends from December to July. This does not mean that the remainder of the year, August to November, is unimportant, because the qualities that render the area a "serviceable breeding location" (see Section A5.1) may need to be present throughout the year. This is an important consideration when management actions may influence the eagles' fat stores or their perception of the chances of a successful breeding attempt. Maintaining the habitat components of breeding areas may be especially important in Arizona where adults remain on the territories year round.

Arizona bald eagles have built nests from July–September (Horseshoe 1987) to February, and occasionally as late as March, following failure of the initial nesting attempt (Fort McDowell 1988, Bartlett 1990). Courtship behavior has been recorded from September to March, but increases in duration and frequency from November to February. Adults have been observed copulating in all months of the year. The standard date for closures at bald eagle breeding areas in Arizona is 1 December to 30 June, but it should be noted that courtship in November may also be influenced by disturbance near the nest.

In summary, the Arizona bald eagle breeding season extends from December to July. The egg-laying period ranges from December to March, with hatching from January to April and fledging from April to July (Figure C2.1-1). Radio-tagged juveniles departed on migration in June and July.

C2.1.1 Pre-Incubation Period

Activities of adult bald eagles prior to incubation include courtship, copulations, and nest building. Some pairs also become more aggressive in defending their territory during this period. Courtship behavior in Arizona bald eagles involves various forms of pair-bonding, including vocalizations, chasing flights, stoops from high elevations, and the enchanting aerial cartwheel. An individual eagle's vocalizations can vary in pitch, form, and presentation. These vocalizations, which undoubtedly have numerous meanings and functions, can also vary between different eagles. Chasing flights range from tail-chases with erratic maneuvering, to inverted flight and talon grappling. During this flight, the eagles may exchange positions, creating a barrel-roll effect. In another courtship display, one bird will ring up to high elevations, fold its wings, and plummet down to its mate. The eagle will swing up prior to contact, and usually repeat the process. We have observed the stooping display mainly in males, but the female may also perform this flight. In the aerial cartwheel, the pair will lock talons and free-fall down to near ground level before separating. Although some displays are limited to the courtship period, we have observed chasing flights and vocalizations throughout the season. These courtship displays appear to be standard for all populations of bald eagles, as well as most other sea eagles (*Haliaeetus* sp.) and are a

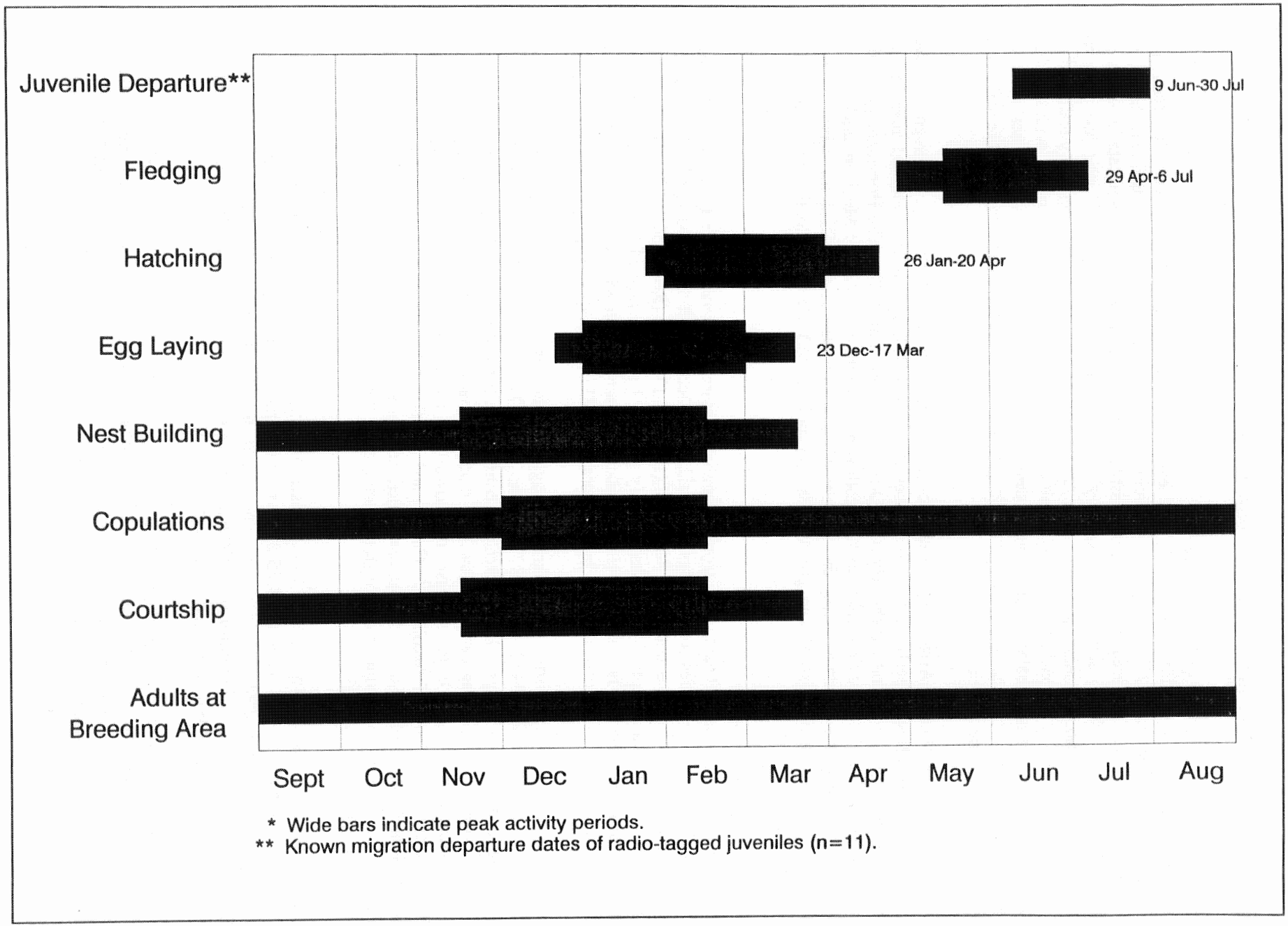


Figure C2.1-1. Nesting chronology of bald eagles in Arizona.

precursor to sexual activity (Stalmaster 1987).
We have observed copulation in Arizona's bald eagles throughout the year; however, the frequency increases from November to February. This behavior may occur year-round in Arizona due to the eagles occupation of the breeding area all year, in contrast to populations where the adults migrate in winter or summer. Low guttural vocalizations are often given between the closely perched pair just prior to copulation. Copulation is usually initiated by the female leaning forward and uttering low vocalizations. The male then hops on her back, she moves her tail to the side, and cloacal contact ensues, with the male using his wings to maintain balance during the process. The pair will occasionally rearrange nest material or simply perch close to each other before or after copulation, but we have also observed the male take flight from the female's back.

Most nest construction by Arizona bald eagles occurs from November to January, although we have observed nest building as early as July–September (Horseshoe 1987), and nest refurbishment in late March when pairs laid second clutches (Fort McDowell 1988, Bartlett 1990). The Horseshoe pair built a new nest between July and September in 1987 following a severe infestation of Mexican chicken bugs in the only nest in the territory during the 1987 breeding season (see Section C3.4 for details on nest parasites). Nest material (sticks and green grass, vegetation, etc.) are added to the nest continually throughout the season.

C2.1.2 Incubation Period

Eggs are laid at Arizona bald eagle nests from December to March, with variation between breeding areas spanning 85 days. The earliest known eggs were laid on 23 December (Fort McDowell 1987), while the latest recorded incubation was noted by Hildebrandt (1981) on 17 March (Redmond 1978). The incidence of double-clutching in Arizona bald eagles has only recently been documented (Section C2.4) and may account for some presumed late nesting. Hatching dates also ranged over 85 days, from 26 January (Fort McDowell 1987) to an incident reported by Hildebrandt (1981) of 20 April (Redmond 1978).

The incubation period reported for other bald eagle populations is 34–36 days, averaging 35 days (Herrick 1932, Herrick 1934, Newton 1979, Stalmaster 1987). The similarity in ranges for laying and hatching in Arizona (85 days) likely reflects the consistency of the 35-day incubation period; however, known (observed) egg-laying dates are few, and many incubation dates are estimated from hatch dates or the aging of nestlings. In the six cases of known (first day of incubation observed) egg-laying and hatching dates in Arizona (Driscoll 1985, Camara and Motzkin 1985, Beatty and Housser 1988, Pierson and Galvin 1990, and Section C2.5), the mean incubation period was 35.5 days, ranging from 34 to 37 days. Thus, the Arizona population apparently adheres to the 35-day mean incubation period reported for other bald eagle populations.

Observing at the Redmond nest site in 1985, Driscoll (1985) actually witnessed the eggs being laid and also observed hatching (see Section D4.25.2). Assuming that the first egg laid hatched first, incubation time for the first egg totaled 37 days, 1 hour, and 47 minutes. Incubation time for the second egg, from between 1800 hours on 12 February and 0700 hours on 13 February, to between 1800 hours on 19 March and 0700 hours on 20 March, totaled 35 days (Driscoll 1985).

In clutches of more than one egg, the period between egg-laying ranges from 2–4 days (Herrick 1934, Newton 1979, Stalmaster 1987); however, variations probably occur among birds in the same population and between successive eggs in the clutch (Newton 1979). In the one closely-observed clutch in Arizona, the period between laying of the first and second eggs was 3.5 days (Driscoll 1985). The time needed

for an eaglet to pip out of an egg ranges from 4–5 hours to two days (Herrick 1932, Herrick 1934, Hensel and Troyer 1964, Newton 1979, Stalmaster 1987). In the one instance of hatching observed in Arizona bald eagles, the period from pipping to hatching was four hours and 56 minutes (Driscoll 1985). However, this does not include the time it took for the eaglet to create the first hole in the egg. In addition, the adult male assisted the hatching eaglet by removing a portion of the shell, so actual pipping to hatching time would have likely been longer. The Redmond adult male's assistance to the hatching eaglet contradicts Stalmaster (1987) who stated, "But the adults are only spectators in the hatching process; if an eaglet has trouble breaking free of its shell, the parents will not assist in any manner." It is interesting to note that even though the Redmond eggs were laid 3.5 days apart, they hatched within 1.5 days of each other (Driscoll 1985).

C2.1.2.1 Adult Behavior. Incubation begins immediately after the first egg is laid. The adult female usually spends more time incubating than the male; however, this is not always the case. At some sites the male and female share incubation duties almost equally (Redmond 1985), and in less common instances, the male spends more time incubating than the female (Pinal 1987). In most cases, nest attendance by the female continues to rise through incubation, and peaks at or just after hatching. Nest attendance by the male usually remains fairly constant through incubation, then rapidly declines as he spends more time hunting and provides the bulk of the prey after hatching. The female often vocalizes sporadically when she wants to be relieved of incubation duties, although the male also returns to the nest without enticement. The incubating adult often pulls nest lining up against its body, presumably to create a warmer environment for the eggs (Driscoll 1985, Driscoll and Buckley 1986, Driscoll unpublished field notes). Data on this aspect of bald eagle nesting behavior are available in many of the ABENWP reports. In other populations, the female tends to spend more time incubating than the male (Stalmaster 1987). Rarely are the eggs left unattended, unless the adult is flushed off the nest by some sort of disturbance. If the attending adult does leave the nest, it will often cover the eggs with soft nest lining before departing. The number of nest exchanges (relieving mate of incubation duties) varies between pairs, ranging from 1–6 per day, although 3–4 per day are common. The adult that is not incubating overnight (usually, but not always, the male) will roost near the nest (Driscoll 1985, Driscoll and Buckley 1986, Driscoll unpublished field notes).

C2.1.3 Nestling Period

As mentioned previously, hatching dates for Arizona bald eagles span 85 days, from 26 January (Fort McDowell 1987) to a case reported by Hildebrandt (1981) of 20 April (Redmond 1978). In other populations, the eaglets remain in the nest for 10–12 weeks before fledging (Newton 1979, Stalmaster 1987). In Arizona bald eagles, the fledging age (age at which chicks first exit the nest) varies, and is apparently influenced by periods of high temperatures (heat stress—see Section C3.5) and nest parasites (see Section C3.4). Arizona nestlings have fledged over a range of 69 days, from 29 April (Horse Mesa 1988) to 6 July (Lone Pine 1988). Young have successfully fledged from 60 days (8.6 weeks) of age (Fort McDowell 1978) (Hildebrandt 1981) to 95 days (13.6 weeks) of age (Fort McDowell 1987).

Due to the ABENWP and the previous studies conducted on Arizona bald eagles, there is a large sample of known fledging dates and ages. Hildebrandt (1981) found eaglets fledged at a mean age of 79 days (11.3 weeks), while Haywood and Ohmart (1983) noted a mean age of 75 days (10.7 weeks), and Grubb (1986a) reported a mean fledging age of 82 days (11.7 weeks). Known hatch to fledge dates for 36 eaglets from 1987–1990 averaged 82.4 days (11.8 weeks), ranging from 68 days (9.7 weeks) to 95 days (13.6 weeks) (Table C2.1-1). Juveniles which leave the nest at an early age (10 weeks or younger) tend to spend more time on the ground and are thus susceptible to injury and predation (Stalmaster 1987).

Table C2.1-1. Known hatching and fledging dates of nestling bald eagles in Arizona from 1987–1990.

Breeding Area	Hatch Date	Fledge Date	Fledge Age	
			Days	Weeks
1987				
East Verde	26 February	30 May	93	13.3
Fort McDowell	26 January	1 May	95	13.6 *
Horse Mesa	18 February	9,12 May	80,83	11.4,11.9
Horseshoe	25 February	16,20,23 May	80,84,87	11.4-12.4
Pinal	7 March	25,29 May	79,83	11.3,11.9
1988				
Alamo	3 February	3 May	89	12.7
Bartlett	27,29 February	13,15 May	75,75	10.7,10.7
Blue Point	2 March	14,16 May	73,75	10.4,10.7
Cliff	9 March	27 May	79	11.3
Horseshoe	1 March	2 June	93	13.3
Ive's Wash	6 March	14 May	69	9.9
Ladders	20,21 February	14,16 May	83,84	11.4,12.0
Orme	21 February	7 May	75	10.7
76	17 March	10 June	86	12.3
1989				
Alamo	17 February	5 May	77	11.0
Bartlett	22,24 February	10,11 May	77,76	11.0,10.9
Fort McDowell	24 February	20,22 May	85,87	12.1,12.4
Ive's Wash	17 February	9 May	81	11.6
Ladders	6,8 March	25 May, 9 June	80,93	11.4,13.3
Pinal	23 March	30 May	68	9.7
1990				
Alamo	17 February	16 May	89	12.7
Orme	20 March	9 June	81	11.6
Pinal	12,13 March	2,3 June	82,82	11.7,11.7
Redmond	28 March	6 June	70	10.0
76	21 March	18 June	89	12.7
Mean			81.6	11.7

* Oldest known fledging age for Arizona bald eagles.

C2.1.3.1 Adult Behavior. Hatching of the eggs (if not visible) is usually apparent by prey deliveries to the nest by the male. The female spends most of her time brooding and feeding the eaglets during the first month the young are in the nest while the male does most of the foraging. The adults will often pull nest lining up against their bodies while brooding for the first few weeks, presumably to create a warmer environment for the eaglets. After the eaglets can thermoregulate (at about three weeks of age), the female gradually spends more time foraging for them. After the eaglets are about a month old, the adults leave the nest unattended for increasing amounts of time. One adult remains on the nest at night until the young are about eight weeks old; during this period the other adult usually roosts nearby. The adults continue to roost near the nest until fledging, and often afterwards (Driscoll 1985, Driscoll and Buckley 1986, Driscoll unpublished field notes).

When the eaglets are very small, the adults brood them in a near-incubation posture during cold periods of the morning or evening or on rainy days. On sunny days the adults brood in a higher position, and the young may clumsily move about the nest. Once the eaglets can thermoregulate, they do not require as much brooding, except during the night and in bad weather. As the eaglets grow, brooding by the adults shifts to shading the eaglets. During mid-day, the adults spread their wings to provide shade, and the nestlings often huddle under the any shade provided them. The young and adults usually pant during mid-day, and the adults often fly down to the river to drink or bathe after they have been shading the eaglets on hot days (Driscoll 1985, Driscoll and Buckley 1986, Driscoll unpublished field notes).

The young cannot eat much at first, but the amount consumed increases rapidly. Feeding times are nevertheless long even at first because the adults feed very small pieces. Therefore, the biomass consumed by the eaglets can not be judged by the length of feeding times. Both adults usually participate in feeding the eaglets, but the female takes on the bulk of this chore and may become slightly aggressive toward the male when food is involved. It is not uncommon for the male to deliver prey to the nest, and the female to take the food, then "scream in his face" until he leaves the nest, possibly with the function of causing him to depart on another hunting foray. The female may also vocalize sporadically through the morning, until prey is delivered to the nest by the male. In addition, the female often vocalizes when she wants to be relieved of nest duties. The eaglets begin feeding themselves at about four weeks of age, although the adults continue to feed them most of the time for about two more weeks. The adults still feed the nestlings, at least part of the time, until fledging. The male tends to provide most of the prey through the season, although the female increases her foraging as the young grow larger and require more food (Driscoll 1985, Driscoll and Buckley 1986, Driscoll unpublished field notes).

Foraging times appear to be bimodal at most breeding areas, with the majority of prey delivered to the nest in the morning and late afternoon to early evening; however, prey may be brought to the nest throughout the day and the adults feed the young at any time from prey remains in the nest.

If too many old prey items accumulate in the nest, the adults will take them from the nest and discard them over the river or desert (Driscoll 1985, Driscoll and Buckley 1986). In an extreme example of this behavior, we noted that the Bartlett male would bring several suckers to the nest each morning, but on the following morning, he would often throw what remained of them out of the nest.

The adults often eat the heads off fish before transporting them to the nest. If a large fish is captured, the adults may tear it in half, bringing the prey to the nest in two trips. If available, the adults may also feed on filleted fish remains left by fishermen.

The frequency of prey deliveries varies between and within breeding areas, but ranges from 1–6 per day, with 2–3 per day being common. The adults utilize carrion, and if they are feeding on a large carcass (e.g., cow) they occasionally return to the nest with their head feathers matted by blood (Driscoll 1985, Driscoll and Buckley 1986, Driscoll unpublished field notes).

In some interesting observations, both adults at the Redmond nest in 1985, and the Horse Mesa nest in 1986, began capturing flies daily as prey items accumulated in the nest. This behavior was observed daily as the adults brooded the young, and was also performed by the eaglets as they aged. The adults and eaglets were often successful in capturing flies, and swallowed them following several movements of the beak (Driscoll 1985, Driscoll and Buckley 1986).

The adults deliver sticks and vegetation to the nest throughout the season. The eaglets defecate in the nest during the first 1–2 weeks but soon learn to defecate off the nest rim. The frequency of nest-lining delivery by the adults seems to correspond with that of in-nest defecation. Sticks are also added to the nest over the season (Driscoll 1985). Driscoll observed the Redmond female gathering nest lining on several occasions, "The female would jump onto a pile of grass, flap her wings while holding the grass in her talons, and pull it up from the ground. This behavior usually occurred three to four times before she returned to the nest." We also observed the adults gathering nest sticks, and on one occasion witnessed the Sheep female break a stick off a tree. The female flew along side the nest tree and directly into a stick, snapping it off in her beak as she passed. The Arizona eagles utilize a variety of vegetation and woody plants, including cactus 'skeletons', in their nest construction. The species used are described in Section C2.2.5.

There is much valuable information on nesting behavior in the ABENWP reports, and anyone wishing to read further on this topic should consult these documents, most of which are referenced in Section A9. Many of these behaviors are also typical of breeding bald eagles in other populations (Stalmaster 1987).

C2.1.3.2 Nestling Development and Behavior. When the eaglets hatch, they are covered with a light grey down, which is replaced by a thicker and darker smoke-grey down at 9–10 days of age. The nestlings begin to maintain their body temperature after they enter the second down phase and likely are capable of thermoregulation by three weeks of age (Bortolotti 1984a, Bortolotti 1984b). The nestlings' feet at first appear abnormally large compared to their body size, but they soon "grow into them." In their fourth week the eaglets begin to sprout pin feathers on their upper back and wings (primaries and secondaries), followed by the head feathers and retrices (tail feathers) late in the fourth or early in the fifth week. In the fifth week the eaglets take on a dark brown appearance as their contour feathers emerge, although grey down often is visible in the head and lower back. By six weeks of age the eaglets turn dark brown, but some may still retain grey down on their lower back. By the seventh week the plumage of the young is fully dark brown, although feathers continue to grow at least until 12 weeks of age. At this time, the nestlings will appear to be larger than the adults, due to the longer feathers of juvenile birds (Driscoll 1985, Driscoll and Buckley 1986, Driscoll unpublished field notes). Female nestlings are usually larger than sibling males; females grow faster in terms of weight gain, but males develop feathers at a more rapid rate (Bortolotti 1984a, Bortolotti 1984b, Stalmaster 1987). This may give the males agility and alleviate the disadvantages they might otherwise have in food competition with larger sisters.

Occasionally in two-chick nests, and often in three-chick nests, one eaglet will be noticeably slower in development than its siblings. This is likely indicative of competition for food among its nest mates and might occur more frequently if there is a shortage of prey. We have observed nestlings as much as two

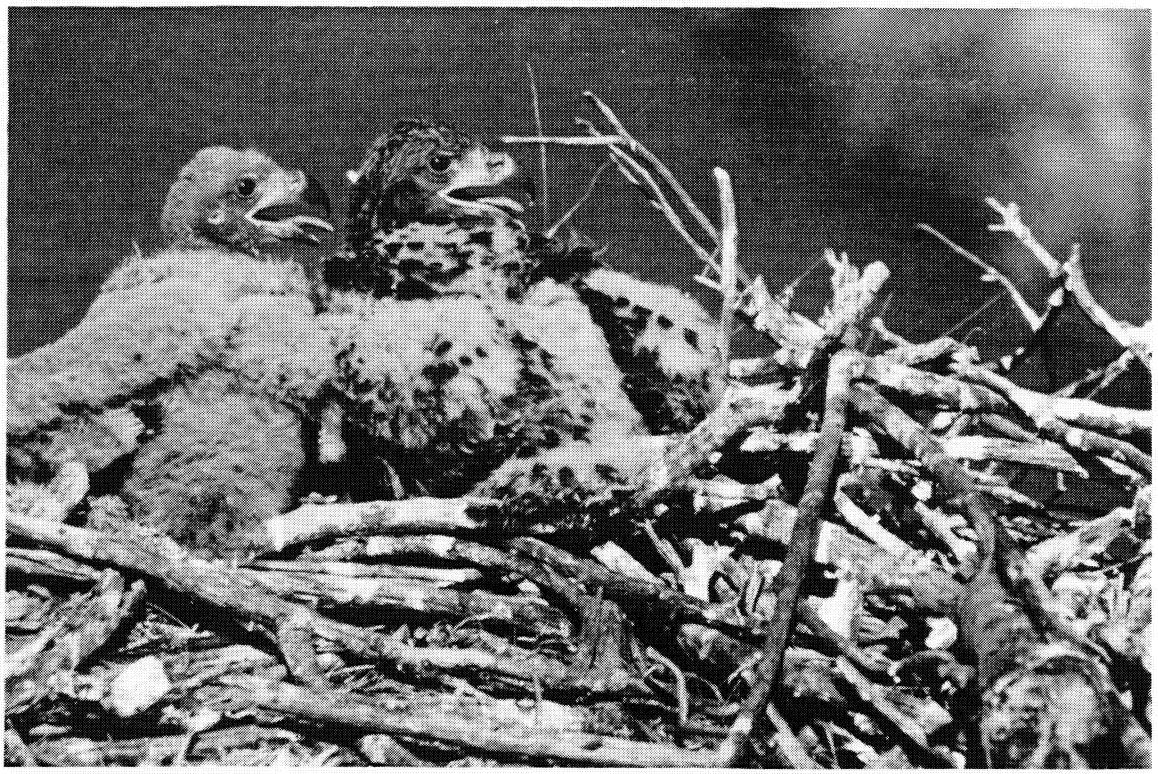


Plate C2. Nestling bald eagles (4-4.5 weeks old) at the Lone Pine breeding area, May 1988. Note pin feathers on older eaglet (right), compared to grey down on younger bird (left) (photo by T. Gatz).

weeks (in development) behind their siblings in three-chick nests (Blue Point 1988) and two-chick nests (Alaska) (Driscoll unpublished field notes, Driscoll nestling photographs). Arizona bald eagles develop at similar rates to eaglets described for other populations (Bortolotti 1984a, Bortolotti 1984b, Stalmaster 1987, Carpenter 1989).

The young can raise their heads upon hatching, but can not hold this posture for prolonged periods, and spend most of the time eating or huddled under the adults (apparently sleeping). As the eaglets grow, they clumsily move about the nest on their tarsi and are unable to stand erect on their feet for several weeks. The nestlings begin feeding themselves around four weeks of age, and first vocalize loudly enough to be heard by observers at about five weeks. The eaglets do so from early morning until the first prey delivery, and often 'food-beg' throughout the day. Activities of the eaglets include preening, exercising, playing, and sleeping. The young often pick up sticks from the nest and play with them. Two nestlings may tug on the opposite ends of a stick, or one may fling a stick around in its beak, often having it taken away and placed back in the nest by an adult. Driscoll (1986) observed nestlings striking the adults in the back of the head with sticks on two occasions. The young also sit on the nest rim and watch the goings-on below.

Exercising appears to be standard among Arizona nestlings and progresses in stages:

1. Wing Stretching: Stretching the wings out to the side, usually one at a time, often accompanied by stetching the leg on the same side (three weeks to fledging);

2. Warbling: Stretching both wings over the body at the same time (three weeks to fledging);

3. Exercising Wings: flapping wings while standing in the nest (seven weeks to fledging);

4. Hop-flapping: flapping wings while jumping up and down, across the nest, or onto perches around the nest (eight weeks to fledging);

5. Hovering: flapping wings while hovering over the nest (nine weeks to fledging).

When the eaglets approach eight weeks of age, they become aggressive during prey deliveries, rushing for first chance at the food. The young will take the prey from the adult and mantle (spread wings) over the item to protect the food from siblings and the adults. In one observation, the eaglets struck the adult male while jostling for the prey, and the fish fell from the pinnacle. All three eagles looked over the edge of the nest in apparent bewilderment (Driscoll 1985).

In hot weather the eaglets use whatever shade is available, including placing their heads in the shadow of their siblings. The angle of the sun on some cliff nests produces shade during part of the day, although other nests receive full sun all day. If shade exists in an accessible area when the eaglets are old enough, they may climb some distance to the shade. In some cases, young fall from the nest and die while apparently seeking shade. Eaglets may also perch in the sun when partial or full shade occurs on the nest (Hildebrandt 1981, Driscoll 1985, Driscoll and Buckley 1986, Grubb 1986a, Driscoll unpublished field notes). Further details on shade and heat stress are provided in Section C3.5.

C2.1.4 Post-Fledging Period

After fledging, the juveniles appear clumsy, and their first landings on cliffs or branches can result in injury, or even death. The eaglets are also naive about cactus, and have attempted to land on teddybear cholla during first flights. The young gradually become adept flyers, and learn how to slow themselves down to perch. The fledglings usually remain near the nest for the first week or so, then begin venturing farther from the eyrie, but remaining within the breeding area. The adults continue to feed the young, and the eaglets often pursue adults that have captured prey. Although the bulk of the eaglets' food is still provided by the adults, they occasionally eat carrion, and rarely kill their own food. The young food-beg throughout the day, and vocalize extensively when an adult brings prey. The eaglets tend to return to the nest to roost during the first few days; then they may begin roosting in other areas along the nest cliff. The juveniles begin soaring a few weeks after fledging, often for long periods in mid-day. One day, on an otherwise typical soaring flight, the will young soar northward and migrate over long distances during the next several days. See Section A4 and C5 for details on juvenile behavior prior to migration.

Ten juveniles radio-tagged by BioSystems remained in the breeding area for periods ranging from 18 days (JL20, East Verde 1987) to 65 days (JC50, Bartlett 1989), departing on their northward migrations from 9 June (JZ02, Orme 1987) to 30 July (JW31, "76" 1988).

Six Arizona nestling bald eagles were radio-tagged prior to 1986, two each year from 1977–1979 (Hildebrandt 1981, Sell 1982). Two of the eaglets died and one disappeared shortly after leaving the nest, so post-fledging movements are only available for three of the young. In 1977, the telemetered juvenile

Plate C3. Nestling bald eagle (7.5 weeks old) at the Alamo breeding area, April 1991 (photo by D. Driscoll).

dispersed on 1 July, 37 days after fledging (Hildebrandt 1981). The two 1979 young migrated on 23 June and 4 July, at 44 and 51 days post-fledging, respectively (Sell 1982). The juveniles radio-tagged by BioSystems during 1987–1989 departed on migration from 9 June to 30 July. Ages of those eagles upon departure ranged from 16 to 21.5 weeks, varying from 18 to 65 days after fledging. See sections A4 and C5 for details on juvenile migrations.

C2.1.5 Comparison of Nesting Chronology

The wide range of variation in egg-laying dates in Arizona (85 days) creates a diverse array of hatching dates. Many of the earliest nesters are at lower elevation breeding areas (Alamo, Bartlett, Blue Point, Chino, Fort McDowell, Horse Mesa, Horseshoe, Ive's Wash, Orme), although some low elevation sites

are consistently late (Cliff). Several higher elevation sites are also early (Canyon, East Verde, Ladders, "76"), but others are often late (Redmond, Lone Pine, Cedar Basin) (Table C2.1-2). Early egg-laying would seem to be an adaptation to avoid the intense summer heat, but the timing of egg-laying may also be a response to peaks in prey availability (facultative response) or anticipated prey availability (adaptive response) such as sucker spawns or spawning mortality (see Newton 1979).

On average, eagles nesting at 1000–1999 ft MSL (above mean sea level) breed earlier than at sites at higher elevations. These low-elevation sites are those where the eagles are known to have laid eggs in December or hatched young in January (Figure C2.1-2). At breeding areas from 2000 and 3000 ft MSL, eagles start laying eggs in mid-January. It is interesting that eagles nesting above 3000 ft tend to begin laying and hatching prior to those at 2000 feet. This is largely a result of the fact that the Canyon pair at 3800 ft tends to nest early. Eagles at territories above 4000 ft lay eggs from the end of January through early March, and these hatch from mid-March to mid-April.

Fledging dates can be highly variable at any elevation due to the range of ages when young leave the nest. Heat stress or nest parasites may cause the young to fledge earlier than they would without these influences. Although breeding areas below 2000 ft still fledge the earliest, fledge dates at sites from 1000 to 3999 ft are more concentrated than egg-laying and hatch dates (see Figure C2.1-2). As with hatching, the territories at 3000 ft fledge young sooner than those at 2000 feet. Breeding areas above 4000 ft fledge juveniles well behind the rest of the population. This may be due to cooler temperatures, resulting in a more normal fledging age; however, the three sites above 4000 ft are not as successful as the rest of the population, and thus do not contain as large a sample size of dates as the lower elevation nests.

Similarly, in other bald eagle populations, Stalmaster (1987) noted that eagles at higher elevations nest later than those in the lowlands. This also appears true in the nearby population of bald eagles nesting on the Rio Yaqui in Sonora, Mexico. Eaglets in the Fig Tree breeding area tend to be at least three weeks younger than those at the lower elevation Rio Sahuaripa site when we banded them in 1988. These young were banded in connection with a study being conducted by Bryan Brown in association with the USFWS, SRP, Reclamation, and the Mexican government (Brown and Olivera 1988).

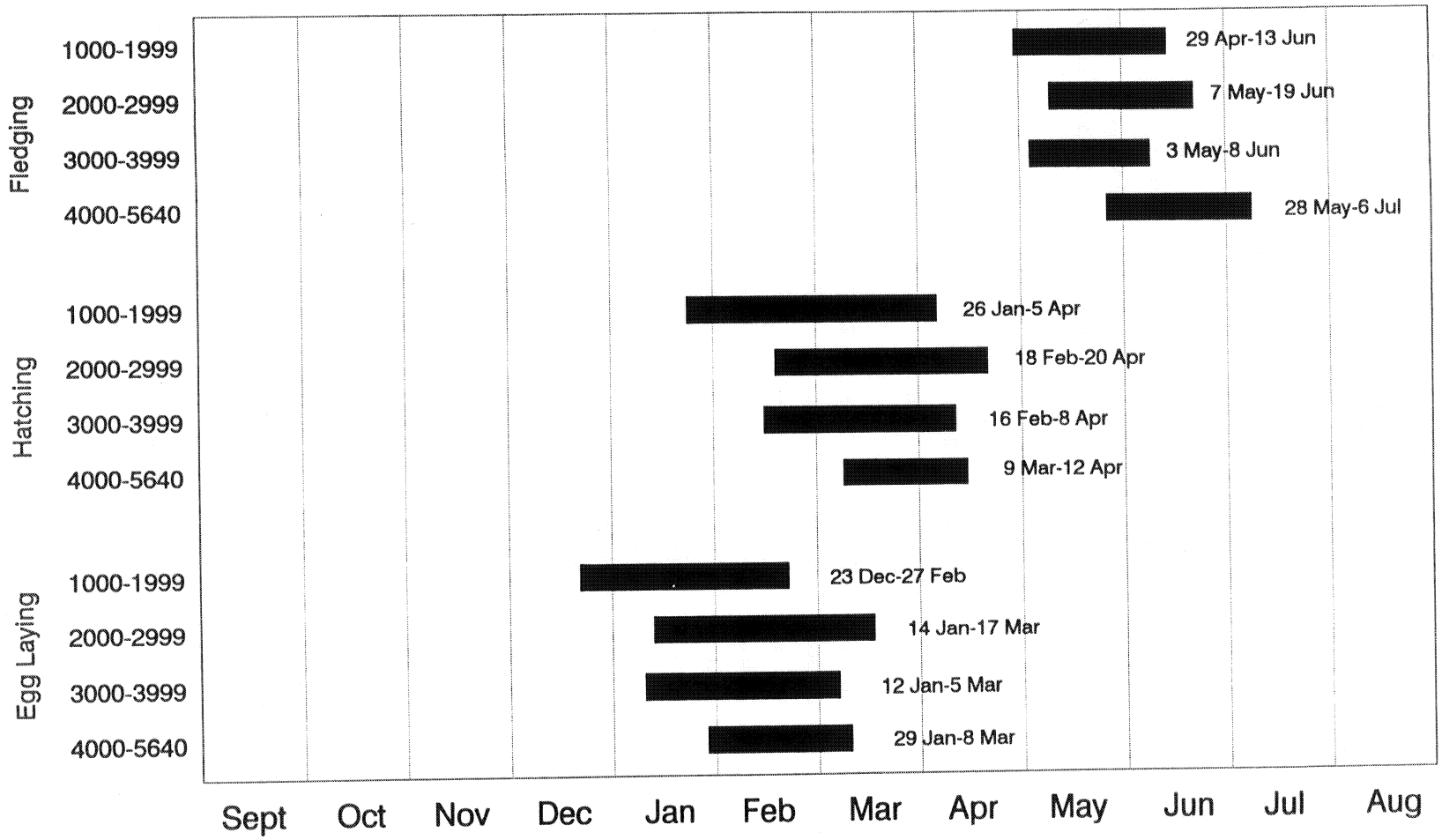
Even though Alamo is the lowest elevation site (1080 ft), breeding eagles on the lower Salt and Verde rivers usually lay eggs and hatch young prior to those near Alamo Reservoir. However, the Bill Williams (Alamo) nests appear to complete egg laying and hatching within a shorter time frame than nests on the lower Salt and Verde (Figure C2.1-3). Territories on the upper Verde River begin laying eggs and hatching young at nearly the same time as those on the upper Salt, although the upper Salt nests extend laying and hatching dates later than any other sites in Arizona. As with fledging by elevation, fledging dates by river system are more concentrated than laying and hatching dates. Similar to laying and hatching periods, the upper Salt River nests fledge eaglets later than the rest of the Arizona population.

It is interesting that even though the lower Salt and Verde nests begin egg-laying and hatching earlier than other sites, the Bill Williams and upper Verde River territories complete hatching and egg laying prior to those on the lower Salt and Verde. It is possible that early fish spawning and larger numbers of waterfowl influence the egg-laying dates on certain river sections. In southeast Alaska, bald eagle egg-laying dates were advanced and nestling survival higher in areas of food abundance (Hansen 1987). Perhaps the lengthy spawning periods associated with cold water releases from the dams (see sections B4 and E3) explains the long duration of egg-laying and hatching on the regulated Lower Salt and Verde rivers.

Table C2.1-2. Nesting chronology of Arizona bald eagle breeding areas, 1973-1990.

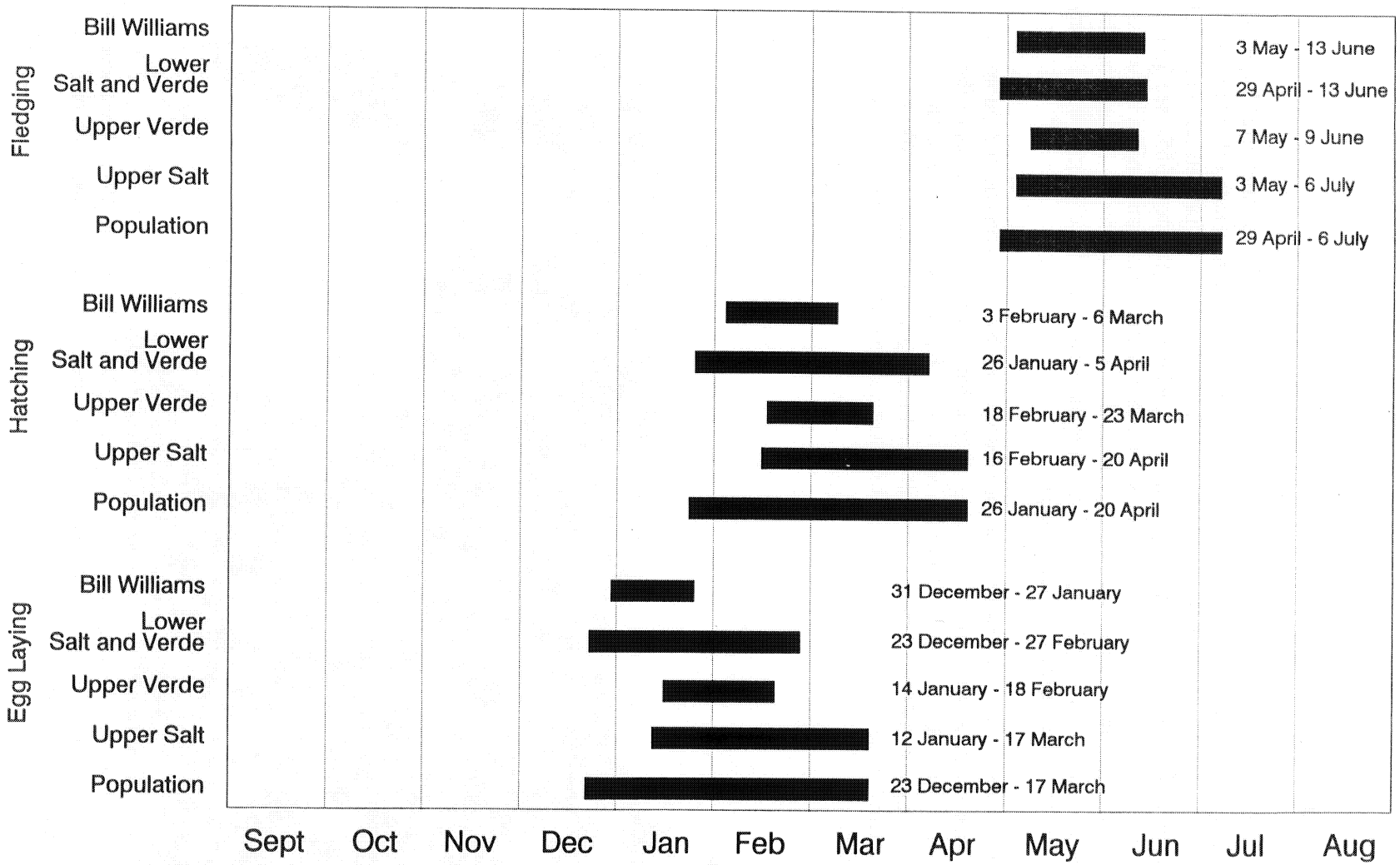
Breeding Area	River Elevation (MSL)	Egg Laying		Hatching		Fledging	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Alamo	1080	31 Dec	13 Jan	3 Feb	17 Feb	3 May	16 May
Ash	5640	30 Jan	6 Feb	6 Mar	13 Mar	4 Jun	11 Jun
Bartlett	1600	5 Jan	10 Feb*	17 Feb	16 Mar	4 May	5 Jun
Blue Point	1340	19 Jan	6 Feb	23 Feb	13 Mar	13 May	7 Jun
Canyon	3800	9–16 Jan	mid-Feb	13–20 Feb	mid-Mar	1–6 May	mid-Jun
Cedar Basin	4000	mid-Feb	mid-Mar	—	—	—	—
Chino	1200	16 Jan	late-Jan	20 Feb	late-Feb	15 May	16 May
Cibecue	3120	27 Jan	5 Mar	3 Mar	8 Apr	13 May	5–12 Jun
Cliff	1860	2 Feb	27 Feb	9 Mar	5 Apr	27 May	8 Jun
Coolidge	2250	25 Jan	2 Feb	1 Mar	10 Mar	24 May	2 Jun
Devil's Post	3080	—	—	—	—	—	—
East Verde	2440	14 Jan	18 Feb	18 Feb	23 Mar	< 7 May	> 5 Jun
Fort McDowell	1430	23 Dec	5 Feb**	26 Jan	12 Mar	1 May	> 2 Jun
Horse Mesa	1660	3–6 Jan	13 Jan	7–10 Feb	18 Feb	< 29 Apr	12 May
Horseshoe	2000	20 Jan	18 Feb	25 Feb	25 Mar	14–17 May	13 Jun
Ive's Wash	1080	13 Jan	27 Jan	17 Feb	6 Mar	5–6 May	14 May
Ladders	2920	19 Jan	2 Feb	20 Feb	8 Mar	14 May	9 Jun
Lone Pine	4180	< 29 Jan	8 Mar	< 5 Mar	12 Apr	28 May	6 July
Mule Hoof	3280	< 3 Feb	< 20 Feb	—	—	—	—
Orme	1320	30 Dec	12–15 Feb	2 Feb	19–22 Mar	3 May	9 Jun
Perkinsville	3820	—	—	—	—	—	—
Pinal	2200	24 Jan	16 Feb	28 Feb	23 Mar	20 May	10 Jun
Pinto	2100	< 28 Feb	—	—	—	—	—
Pleasant	1600	19–21 Jan	< 13 Mar	—	—	—	—
Redmond	2320	31 Jan	17 Mar	5 Mar	20 Apr	12–18 May	19 Jun
76	2760	16 Jan	15 Feb	20–22 Feb	21 Mar	19 May	18 Jun
Sheep	2360	1–2 Feb	28 Feb	8–9 Mar	—	—	—
Table Mountain	2240	mid-Feb	< 20 Mar	< 20 Mar	—	< 1 Jun	—
Population		23 Dec	17 Mar	26 Jan	20 Apr	< 29 Apr	6 Jul

* Excluding second clutch laid on 14 March in 1990.
** Excluding second clutch laid on 9 March in 1988.



* 1000-1999 ft MSL at river: Alamo, Bartlett, Blue Point, Chino, Cliff, Fort McDowell, Horse Mesa, Ive's Wash, Orme, Pleasant.
* 2000-2999 ft MSL at river: Coolidge, East Verde, Horseshoe, Ladders, Pinal, Pinto, Redmond, 76, Sheep, Table Mountain.
* 3000-3999 ft MSL at river: Canyon, Cibecue, Devil's Post, Mule Hoof, Perkinsville.
* 4000-5640 ft MSL at river: Cedar Basin, Lone Pine, Ash.

Figure C2.1-2. Nesting chronology of Arizona bald eagle breeding areas by elevation.



* Bill Williams River (regulated river and reservoir sites): Ive's Wash, Alamo, Chino (1080-1200 ft MSL at river).
* Lower Salt and Verde rivers (regulated river and reservoir sites): Horseshoe, Cliff, Bartlett, Fort McDowell, Orme, Blue Point, Horse Mesa, Pinto, Pinal (1320-2200 ft MSL at river)
* Upper Verde River (free flowing river): Table Mountain, East Verde, Ladders (2240-2920 MSL at river).
* Upper Salt River (free flowing river): Redmond, Canyon, Ash, Cibecue, Mule Hoof, Cedar Basin, Lone Pine (2320-5640 MSL at river).

Figure C2.1-3. Nesting chronology of Arizona bald eagle breeding areas by river system.

C2.2 NESTING HABITAT

Arizona riparian corridors were once lush with grasses and trees, and the waterways supported large fish and beaver populations. Beaver dams created backwater marshes among large stands of cottonwoods, sycamores, and willows (Davis 1982). However, as early as 1870, overgrazing had left soil bare, and erosion had begun clouding streams and cutting deep arroyos in the landscape (Hayden 1965) (see Section D2 for a discussion of Arizona habitat in historical times). Further abuse of riparian habitats in Arizona from overgrazing has resulted in riparian forests being reduced to scattered groves or isolated mature trees. Regeneration of cottonwoods, willows, and sycamores has been diminished by grazing in many drainages, leaving only mature trees and decaying snags.

The health of riparian habitats in Arizona has also been weakened by development and pumping of ground water which has drastically lowered water tables near urban and agricultural areas of the state. The lack of regeneration in riparian forests offers bald eagles in Arizona fewer nest trees, and in some cases only decaying snags or half-dead trees (especially at breeding areas lacking cliffs, e.g., Fort McDowell, Sheep). Once these trees fall, the lack of sufficient nesting substrate may render some sites unsuitable for breeding.

Plate C4. Habitat within a bald eagle breeding area on the free-flowing Verde River, May 1991. Brush along the shoreline (left) shows how salt cedar has encroached upon the riparian areas. A bald eagle pair nests on the south facing cliff at the left (photo by D. Driscoll).

There are currently 28 known bald eagle breeding areas in Arizona, with a total of 111 nests documented through aerial surveys and interviews with USFWS, USFS, and other knowledgeable personnel. Details on each nest are provided under the appropriate breeding area history in Section D4. Of the known nests, 48 percent are on cliffs (n = 36) or pinnacles (n = 17), 51 percent are in trees (n = 46) or snags (n = 11), and 1 percent (n = 1) on an artificial nesting structure (tower)(see Table C2.2-1). Six Arizona breeding areas contain only cliff or pinnacle nests (Cibecue, Horse Mesa, Ladders, Mule Hoof, Pinal, Redmond), while seven (Alamo, Ash, Chino, Fort McDowell, Perkinsville, Pinto, Sheep) have only tree nests available. The "76" territory nested on a cliff prior to 1974 (see Section D4.26); however, only tree nests are currently available. Both tree and cliff nests exist at the remaining 14 breeding areas.

The Devil's Post eagles have apparently not laid eggs since the breeding area's discovery in 1988. Of the remaining 13 territories containing both tree and cliff nests, cliffs were selected in 73 percent (n = 81) and trees in 27 percent (n = 30) of the 111 active nest-years in the data set, which (assuming an equal chance of the eagles choosing a tree or cliff nest) was very highly significant ($\chi^2 = 23.4$, df = 1, $p < 0.0001$)(Table C2.2-2). On an individual basis, the only breeding pairs that selected tree sites in more than 25 percent of active years included Cedar Basin (40%), Horseshoe (44%), Table Mountain (67%), Coolidge (75%), and Lone Pine (83%). We observe that three of these five breeding areas (Cedar Basin, Lone Pine, and Coolidge) are in remote or protected river sections where human disturbance is likely minimal or nonexistent. Lone Pine and Cedar Basin are located on the upper Salt River, with no road access nearby. Due to dangerous river features, white-water rafting and kayaking are rarely (if ever) attempted, so river access to these two nests is also protected. The Coolidge nest site is located on the Gila River below Coolidge Dam. Road access is blocked by a locked gate at the dam, and further discouraged by dilapidated wooden bridges.

Therefore, the apparent lack of utilization of tree nests in many breeding areas may be due to the increase in recreation and subsequent human disturbance during the 1980s. During this period, the population of Phoenix grew from approximately 110,000 to over 260,000. The 1990 census revealed that over one million people now live in the Phoenix Metropolitan Area. Even in territories not accessible by road, rafting and kayaking groups can disturb tree nests more readily than cliff nests. In several breeding areas containing cliff and tree nests, the tree nests have not been used since the breeding area was discovered (see Section D4), so it is possible that tree nests were used more often in previous periods (1960s–1970s) when recreation pressure was not as great.

In summary, nests in live trees have the advantage of cooler temperatures due to shading (snags do not provide this benefit). Tree nests, however, are more accessible to terrestrial predators and human disturbance. Cliff nests obviously offer more protection from human disturbance due to their height and (in most cases) inaccessibility. However, most cliff sites are exposed to direct, reflected, and conducted sunlight and therefore are hotter for nestlings and incubating, brooding, or shading adults (see Section C3.5). In addition, parasites that may contribute to eaglet mortality, specifically Mexican chicken bugs (see Section C3.4) have been found in Arizona bald eagle cliff nests, but we found none in tree nests.

Cliff nests are more permanent, whereas tree nests more often blow out in storms, nest branches break, or the whole tree may fall. A few cliff nests have fallen (see Section D3.1 for details); however, most cliff nests found on the early Arizona bald eagle nest surveys (Rubink and Podborny 1976), some with histories dating to the 1930s, are still in existence today.

Table C2.2-1. Number and type of nests known in Arizona bald eagle breeding areas.

Breeding Area	Cliff Nests		Tree Nests		Artificial Tower	Total Nests
	Cliff	Pinnacle	Snag	Live		
Alamo	—	—	3	—	—	3
Ash	—	—	—	2	—	2
Bartlett	1	1	—	1	—	3
Blue Point	1	2	—	3	—	6
Canyon	—	5	—	1	—	6
Cedar Basin	2	1	—	1	—	4
Chino	—	—	1	1	—	2
Cibecue	2	1	—	—	—	3
Cliff	2	1	—	1	—	4
Coolidge	1	—	—	2	—	3
Devil's Post	2	—	—	2	—	4
East Verde	4	—	1	2	—	7
Fort McDowell	—	—	2	11	—	13
Horse Mesa	1	1	—	—	—	2
Horseshoe	2	—	2	4	1	9
Ive's Wash	1	—	—	1	—	2
Ladders	5	—	—	—	—	5
Lone Pine	1	—	1	2	—	4
Mule Hoof	—	1	1	—	—	2
Orme	1	1	—	1	—	3
Perkinsville	—	—	—	2	—	2
Pinal	2	1	—	—	—	3
Pinto	—	—	—	3	—	3
Pleasant	1	—	—	1	—	2
Redmond	4	2	—	—	—	6
76	1	—	—	2	—	3
Sheep	—	—	—	1	—	1
Table Mountain	2	—	—	2	—	4
Totals	36	17	11	46	1	111
	53		57		1	111

Table C2.2-2. Nest site selection at the 13 Arizona bald eagle breeding areas containing both cliff and tree nests.

Breeding Area	Cliff Nests Years	Cliff Nests Percent	Tree Nests Years	Tree Nests Percent	Total Known Active Years
Bartlett	22	92	2	8	24
Blue Point	10	83	2	17	12
Canyon	5	100	0	—	5
Cedar Basin	6	60	4	40	10
Cliff	5	100	0	—	5
Coolidge	1	25	3	75	4
East Verde	13	76	4	24	17
Horseshoe	9	56	7	44	16
Ive's Wash	3	75	1	25	4
Lone Pine	1	17	5	83	6
Orme	3	100	0	—	3
Pleasant	2	100	0	—	2
Table Mountain	1	33	2	67	3
Totals	81	73	30	27	111

Nest success or failure is dependent on a multitude of factors, and any one breeding area may be successful on cliffs or in trees if food is plentiful and natural- or human-induced mortality does not occur. We compared nest success at cliff and tree nests for all known active (eggs laid) years in Arizona. Of 149 clutches laid in cliff nests, 97 (65 percent) were successful, while in tree nests 41 of 72 clutches (57 percent) were productive (not significantly different by Chi-Square analysis; Table C2.2-3).

C2.2.1 Breeding Area Distribution

Along the Salt and Verde rivers there are several relatively large gaps between *known* breeding areas. Such a gap occurs between Cibecue and Redmond on the upper Salt River, and between Pinto and Horse Mesa on the regulated system from lower Roosevelt Reservoir to Apache Reservoir (see Figure D3.1-1). A pair of adults have been sighted on numerous occasions near Theodore Roosevelt Dam and on upper Apache Reservoir; however, no nests are *known* to exist in this area (see Section D6 for details on possible nest sites and unverified reports).

Gleason Flat (Km 161–165), on the Salt River between Cibecue and Redmond, appears to have ample foraging habitat for bald eagles. Suitable nesting structure is available in 4–5 trees (these trees, however, are of only moderate height), on cliff substrate on Canyon Creek Butte, and on cliffs set back from the river. Although Canyon Creek Butte appears to supply sufficient cliff structure for a nest, no known nests occur there. Adult bald eagles have been sighted at Gleason Flat in winter (D. Hughes pers.

Table C2.2-3. Success of cliff and tree nests at Arizona bald eagle breeding areas.

	Cliff Nests			Tree Nests			
	Years Eggs Laid	Years Successful	%	Years Eggs Laid	Years Successful	%	Total Known Active Years
Alamo	— *	—	—	3	3	100	3
Ash	—	—	—	2	2	100	2
Bartlett	22	13	59	2	2	100	24
Blue Point	10	9	90	2	1	50	12
Canyon	5	5	100	0	0	—	5
Cedar Basin	6	1	17	4	0	—	10
Chino	—	—	—	3	1	33	3
Cibecue	14	8	57	—	—	—	14
Cliff	5	2	40	0	0	—	5
Coolidge	1	1	100	3	2	67	4
Devil's Post	0	0	—	0	0	—	0
East Verde	13	11	85	4	3	75	17
Fort McDowell	—	—	—	21	18	86	21
Horse Mesa	8	4	50	—	—	—	8
Horseshoe	9	6	67	6	1 **	17	15
Ive's Wash	3	3	100	1	0	—	4
Ladders	15	8	53	—	—	—	15
Lone Pine	1	1	100	5	1	20	6
Mule Hoof	4	1	25	0	0	—	4
Orme	3	3	100	0	0	—	3
Perkinsville	—	—	—	0	0	—	0
Pinal	12	9	75	—	—	—	12
Pinto	—	—	—	1	0	—	1
Pleasant	2	0	—	0	0	—	2
Redmond	15	11	73	—	—	—	15
76	0	0	—	9	7 ***	78	9
Sheep	—	—	—	4	0	—	4
Table Mountain	1	1	100	2	0	—	3
Totals	149	97	65	72	41	57	221

* — indicates no nests of that type available.
** Young fostered into another breeding area in two other years due to nest inundation.
*** Young fostered into another breeding area in one other year due to death of adult female.

comm.) and during the breeding season (M. Cross pers. comm.). The area receives moderate recreational use (hunting, fishing, and camping) which may discourage tree nesting by eagles. The available trees are of only moderate height, are accessible to the public most of the year. The confluence of Canyon and Ash creeks (with the Salt River) are located just upstream of Gleason Flat. Both of these tributaries support nesting eagles at air distances of 11.0 and 11.5 km, respectively, from the Salt River. The Ash pair has been known to deliver suckers to the nest during periods when Ash Creek was dry (Driscoll 1985b), likely indicating use of the Salt River. Ash is also 11.0 air km from Mule Hoof Bend (Km 191) on the upper Salt, and the pair may utilize that portion of the river as well. It is possible that the Ash and Canyon pairs both utilize Gleason Flat for foraging, thus excluding a third pair from nesting, a matter that could be confirmed by telemetry.

On the upper Verde River, gaps occur from Sullivan Lake to Perkinsville, and between Perkinsville and Ladders (see Figure D3.1-1). Large cliff nests have been found on the upper Verde River; however, these nests have not been occupied by bald eagles since they were found (see Section D5 for details on historical nest sites). A nest has also been found at Cold Water Creek between the Ladders and East Verde territories. Although adults are commonly sighted in this area (D. MacPhee pers. comm.), the nest has not been found occupied by a breeding pair since its discovery. We judge that very good foraging habitat exists on the lower Verde River between Bartlett and Fort McDowell; however lack of nesting substrate (trees or cliffs) and high recreational use may render this section of river unsuitable for nesting. Nests have been reported in this area in the past near Needle Rock and Box Bar Ranch (Section D3.2). High levels of recreational use on the lower Salt and Verde rivers may be the reason the Orme (nests 1 and 3) and Blue Point (nest 6) pairs have selected nest sites relatively far from water in recent years.

C2.2.2 Alternate Nests

The Sheep breeding area contains only one nest. It is in a dilapidated tree which appears to lack suitable future support (see Section D4.27). Most breeding areas have several alternate nests which the eagles tend to choose from one season to the next. Alternate nests may serve an important function in breeding ecology by: (1) allowing eagles to avoid infestations of nest parasites from year to year; (2) providing a secondary nesting structure in case the primary nest falls or is otherwise rendered unusable; and, (3) advertising to other eagles that they are within a breeding area, possibly reducing the number of altercations. Also, nest building is a part of bald eagle courtship behavior, and pairs may build new nests or refurbish old ones while subsequently utilizing another existing nest. In record cases outside Arizona, new nests have been completed by adult eagles within four days (Stalmaster 1987).

It has been suggested in the past (Grubb 1986a, Forbis 1986) that entering nests to band eaglets adversely effects reproduction and causes the adults to move to a new nest the following year. Grubb (1986a) argued that 75 percent of pairs moved or failed the year following banding, and Forbis (1986) invoked nest-entry as the cause of reduced productivity ("percent change," see below) the following year. However, by combining nest failure and moving to a new nest as one statistic, these authors overlooked the many factors involved in nest failures. Percent change in productivity is probably not a reasonable variable to use. For example, the difference in a nest producing two young in a banding year and one eaglet the following year represents a 100 percent decrease. However, a site producing two eaglets in a banding year, and three young the next year only results in a 67 percent increase, even though we are still referring to one eaglet. In addition, a nest that apparently did not lay eggs one year would obviously not be climbed, but if this nest hatched two young the next year, it would represent a 200 percent increase.

Grubb (1986a) notes that the Fort McDowell pair moves almost every year, but fails to mention that tree nests in this breeding area fall at high rates (see Section D4.13). These methods also fail to recognize the large amount of human-induced disturbance (recreation) not related to research, which occurs annually during various periods in the nesting cycle. Human disturbance is especially prevalent at Blue Point, where Grubb (1986a) attributes the alternate nest use and decrease in the number of young from one year to the next as related to nest climbs for banding. Some stages of the nesting cycle are more prone to nest failure than others; for example incubation and early hatching. A disturbance just before egg laying may cause a pair to choose an alternate nest, away from the problem area. Finally, there are no doubt many unobserved disturbances at nest sites, and these are not documented in relation to nest success.

The selection of one alternate nest over another may be the result of a multitude of factors including, (1) stability of nesting structure; (2) changes in the adult pair; (3) past experiences of adults in that nest or area; (4) protection from the elements; (5) human disturbance; (6) intraspecific and interspecific interactions; (7) visibility of the surroundings from within the nest; and, (8) nest parasites. Possible factors contributing to Arizona bald eagle alternate nest utilization from 1987–1990 are presented in Table C2.2-4. The table shows nest utilization for 1988–1990, preceded by the previous year's productivity, the number of nest climbs, and other known reasons the pair might move to a different nest the following year.

At breeding areas where we did not climb into the nest (n = 33), eight pairs (24%) remained in the same nest, while 25 (76%) moved to an alternate site or did not nest the following year. At sites where nests were climbed for banding and prey remains (n = 47), 22 pairs (47%) remained in the same nest, while 25 (53%) moved to an alternate site or did not nest the following year. Thus, climbing into nests to band eaglets and collect prey remains does not appear to cause the eagles to move to an alternate site the following year ($\chi^2 = 4.2123$, df = 1, $p < 0.05$). In fact, the percentage of pairs using the same nest the following year was higher when the nest was climbed (47%, n = 22) than not climbed (24%, n = 8). Table C2.2-4 suggests a number of possible reasons for nest switching; there are probably many more.

To gain additional insight into this aspect of bald eagle breeding behavior, we compared the rate of alternate nest use among pairs which: (1) failed in the egg stage (nest did not contain a brood); (2) failed in the nestling stage; (3) successfully fledged young; and, (4) hatched young (Table C2.2-5). Note that the presence of a brood had no apparent effect on the pair's nest site selection the following year, nor did failure in the egg stage. However, although the sample size is too small for statistical inference, five of seven breeding attempts which failed due to nestling mortality resulted in pairs selecting an alternate nest (or not nesting) the following year. If this relationship is eventually borne out in a larger sample, the adaptive value of nest-switching in response to nestling mortality seems obvious.

C2.2.3 Bald Eagle Nests Constructed On Nests Of Other Species

Arizona bald eagles have built six nests on top of the nests of other species of birds, including great blue herons, ravens or red-tailed hawks, Harris' hawks, and unknown buteos. Nest 2 (see Section D4) at the Orme breeding area was built in 1986 on top of two great blue heron nests in a rookery, but the nest was not used by the eagles and has since fallen. Similarly, nest 3 at the Cliff territory was built on top of a great blue heron nest in a rookery in December 1984, was not used, and has fallen. Nest 2 at the Pinto breeding area was built in December 1987 on top of a great blue heron nest within a rookery. The Pinto female laid at least one egg in this nest in 1989, but the egg(s) did not hatch. In addition, the Perkinsville eagles have built a nest within a great blue heron rookery, but not on top of a nest.

Table C2.2-4. Possible factors contributing to Arizona bald eagle alternate nest utilization, 1987–1990.

Breeding Area	1987 PRODUCTIVITY* Status	No. Eggs	No. Young Hatched	No. Young Fledged	No. Climbs	Comments	1988 NEST UTILIZATION** Did Not Move: Not Climbed	Did Not Move: Climbed	Moved Or Did Not Nest: Not Climbed	Moved Or Did Not Nest: Climbed
Alamo	Occupied	—	—	—	0	Chino pair.	—	—	1	—
Ash	Unoccupied	—	—	—	0		—	—	0	—
Bartlett	Failed	?	0	0	0	New male.	1	—	—	—
Blue Point	Successful	3+	3	3	2	Captured male, 1 fledgling died.	—	5	—	—
Canyon	Successful	1+	1+	1	0		—	—	0	—
Cedar Basin	Failed	3	0	0	1		—	1	—	—
Chino	Failed	2	0	0	0	New pair, nest branch fell.	—	—	1	—
Cibecue	Failed	1+	1	0	1	Female and young died, third adult, chicken bugs.	—	—	—	6
Cliff	Occupied	—	—	—	0		0	—	—	—
Coolidge	Successful	2+	2	2	2		—	—	—	2
Devil's Post	—	—	—	—	—		—	—	—	—
East Verde	Successful	2	1	1	2	Captured male.	—	3	—	—
Fort McDowell	Successful	1+	1	1	2		—	—	—	2
Horse Mesa	Successful	2+	2	2	2	Male died.	—	4	—	—
Horseshoe	Successful	3+	3	3	2	Captured female, chicken bugs.	—	—	—	4
Ive's Wash	Successful	1+	1+	1	1		—	2	—	—
Ladders	Failed	2+	2	0	3	Two young died, chicken bugs.	—	—	—	5
Lone Pine	Failed	1+	0	0	1		—	—	—	1
Mule Hoof	Unoccupied	—	—	—	0		—	—	0	—
Orme	Successful	2+	2	2	2		—	3	—	—
Perkinsville	—	—	—	—	—		—	—	—	—
Pinal	Successful	2+	2	2	2	Captured female twice.	—	—	—	4
Pinto	—	—	—	—	—		—	—	—	—
Pleasant	Occupied	—	—	—	0		—	—	0	—
Redmond	Successful	3+	2	2	2	Chicken bugs.	—	—	—	4
76	Failed	3	0	0	1	Photographer.	—	2	—	—
Sheep	Failed	1+	0	0	1		—	1	—	—
Table Mountain	Occupied	—	—	—	0		—	—	0	—

Summary	1987	1988			
Number of Breeding Areas	25	2	8	7	8
Nest Success	47.8%				
Mean Brood Size	1.8	10		15	
Productivity	0.87				
Number of Eggs	35+	4+	13+	3	13
Number of Young Hatched	23	4	10	2	10
Number of Young Fledged	20	4	10	2	8

* Unoccupied status indicates unoccupied at known nest sites.

** Value indicates known possible reasons for pair to choose an alternate nest site. Other unknown incidents may have also occurred. Changes in adult pairs would influence the current years nest site selection. Most other factors would influence the following years nest site selection.

Table C2.2-4. (Page 2 of 4)

Breeding Area	1988 PRODUCTIVITY* Status	No. Eggs	No. Young Hatched	No. Young Fledged	No. Climbs	Comments	1989 NEST UTILIZATION** Did Not Move: Not Climbed	Did Not Move: Climbed	Moved Or Did Not Nest: Not Climbed	Moved Or Did Not Nest: Climbed
Alamo	Successful	1+	1	1	3	New female, young fell.	—	3	—	—
Ash	Unoccupied	—	—	—	0		—	—	0	—
Bartlett	Successful	2	2	2	0	New male, captured male.	1	—	—	—
Blue Point	Successful	3+	3	3	2	New female, 3 fledglings died.	—	—	—	3
Canyon	Successful	1+	1	1	0		0	—	—	—
Cedar basin	Failed	1+	0	0	1		—	—	—	1
Chino	Unoccupied	—	—	—	0		—	—	0	—
Cibecue	Occupied	—	—	—	0	New female, captured injured male.		—	—	2—
Cliff	Successful	2+	2	2	2	Captured male and juvenile.	—	4	—	—
Coolidge	Successful	2+	2	2	2	Chicken bugs.	—	—	—	3
Devil's Post	Occupied	—	—	—	0	Discovered 23 February.	—	—	0	—
East Verde	Successful	2+	2	2	1		—	1	—	—
Fort McDowell	Failed	2+	0	0	1	Farming, woodcutting, and vehicle traffic.	—	5	—	—
Horse Mesa	Successful	1+	1	1	1	New male.	—	1	—	—
Horseshoe	Successful	1+	1	1	2	Captured male, chicken bugs.	—	4	—	—
Ive's Wash	Successful	1+	1	1	2	New male.	—	2	—	—
Ladders	Successful	2	2	2	2	Captured female, 1 fledgling died.	—	—	—	4
Lone Pine	Successful	2+	2	2	2		—	—	—	2
Mule Hoof	Unoccupied	—	—	—	0		—	—	0	—
Orme	Successful	1+	1	1	2	New male.	—	3	—	—
Perkinsville	—	—	—	—	—		—	—	—	—
Pinal	Failed	2	1	0	1	1 Young died, monofilament.	—	—	—	2
Pinto	Occupied	—	—	—	0	Captured female.	1	—	—	—
Pleasant	Unoccupied	—	—	—	0		—	—	0	—
Redmond	Successful	2+	2	1	2	New male, 2 young died, chicken bugs, captured male	—	—	—	5
76	Successful	2+	2	2	5	Young fell twice, nest fell.	—	—	—	7
Sheep	Failed	2+	0	0	1	Male disappeared, nest fell.	—	—	—	3
Table Mountain	Failed	1+	0	0	0		—	—	0	—

Summary	1988	1989			
		3	8	7	9
Number of Breeding Areas	27	11		16	
Nest Success	65.2%				
Mean Brood Size	1.6				
Productivity	1.04				
Number of Eggs	33+	5+	14+	3+	9+
Number of Young Hatched	26	4	9	2	8
Number of Young Fledged	24	3	6	1	3

Table C2.2-4. (Page 3 of 4)

Breeding Area	1989 PRODUCTIVITY * Status	No. Eggs	No. Young Hatched	No. Young Fledged	No. Climbs	Comments	1990 NEST UTILIZATION ** Did Not Move: Not Climbed	Did Not Move: Climbed	Moved Or Did Not Nest: Not Climbed	Moved Or Did Not Nest: Climbed
Alamo	Successful	2+	1	1	2	New female	—	3	—	—
Ash	Unoccupied	—	—	—	0		—	—	0	—
Bartlett	Successful	3	3	2	0	One young died, captured two juveniles.	2	—	—	—
Blue Point	Failed	2+	2	0	1	Two young died, much disturbance due to dry river bed, third adult	—	—	—	5
Canyon	Successful	1+	1	1	0		0	—	—	—
Cedar Basin	Failed	1+	0	0	0		0	—	—	—
Chino	Unoccupied	—	—	—	0		—	—	0	—
Cibecue	Successful	2+	2	1	0	New male, one young died.	—	—	2	—
Cliff	Failed	3+	1	0	1	One young died.	—	—	—	3
Coolidge	Occupied	—	—	—	0		—	—	0	—
Devil's Post	Occupied	—	—	—	0		—	—	0	—
East Verde	Successful	2+	2	2	1	Nest fell.	—	2	—	—
Fort McDowell	Successful	2+	2	2	2	New F. Helicopters spraying cotton —mesquite bosque cut below nest.	—	4	—	—
Horse Mesa	Failed	1+	0	0	1		—	1	—	—
Horseshoe	Failed	2+	1	0	1	One young decapitated— great horned owl?	—	2	—	—
Ive's Wash	Successful	2+	2	1	5	One young died, one removed for surgery.	—	—	—	7
Ladders	Successful	2+	2	2	2	Captured male, male died, chicken bugs, helicopter.	—	—	—	7
Lone Pine	Occupied	—	—	—	0		—	—	0	—
Mule Hoof	Unoccupied	—	—	—	0		—	—	0	—
Orme	Occupied	—	—	—	1	New female.	—	—	—	1
Perkinsville	Occupied	—	—	—	1	New pair.	—	—	—	1
Pinal	Successful	2+	2	1	2	One young died.	—	—	—	3
Pinto	Failed	1+	0	0	0	Captured female.	—	—	1	—
Pleasant	Occupied	—	—	—	0		—	—	2	—
Redmond	Failed	2	2	0	1	Two young died, chicken bugs.	—	3	—	—
76	Occupied	—	—	—	0	Third adult.	—	—	1	—
Sheep	Occupied	—	—	—	0	New male.	—	—	0	—
Table Mountain	Failed	1+	0	0	1		—	—	—	1

Summary	1989	1990			
Number of Breeding Areas	28	3	6	11	8
Nest Success	36.0%	9		19	
Mean Brood Size	1.4				
Productivity	0.52	6+	9+	3+	8+
Number of Eggs	31+	2	7	2	4+
Number of Young Hatched	23	2	7	1	4+
Number of Young Fledged	13				

Table C2.2-4. (Page 4 of 4)

Breeding Area	1990 PRODUCTIVITY* Status	No. Eggs	No. Young Hatched	No. Young Fledged	No. Climbs	Comments	1988-1990 SUMMARY Did Not Move: Not Climbed	Did Not Move: Climbed	Moved Or Did Not Nest: Not Climbed	Moved Or Did Not Nest: Climbed
Alamo	Successful	2+	2	2	1	New male	—	—	—	—
Ash	Unoccupied	—	—	—	0		—	—	—	—
Bartlett	Failed	3+	0	0	1	People and vehicles in closure.	—	—	—	—
Blue Point	Occupied	—	—	—	0	New female—subadult (*ca.* 3 yrs.)	—	—	—	—
Canyon	Successful	2+	2	2	0		—	—	—	—
Cedar Basin	Failed	1+	?	0	0	Failed between 26 April & 1 June.	—	—	—	—
Chino	Unoccupied	—	—	—	0		—	—	—	—
Cibecue	Failed	1+	1	0	0	One young died; new female—near-adult (*ca.* 4–5 yrs old); photographers may have contributed.	—	—	—	—
Cliff	Occupied	—	—	—	0	Lots of disturbance & shooting.	—	—	—	—
Coolidge	Occupied	—	—	—	0	Two pair of adults sighted on San Carlos Reservoir in Jan.	—	—	—	—
Devil's Post	Occupied	—	—	—	0	Adults with grease or oil smears on head and tail.	—	—	—	—
East Verde	Failed	1+	?	0	0	Failed between 5 Feb. & 9 May.	—	—	—	—
Fort McDowell	Failed	1+	0	0	1		—	—	—	—
Horse Mesa	Successful	2+	2	2	1		—	—	—	—
Horseshoe	Successful	2+	2	2	1	Nest 9 built, but not used.	—	—	—	—
Ive's Wash	Failed	1+	0	0	1	Lots of disturbance from hunting, fishing, and camping.	—	—	—	—
Ladders	Failed	2	0	0	1	New male; 2nd pair defending river upstream of W.Clear Creek.	—	—	—	—
Lone Pine	Failed	1+	?	0	0	Failed between 21 Mar. & 1 June.	—	—	—	—
Mule Hoof	Occupied	—	—	—	0		—	—	—	—
Orme	Successful	2	1	1	1	Four adults in area.	—	—	—	—
Perkinsville	Occupied	—	—	—	0	Near-adult pair.	—	—	—	—
Pinal	Successful	2+	2	2	1		—	—	—	—
Pinto	Occupied	—	—	—	0		—	—	—	—
Pleasant	Occupied	—	—	—	0	New pair.	—	—	—	—
Redmond	Successful	1+	1	1	1		—	—	—	—
76	Successful	1+	1	1	1		—	—	—	—
Sheep	Occupied	—	—	—	0		—	—	—	—
Table Mountain	Successful	1+	1+	1+	0		—	—	—	—

Summary	1990	1988-1990 TOTALS			
Number of Breeding Areas	28	8	22	25	25
Nest Success	34.6%	30		50	
Mean Brood Size	1.6				
Productivity	0.54	15	36	8	29
Number of Eggs	26+	10	26	6	22
Number of Young Hatched	15+	9	23	4	18
Number of Young Fledged	14+				

Table C2.2-5. Alternate nest use by Arizona bald eagles following the success or failure of a breeding attempt from 1987–1989.

Nest Status	Remained in same nest the following year					Moved to alternate nest or did not nest the following year					Total
	1987	1988	1989	Total	(%)	1987	1988	1989	Total	(%)	
Failed in egg stage	4	1	2	7	(50.0)	2	3	2	7	(50.0)	14
Failed in nestling stage	0	0	2	2	(28.6)	2	1	2	5	(71.4)	7
Successful	5	9	5	19	(54.3)	6	6	4	16	(45.7)	35
Contained a brood	5	9	7	21	(50.0)	8	7	6	21	(50.0)	42

At Blue Point in 1972, the eagles built nest 3 on top of a Harris' hawk nest, and laid two eggs. The chicks hatched, but did not survive to fledging. At the Sheep breeding area, the pair built a nest in 1982 on top of a buteo nest. The adults laid eggs in the nest in 1983, but the eggs did not hatch, and the nest fell after the 1983 season. The Pleasant eagles built nest 2 on top of a raven or red-tailed hawk nest, and laid eggs in the nest in 1984 and 1985, but the eggs did not hatch. It is interesting that none of the eagle nests known to be built on top of other species' nests has fledged young.

C2.2.4 Artificial Nests

Thirteen artificial nests have been constructed at eight known bald eagle breeding areas (Bartlett, Blue Point, Cliff, East Verde, Horseshoe, Fort McDowell, "76", Sheep) and at one historical nest site (Havasu) in Arizona. In most cases, artificial nests were constructed after a nest had fallen from a cliff or tree.

At the Bartlett breeding area, nest 3 fell in 1978, when the supporting branch broke (Sell 1982). An artificial nest was constructed in the same tree by Teryl Grubb, USFS, in October 1978 (Grubb pers. comm.). The eagles used the artificial nest in 1980, fledging one young (Sell 1982). In 1985, the supporting limb broke and the nest fell again. At Blue Point, nest 4 was an artificial nest built in 1979 by Grubb (Grubb pers. comm.). The eagles sat on nest 4 in 1979 and refurbished it in 1980, although no eggs were laid (Haywood and Ohmart 1983). Nest 4 and the entire Blue Point cottonwood grove burned in November 1987; however the snags are still standing. An artificial cliff nest (2) was also constructed at the Cliff territory by Grubb in November 1984 (Grubb pers. comm.), and has not been used by the eagles.

At the East Verde breeding area, nest 6 was an artificial nest constructed by Teryl Grubb in January 1981 after nest 1 had fallen. Nest 6 was placed further upstream, due to the cliff falling apart at the old site of nest 1 (Grubb pers. comm.). Eight eaglets fledged from nest 6 before it was blown off the cliff between 27 May and 4 June 1989. A nest was then built by the eagles in the same location between July and December 1989.

The Fort McDowell eagles built nest 12 in 1985, used it during 1985 and 1986, then the nest fell in July 1986. An artificial nest was constructed in the same location of the same tree, using the original nest sticks, by Robert Mesta, USFWS, and Daniel Driscoll, BioSystems, on 9 October 1987. The artificial nest was reinforced with wire mesh at the base and still exists. Nest 3 was built at the "76" breeding area in 1985 (Forbis 1985), just upstream of nest 2, but fell between 15–25 June 1988. An artificial nest was constructed in the same location of the same tree, with the original nest sticks, on 8 October 1988 by Robert Mesta, USFWS. A wire mesh reinforcement was placed at the base of the nest, to secure the nest on the branch. The "76" pair used nest 3 from 1985–1990, fledging young from the artificial nest in 1990.

The Sheep breeding area was discovered in May 1982, when the eagles were observed perched together in a tree containing a buteo nest. The adults built their only known nest (1) on top of the buteo nest in a snag-top cottonwood tree that year, and have used the nest from 1982–1990. The supporting branch broke, and the nest fell between July and August 1983, but the eagles rebuilt the nest in the same tree in 1984 (Forbis pers. comm., Eakle pers. comm.). The supporting branch broke again in October 1988, and the nest fell. An artificial nest was constructed in the same tree, using the original nest sticks, on 12 November 1988 by Robert Mesta, USFWS, and Daniel Driscoll, BioSystems. The nest tree lacked a strong solid location for support in the upper branches; thus the nest had to be placed lower in the tree.

The Sheep territory contains few other large trees suitable for nesting, and all the large trees are falling apart rapidly.

In addition, an artificial nest was constructed by USFWS personnel at the Havasu National Wildlife Refuge in 1976. Eagles had built a nest in 1975 and added to it in 1976. The nest tree was destroyed in a storm in September 1976, and an artificial nest was constructed in a nearby tree, using the original nest sticks. The adults refurbished the artificial nest in 1977, but apparently did not lay eggs that year, or from 1978–1979. The breeding area was unoccupied from 1980–1981 and dropped from nest surveys in 1982.

Horseshoe. The Horseshoe breeding area was discovered in 1975 (Rubink and Podborny 1976), and the eagles have built eight nests there, all located on the free-flowing river (or upper reservoir depending on water levels) near Chalk Mountain. In addition, Teryl Grubb, USFS, constructed five artificial nests in response to rising reservoir levels inundating tree nests.

The Horseshoe eagles have built two cliff nests on Chalk Mountain (1, 8), four in live willow trees (2, 4, 5, 9), and two in willow snags (6, 7). Nest 1 was found in 1975 (Rubink and Podborny 1976) and used by the eagles in 1975, 1976, 1978 (Rubink and Podborny 1976, Rubink pers. comm.), 1983 (Haywood and Ohmart 1983), 1985 (Eakle pers. comm.), and 1987. Nest 2 was found in 1975 (Rubink and Podborny 1976) and used by the eagles in 1977. The nest tree fell in February 1977 along with the two eggs, which were later found to contain embryos (Rubink pers. comm.). An artificial tripod structure was constructed in the location of nest 2 in September 1977, and the original nest sticks used to construct a new nest. The Horseshoe pair refurbished the tripod nest in 1978, but later laid eggs in nest 1 (Forbis pers. comm.).

The eagles used the tripod nest in 1979; however, the tripod was not built above the high water level, and the nest was inundated by the rising reservoir (Forbis, Grubb, and Eakle pers. comm.). In November 1979, the tripod was moved to a new location on higher ground (nest 3). The adults refurbished nest 3 in 1980; however, the rising reservoir again inundated the tripod. A superstructure was added to the tripod and the Horseshoe pair nested on the addition. Once again the structure was not above the high water level, and the nest was inundated. The adults refurbished nest 3 in 1981, but apparently did not lay eggs. The tripod fell after the 1981 breeding season (Forbis, Grubb, and Eakle pers. comm.).

Nest 4 was built by the eagles in 1982; however the nest was inundated and the tree fell. The two eaglets were removed prior to inundation and fostered into the Ladders breeding area (Haywood and Ohmart 1983). An artificial tower was constructed in the same location later that year (Eakle pers. comm.); however, the tower was inundated in 1985 (Heisler 1985), never used by the eagles, and fell in March 1986. Nest 5 was built by the Horseshoe pair in 1983, but the tree fell before eggs were laid. The eagles then moved to nest 1. An artificial tower was constructed in the location of nest 5 later in 1983 (Eakle pers. comm.); however, the tower was inundated in 1985 (Heisler 1985), never used by the eagles, and fell in 1989. The eagles built nest 6 in 1984. The nest branch broke on 25 April, and the nest and two young fell. An artificial nest was constructed lower in the snag on the same day, and the young were placed in the new nest (Eakle pers. comm., Chorpenning and Crane 1984). Nest 6 and the snag fell prior to 1986.

Plate C5. Horseshoe nest cliff and reservoir, during riverine conditions, April 1990 (photo by D. Driscoll).

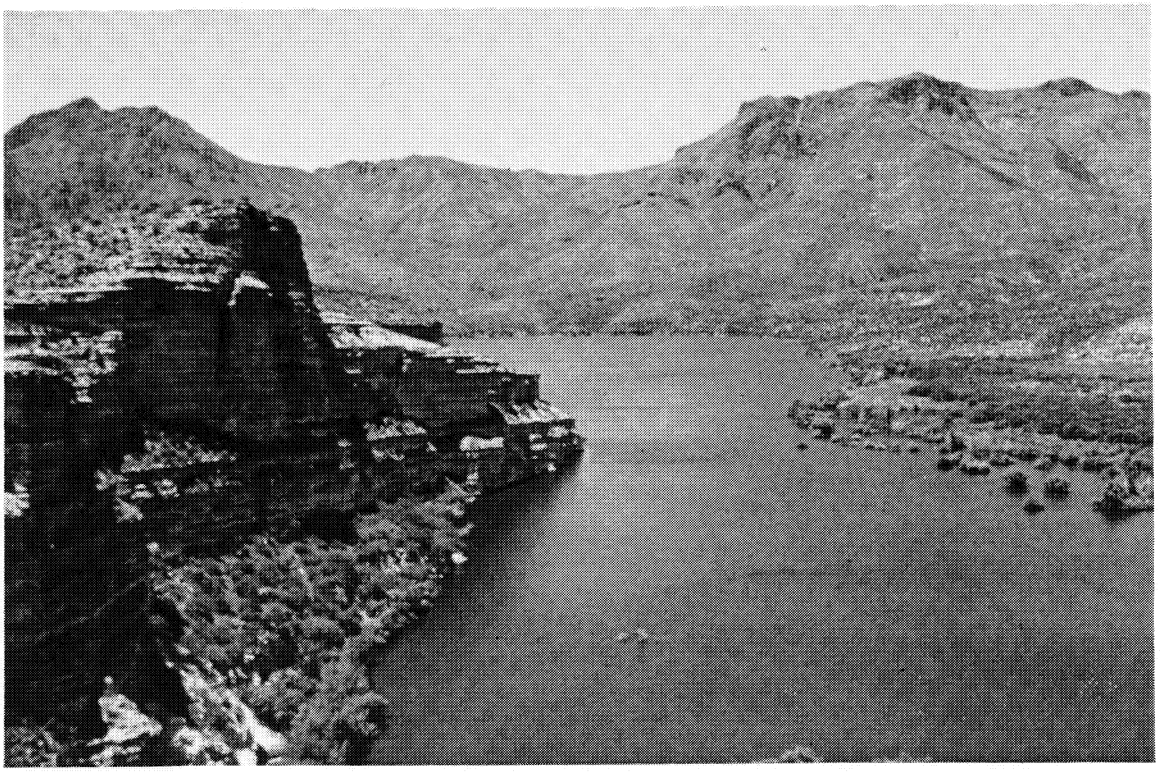


Plate C6. Horseshoe nest cliff and reservoir at high water level, May 1991 (photo by D. Driscoll).

The adults built nest 7 in 1986, but once again rising reservoir levels inundated the nest on 24 March and the supporting branches broke. The two eaglets were removed prior to inundation and fostered into the Chino breeding area (Mesta 1986). Nest 8 was built between July and September 1987, possibly in response to a severe infestation of Mexican chicken bugs found in nest 1 (used in 1987 and the only remaining nest) in October 1987. Nest 8 was used from 1988–1990. The Horseshoe eagles built nest 9 between November and December 1989; however the pair used nest 8 in the 1990 breeding season. Nests 1, 8, and 9 are still in existence.

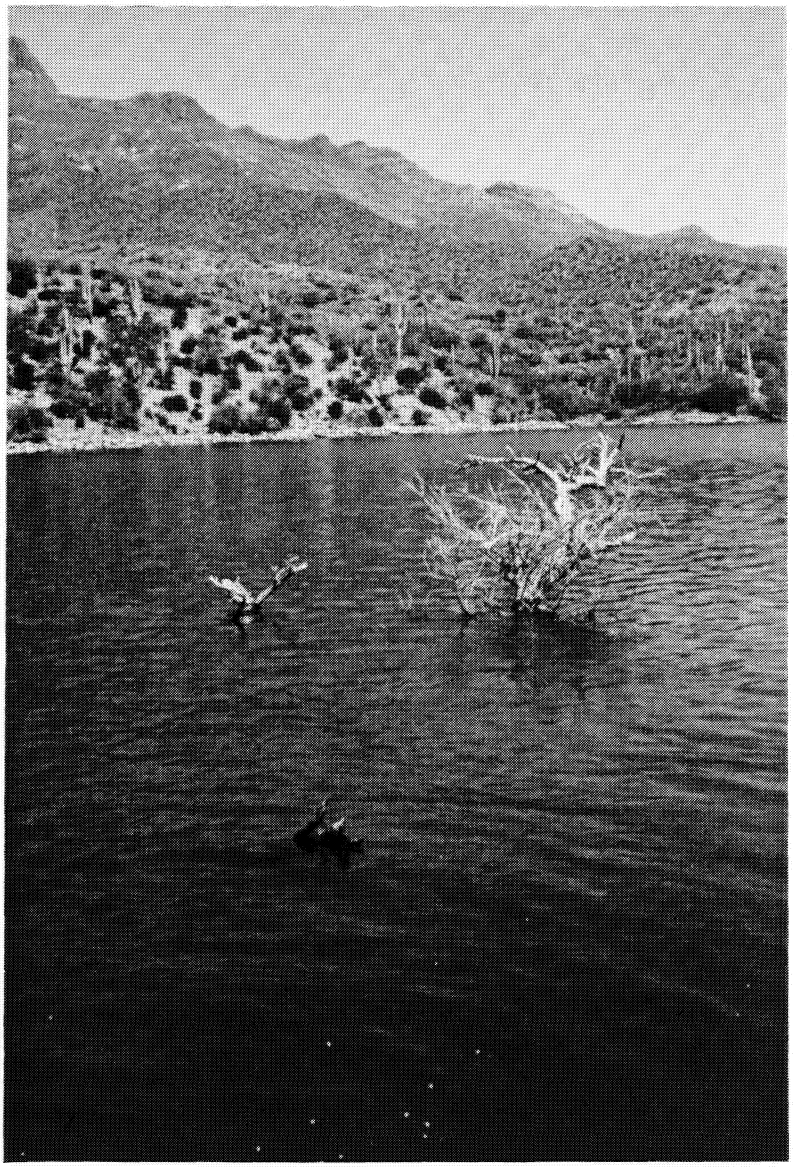


Plate C7. Horseshoe nest 9 was built in a live willow tree in 1989, when the reservoir was in riverine condition, as it also was in late February 1991 when the eagles laid two eggs. In early March, during heavy rainfall, the reservoir level rose and inundated the entire nest tree within three days. This photo shows the nest tree, still inundated, in May 1991 (photo by D. Driscoll).

In summary, the establishment of artificial nesting structures at Horseshoe has probably been counterproductive because of frequent inundation. All artificial nest structures have fallen, and since two cliff nests now exist, no further artificial nest structures are recommended.

C2.3 EGG CHARACTERISTICS

The first bald eagle eggs collected for analysis were recovered from the 1977 Horseshoe nest tree which had fallen (the eggs remained intact, Grubb and Rubink 1978). From 1977–1985, 15 bald eagle eggs were collected from nests following failure or abandonment (Grubb and Rubink 1978, Ohmart and Sell 1980, Haywood and Ohmart 1983, Grubb *et al.* 1983, Grubb 1984, Grubb 1986a). We collected an additional 11 whole eggs during 1986–1990, totaling 26 known whole eggs recovered from Arizona bald eagle nests (Table C2.3-1).

Table C2.3-1. Whole eggs collected at Arizona bald eagle breeding areas.

Year	Breeding Area	Nest	No. Eggs
1977	Horseshoe	2	2
	Ladders	3	1
1978	East Verde	1	2
1982	Bartlett	1	1
	Ladders	4	2
1983	Bartlett	2	2
	Horse Mesa	2	1
1984	Ash	2	1
	Bartlett	2	3
1986	Chino	1	1
	Horse Mesa	2	1
1988	Cedar Basin	4	1
	Fort McDowell	1	1
1989	Alamo	2	1
	Cliff	4	1
	Horseshoe	8	1
1990	Fort McDowell	11	1
	Ive's Wash	2	1
	Ladders	4	2
Total			26

Of the 26 eggs, embryos were detected in only four (15%). Grubb and Rubink (1978) noted ca. 27-day-old embryos in the two 1977 Horseshoe eggs. We found an embryo about 12 days old in the 1989 Alamo egg, and a 26-day-old embryo in the 1986 Horse Mesa egg (see sections C3.1 and E4). We found the Horse Mesa egg on 3 July 1986 buried under 15–20 cm of soft nest material, after two young had successfully fledged on 8 May. The egg-laying date at Horse Mesa was 6 January 1986, so the egg had been there for about 180 days before its discovery (88 days with two eaglets in the nest). Perhaps the Horse Mesa egg died due to neglect by the adults after the two eaglets hatched. We observed a similar situation at East Verde in 1987, where one eaglet hatched on 26 February. The second eaglet was pipping on 26 February, during a snow storm, but the adults left part of the egg exposed when brooding the hatched young, and the pipping eaglet died.

The average size of nearly 300 eggs measured throughout the bald eagle's range has been reported as 70–76 mm in length and 53–58 mm in breadth (Stalmaster 1987). Measurement data were available for 18 of the 26 known whole eggs collected in Arizona from 1977–1990; however, we removed the Fort McDowell 'runt' egg (see below), resulting in a sample size of 17 eggs. These Arizona bald eagle eggs had a mean length of 70.3 mm, ranging from 67.5 to 72.6 mm, and a mean breadth of 55.6 mm, varying from 52.9 to 59.5 mm. Eighty California eggs averaged 73.0 mm in length and 55.8 mm in breadth (Ohmart and Sell 1980), and 263 bald eagle eggs from Florida had a mean length of 71.2 mm and 55.3 mm (A. Jenkins, George Miksch Sutton Avian Research Center). The mean length for Arizona eggs was 2.7 mm shorter than California and 0.9 mm shorter than Florida.

If a larger sample confirms that the size of Arizona eggs is smaller on average than those of Florida eagles (as the 17-egg data indicate), this would contradict Stalmaster's (1987) statement that the largest bald eagle eggs are from Alaska and the smallest from Florida. One whole egg collected from a bald eagle nest (Fig Tree 1989) along the Rio Yaqui, Sonora, Mexico was larger than the means for Arizona, Florida, and California eagles, measuring 57.0 mm in breadth and 74.0 mm in length (R. Mesta pers. comm.). An unusually small runt egg (Rothstein 1973) was collected from the Fort McDowell nest in 1990. The egg measured 47.0 mm in length and 40.0 mm in breadth. More details on this "runt" egg are provided below.

In general, a bald eagle's egg averages 3 percent of the female's body weight, with the first egg of the clutch being the heaviest and the last egg the lightest (Stalmaster 1987). The average weight of eight eggs in Alaska was 130 grams (Stalmaster 1987), while the calculated mean weight at laying of 263 eggs in Florida was 122.8 grams with an estimated volume of 111.2 cc (A. Jenkins, George Miksch Sutton Avian Research Center). The mean weight of Arizona eggs was 87.9 grams, with an estimated volume of 111.2 cc (Table C2.3-2). The amount of water loss in unhatched eggs is likely higher in the desert climate of Arizona, and because eggs are often collected late in the season, a point which probably accounts for the lower weight of Arizona eggs (compared to weight at laying of Florida eggs), even though the inferred volumes are identical.

Since the first Arizona bald eagle eggs analyzed were collected in 1977, no pre-DDT (1946) measurements are available for comparison. The closest population with pre-DDT eggshell thickness data is in Baja California where eggshells averaged 0.591 mm (see Section E5). Eggshell thickness of 15 whole eggs collected in Arizona from 1977–1985 averaged 0.55 mm, 6 percent thinner than pre-DDT levels for Baja California. In addition, data for 45 eggshell measurements from whole eggs and fragments collected in Arizona bald eagle nests from 1977–1985 showed a mean eggshell thickness of 0.54 mm (Grubb 1986a), 7 percent thinner than pre-DDT levels. These previous studies indicated that

Table C2.3-2. Measurements and contamination levels of whole eggs collected at Arizona bald eagle breeding areas from 1977–1985.

	Horseshoe[1] 1977	Horseshoe[1] 1977	Ladders[1] 1977	East Verde[2] 1978	East Verde[2] 1978	Bartlett[2] 1982	Ladders[2] 1982	Ladders[2] 1982
Length (mm)	72.10	70.10	69.20	68.50	68.40	72.60	68.30	—
Breadth (mm)	52.90	53.80	54.90	54.00	55.80	56.60	59.50	—
Estimated Volume (cc)	107.00	105.00	106.00	—	—	118.00	106.00	106.00
Total Weight (gm)	89.41	92.98	77.99	—	—	92.83	86.88	88.59
Shell Thickness (mm)	0.51	0.52	0.54	—	—	0.59	0.57	0.56
Percent Pre-DDT Shell Thickness	-13.00	-11.00	-7.00	—	—	+1.00	-1.00	-4.00
Development (Days)	27.00	27.00	0.00	—	—	0.00	0.00	0.00
p,p'-DDE (ppm)	6.80	9.00	4.90	—	—	2.40	1.30	1.10
p,p'-DDE (ppm)	0.14	0.11	0.13	—	—	—	0.06	0.07
p,p'-DDT (ppm)	—	—	—	—	—	—	—	—
Dieldrin (ppm)	0.13	0.14	0.20	—	—	—	—	—
Heptachlor epoxide (ppm)	—	—	—	—	—	—	—	—
Oxychlordane (ppm)	—	—	—	—	—	—	—	—
cis-Chlordane (ppm)	0.06	0.07	0.09	—	—	—	—	0.16
trans-Nonachlor (ppm)	0.04	0.05	0.07	—	—	—	0.08	0.19
cis-Nonachlor (ppm)	0.15	0.11	0.21	—	—	—	—	—
Endrin	—	—	—	—	—	—	—	—
Toxaphene (ppm)	—	—	0.04	—	—	—	—	—
HCB (ppm)	—	—	—	—	—	—	—	—
Mirex (ppm)	—	—	—	—	—	—	—	—
Estimated PCB (ppm)	1.20	1.70	8.50	—	—	0.90	0.54	0.38
Mercury	—	—	—	—	—	0.12	0.12	0.25

	Horse Mesa[3] 1983	Bartlett[3] 1983	Bartlett[3] 1983	Bartlett[4] 1984	Bartlett[4] 1984	Bartlett[4] 1984	Ash[4] 1984	*N*	Mean
Length (mm)	72.60	70.90	71.70	69.70	69.90	70.30	72.60	14	70.50
Breadth (mm)	54.30	56.80	56.70	56.00	57.200	57.10	57.10	14	55.90
Estimated Volume (cc)	110.00	116.00	115.00	110.00	114.00	114.00	119.00	13	111.20
Total Weight (gm)	93.58	67.22	101.52	—	—	101.42	74.17	11	87.87
Shell Thickness (mm)	0.51	0.55	0.56	0.54	0.56	0.59	0.53	13	0.55
Percent Pre-DDT Shell Thickness	-13.00	-6.00	-4.00	-7.00	-4.00	+1.00	-9.00	13	-6.00
Development (Days)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	—
p,p'-DDE (ppm)	4.40	2.90	3.00	—	—	2.90	2.20	11	3.70
p,p'-DDE (ppm)	0.09	0.10	0.05	—	—	0.04	0.06	10	0.09
p,p'-DDT (ppm)	—	—	—	—	—	—	—	—	—
Dieldrin (ppm)	0.03	—	—	—	—	0.05	—	5	0.11
Heptachlor epoxide (ppm)	—	—	—	—	—	—	—	—	—
Oxychlordane (ppm)	—	—	—	—	—	—	—	—	—
cis-Chlordane (ppm)	—	—	—	—	—	0.06	—	5	0.09
trans-Nonachlor (ppm)	0.12	0.03	0.05	—	—	0.14	0.06	10	0.08
cis-Nonachlor (ppm)	0.10	0.05	0.05	—	—	0.04	0.02	8	0.09
Endrin	—	—	—	—	—	—	—	—	—
Toxaphene (ppm)	—	0.04	—	—	—	—	—	2	0.04
HCB (ppm)	—	—	—	—	—	—	—	—	—
Mirex (ppm)	—	—	—	—	—	—	—	—	—
Estimated PCB (ppm)	1.60	0.77	0.59	—	—	0.57	0.29	11	1.55
Mercury	0.17	0.066	0.11	—	—	0.17	0.29	8	0.16

1 Grubb and Rubink 1978. 2Haywood and Ohmart 1983. 3Grubb et al. 1983. 4Grubb 1984, Grubb 1986a.

DDE and organochlorine levels were not considered high enough to cause reproductive problems. Mercury levels were well above normal for most bald eagle populations, indicating exposure of Arizona bald eagles to mercury contamination; however, Arizona levels were below those associated with diminished reproductive success (0.50 ppm) in other species (Grubb and Rubink 1978, Haywood and Ohmart 1983, Grubb *et al.* 1983, Grubb 1986a).

We collected 11 whole eggs at 10 breeding areas from 1986–1990 (Table C2.3-3) which were sent to Robert Risebrough at the Bodega Bay Institute. Seven of these eggs (1986–1989) have been analyzed, and again suggest that DDE and PCB residues do not appear to pose a threat to Arizona bald eagles at this time (see Section E4 for results and discussion of the analysis). We also collected four whole eggs ("76" 1987, Sheep 1987, Horse Mesa 1989, Cliff 1989) in which the tops were crushed and contents dried.

Table C2.3-3. Whole eggs collected at Arizona bald eagle breeding areas, 1986–1990.

Year	Breeding Area	Nest	Length (mm)	Breadth (mm)
1986	Chino	1	—	—
1986	Horse Mesa	2	—	—
1988	Cedar Basin	4	—	—
1988	Fort McDowell	11	—	—
1989	Alamo	2	—	—
1989	Cliff	4	—	—
1989	Horseshoe	8	—	—
1990	Fort McDowell	11	47.0	40.0 *
1990	Ive's Wash	2	72.0	54.6
1990	Ladders	4	67.5	54.0
1990	Ladders	4	69.0	53.7

* Unusually small "runt" egg (see text).

We also collected 71 sets of eggshell fragments from 23 breeding areas during 1986–1990 (Table C2.3-4). The fragments were sent to Lloyd Kiff at the Western Foundation of Vertebrate Zoology for measurement and archiving. In a partial sample, Kiff found a mean eggshell thickness of 0.561 mm, 4.9 percent thinner than pre-DDT levels for Baja California (see Section E5). The Arizona eggshells were thicker than the 10 percent thinning level (0.53 mm) associated with reduced productivity in other bald eagle populations (Wiemeyer *et al.* 1984, Nisbet 1989).

Similarly, in 26 samples selected for an electron micrographic examination of eggshell qualities, D. Bland (Section E5) found a mean shell thickness of 0.562 mm, ranging from 0.455 to 0.651. These represent the thinnest and thickest eggshells, respectively, known for Arizona bald eagles. Compared to pre-DDT levels, the 26 samples varied from 23.0 percent thinner ("76" 1987) to 10.2 percent thicker (Cedar Basin

Table C2.3-4. Eggshell fragments collected from Arizona bald eagle nests, 1986-1990.

Sample	Breeding Area	Nest No.	Individual Breeding Areas Sampled Each Year	Total Breeding Areas Sampled in Population
AZ-86-01	Lone Pine	1	—	—
AZ-86-02	Cibecue	2	—	—
AZ-86-03	Cliff	4	—	—
AZ-86-04	Redmond	4	—	—
AZ-86-05	East Verde	7	—	—
AZ-86-06	Redmond	5	—	—
AZ-86-07	Canyon	5	—	—
AZ-86-08	Cedar Basin	4	7	7
AZ-87-01	Redmond	4	—	—
AZ-87-02	Coolidge	1	—	—
AZ-87-03	Blue Point	6	—	—
AZ-87-04	Pinal	2	—	—
AZ-87-05	Pinal	2	—	—
AZ-87-06	Cedar Basin	4	—	—
AZ-87-07	Redmond	5	—	—
AZ-87-08	Orme	1	—	—
AZ-87-09	Chino	2	—	—
AZ-87-10	Horse Mesa	2	—	—
AZ-87-11	Coolidge	1	—	—
AZ-87-12	Horseshoe	1	—	—
AZ-87-13	Lone Pine	2	—	—
AZ-87-14	Ladders	3	—	—
AZ-87-15	East Verde	6	—	—
AZ-87-16	Blue Point	6	—	—
AZ-87-17	Redmond	5	—	—
AZ-87-18	Sheep	1	—	—
AZ-87-19	Sheep	1	—	—
AZ-87-20	76	3	—	—
AZ-87-21	76	3	—	—
AZ-87-22	76	3	14	17
AZ-88-01	Alamo	2	—	—
AZ-88-02	Blue Point	6	—	—
AZ-88-03	Horseshoe	8	—	—
AZ-88-04	Redmond	6	—	—
AZ-88-05	76	3	—	—
AZ-88-06	Blue Point	6	—	—
AZ-88-07	76	3	—	—
AZ-88-08	Pinal	3	—	—
AZ-88-09	Ive's Wash	1	—	—

Table C2.3-4. (Continued)

Sample	Breeding Area	Nest No.	Individual Breeding Areas Sampled Each Year	Total Breeding Areas Sampled in Population
AZ-88-10	Sheep	1	—	—
AZ-88-11	Ladders	4	—	—
AZ-88-12	Alamo	2	—	—
AZ-88-13	Coolidge	3	—	—
AZ-88-14	Cliff	4	—	—
AZ-88-15	Horseshoe	8	—	—
AZ-88-16	Ladders	4	—	—
AZ-88-17	Ladders	5	—	—
AZ-88-18	Redmond	6	—	—
AZ-88-19	Lone Pine	4	12	19
AZ-89-01	Perkinsville	*	—	—
AZ-89-02	Ladders	3	—	—
AZ-89-03	Fort McDowell	11	—	—
AZ-89-04	Cliff	4	—	—
AZ-89-05	Cliff	4	—	—
AZ-89-06	Cliff	4	—	—
AZ-89-07	Orme	1**	—	—
AZ-89-08	Pinal	1	—	—
AZ-89-09	Table Mountain	3	—	—
AZ-89-10	Pinal	1	—	—
AZ-89-11	Pinal	1	—	—
AZ-89-12	Horse Mesa	2	—	—
AZ-89-13	Redmond	5	—	—
AZ-89-14	Horseshoe	8	—	—
AZ-89-15	Blue Point	1	—	—
AZ-89-16	Sheep	1	—	—
AZ-89-17	Ive's Wash	1	—	—
AZ-89-18	Alamo	2	14	22
AZ-90-01	Alamo	2	—	—
AZ-90-02	Bartlett	1	—	—
AZ-90-03	Orme	3	—	—
AZ-90-04	Redmond	5	4	23***

* Eggshell fragments collected on ground below nest tree, and may be great blue heron eggshells.
** Old eggshell fragments, possibly from 1988.
*** No samples from Ash, Devil's Post, Mule Hoof, Pinto, and Pleasant breeding areas.

1990), again with a mean of 4.9 percent thinner. A detailed analysis (including photographs) of the eggshell qualities, as well as an informative narration are presented in Section E5. It is noteworthy that the Arizona breeding area with the highest rate of nest failure (Cedar Basin, 2 of 14 eggs hatched) (Section D4.6) had the thickest eggshells (0.651 mm) (Section E5) and the lowest contaminant levels (31 ppm DDE and 18 ppm PCB's lipid weight) (Section E4). This likely indicates other factors are operating to reduce productivity at Cedar Basin. The 1987 "76" eggshells showed the highest level of thinning (0.455 mm, 23% thinner than pre-DDT levels). When we entered the nest following abandonment (due to prolonged disturbance), we found the fragments from one egg in a small group, another crushed egg with desiccated contents, and a third whole egg with the top crushed and contents dried. Eggshell fragments collected from the "76" nest in 1984, when two young fledged, were similarly thin (0.479 mm) (Grubb 1986a). The only other Arizona eggshells ranging below 0.50 mm were collected at Horseshoe in 1979 (0.470 mm) by Grubb (1986a) when a flood inundated the nest.

As shown in Table C2.3-4, we collected eggshell fragments from 23 of the 28 known bald eagle breeding areas in Arizona, although the Perkinsville sample may be great blue heron eggshells. The five nest sites lacking data include Ash, Devil's Post, Mule Hoof, Pinto, and Pleasant. The Devil's Post eagles are not known to have laid eggs (Section D4.11), and the Mule Hoof breeding area has not been active at known nest locations since 1979 (Section D4.19). The only known egg(s) at Pinto were laid in 1989, but we could not collect them without possibly damaging the nest branch, which was built on small branches (Section D4.23). The Ash (Section D4.2) and Pleasant (Section D4.24) breeding areas have not been active at known nest locations since 1985. However, mean eggshell thickness measurements for Ash and Pleasant in 1984 and 1985, were 0.532 mm for Ash and 0.542 mm for Pleasant (Grubb 1986a). These means are 7 percent (Pleasant) and 9 percent (Ash) thinner than pre-DDT levels. Thus, the only Arizona breeding areas lacking eggshell thickness data are Devil's Post, Mule Hoof, Pinto, and likely Perkinsville.

Arizona bald eagle eggshells appear to be getting thicker, as reported means have increased from 0.526 mm (10% thinner than pre-DDT Baja California) (Grubb and Rubink 1978), to 0.55 mm (6% thinner) (Haywood and Ohmart 1983), to 0.561 mm (4.9% thinner, this study).

We collected an unusually small egg at the Fort McDowell breeding area in 1990. The Fort McDowell egg(s) laid prior to 13 January did not hatch (they should have hatched by 17 February). The adults continued incubating until 29 March, then were on and off the egg(s) until 7 April. We entered the nest on 7 April and collected the runt egg. The egg was round in shape and measured 47.0 mm in length and 40.0 mm in breadth. Arizona bald eagle eggs collected from 1977–1985 had a mean length of 70.5 mm, ranging from 68.3 to 72.6 mm, and a mean breadth of 55.9 mm, varying from 52.9 to 59.5 mm (see Table C2.3-2). The runt egg was 33 percent smaller in length and 28 percent smaller in breadth than the average Arizona bald eagle egg. In addition, the runt egg was 31 percent smaller in length and 24 percent smaller in breadth than the minimum measurements for Arizona.

This is the first abnormal bald eagle egg documented in Arizona, and no records of runt eggs have been found for bald eagles in the literature. However, runt eggs have been documented in another raptor species, the peregrine falcon (Jenkins 1984). Rothstein (1973) states, "... runt eggs, variously called dwarf, cock, wind, or witch eggs, are extremely rare." Runt eggs have been recorded occurring in the chicken at a frequency of 0.05 to 0.09 percent (Romanoff and Romanoff 1949). In his examination of natural nests, Rothstein (1973) found dwarf eggs of three songbird species at frequencies of 0.08 to 0.18 percent. He concluded, "... dwarf eggs seem to be caused by temporary disturbances, accidents, or infections in the oviduct and apparently do not have a genetic basis." The Fort McDowell female,

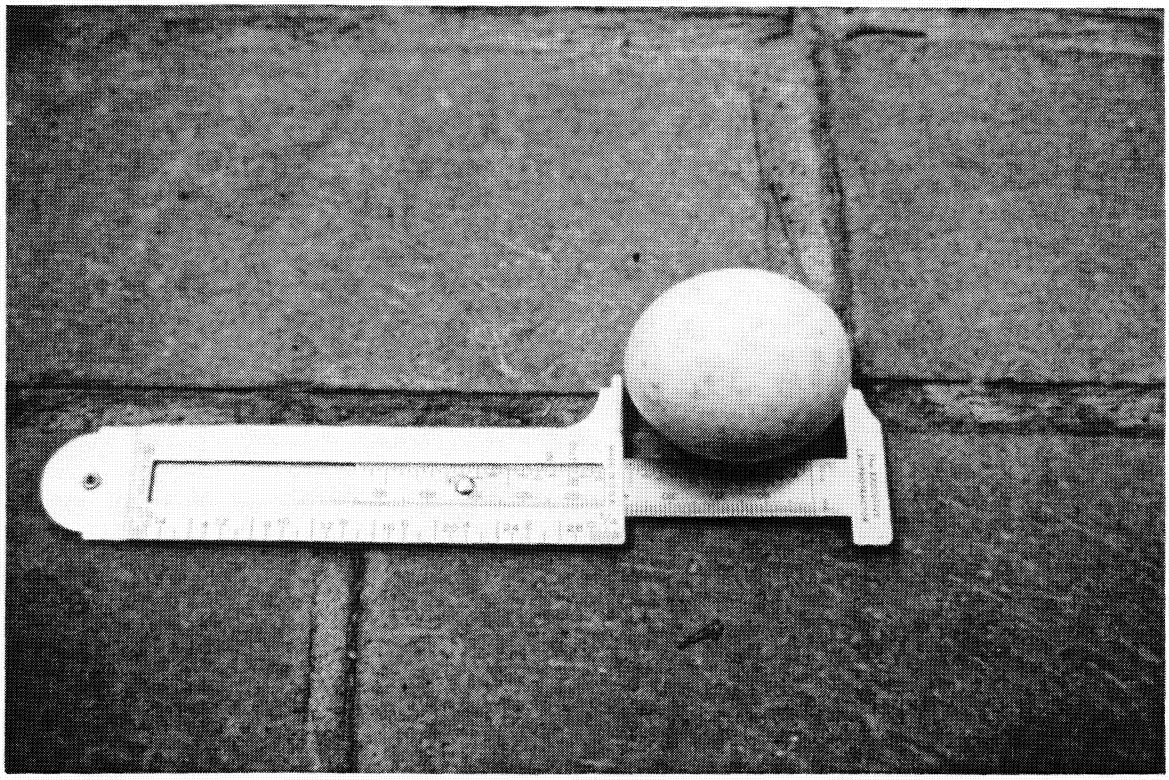


Plate C8. Unusually small "runt" egg found in the 1990 Fort McDowell nest. The egg measured 47.0 × 40.0 mm (photo by D. Driscoll).

banded on her left tarsus, had entered the breeding pair in 1989 and successfully fledged two young that year. This lends support to Rothstein's conclusion that runt eggs do not have a genetic basis. This Arizona runt egg is apparently the smallest egg recorded for bald eagles.

C2.4 DOUBLE CLUTCHING

Bald eagles have been known to lay a second clutch of eggs from two weeks to up to two months following removal or early failure of the first clutch (Stalmaster 1987). In Florida, this aspect of eagle biology is used to benefit reintroduction programs. The first clutch is removed and transported to George Miksch Sutton Avian Research Center (in Oklahoma). There the eggs are artificially incubated and the young released to the wild in a method called "hacking", where eaglets are placed in a tower at eight weeks of age in good eagle habitat, artificially fed (without seeing humans), and allowed to fledge in a semi-natural setting. Meanwhile, most of the Florida eagles lay a second clutch and raise their own young, thereby essentially doubling the productivity of the breeding area.

Double clutching has not been previously recorded for bald eagles in Arizona; however, we documented three incidents of second clutches from 1987–1990 (Redmond 1987, Fort McDowell 1988, and Bartlett 1990). USFWS biologist Robert Mesta and BioSystems biologist Daniel Driscoll collected prey remains from Arizona bald eagle nests following the 1986 breeding season. At the Redmond breeding area, we

discovered a second nest (nest 4) on the north face of the pinnacle, immediately below nest 5 which sits on top of the pinnacle. We removed all prey remains and eggshell fragments from both nests. In 1987, at least one egg was laid in nest 4, and two young were raised in nest 5. The fragments from nest 4 were confirmed as bald eagle eggshells by Lloyd Kiff, Western Foundation of Vertebrate Zoology. This was the first documented incidence of double clutching in Arizona bald eagles.

The second record of double clutching occurred in 1988 at the Fort McDowell breeding area. Robert Mesta, USFWS, witnessed incubation in nest 13 on 24 January. The nest attempt failed prior to 11 February. There was much disturbance from farming activity, wood-cutting below the nest, and vehicle traffic along the river which may have contributed to the initial failure. On 9 March, the pair laid a second clutch of eggs in nest 11 (Farrara *et al.* 1988), which failed prior to 27 April. Nest 13 was not climbed due to its location in the upper branches of a decomposing snag, so eggshells were not collected. Nest 13 and the snag fell between June and December 1989. We collected one whole egg from nest 11 following its failure.

A third incidence of double clutching was documented at the Bartlett breeding area in 1990. During an ORA flight on 5 February, USFWS, Reclamation, and AGF biologists observed incubation in nest 2. BioSystems accompanied ABENWP biologists to the nest site on 9 February. The closure gate was open (broken) and appeared to have been rammed by a truck. Multiple sets of tire tracks led to the closure fence, which had been cut. The tracks continued up the road which runs immediately behind the nest cliff. At this point, the adults were still incubating in nest 2. On 12 February, the pair abandoned the eggs (1+) in nest 2 and began refurbishing nest 1. The eagles laid a second clutch of eggs (2+) in nest 1 on 14 March. The second nest attempt failed on 22 March when the adults stopped incubating (Kime and Upton 1990). It is likely that disturbance contributed to the early failure and subsequent double clutching at Fort McDowell in 1988 and Bartlett in 1990.

C2.5 PRODUCTIVITY

Although early historians documented the occurrence of wintering and nesting bald eagles in Arizona (Coues 1866, Henshaw 1875, Mearns 1890, Bent 1937, Jenks and Stevenson 1937, Hargrave 1939, and Phillips *et al.* 1964), little was known about the bald eagle (*Haliaeetus leucocephalus*) in Arizona (once known as the southern bald eagle (*H. l. leucocephalus*) prior to 1972 when the USFWS began monitoring the population (Rubink and Podborny 1976).

Information on early productivity at Arizona bald eagle nests is sketchy, containing large gaps between breeding areas and years. In addition to historical nest sites (see sections D3 and D5) bald eagles possibly nested at currently known breeding areas prior to the 1900s. According to Chief Haiawatha Hood (pers. comm.), eagles were then nesting on the lower Verde River at Fort McDowell. Bent (1937) reported them nesting on the Salt River prior to 1911 (Possibly Pinto or Rock Creek, Salt River Bird Reservation—now Roosevelt Reservoir). In addition eagles may have been nesting at the confluence of the East Verde River (East Verde) prior to mapping of the area in 1918 near Eagle Nest Corral. The Mule Hoof breeding area has been occupied at least since the 1920s and 1930s, as was the Blue Point nest site (Phillips *et al.* 1964). Nests were present in the White Mountains, possibly near the Lone Pine area as early as 1937 (Jenks and Stevenson 1937). The Bartlett breeding area has been occupied since the early 1940s (Phillips *et al.* 1964, Ohmart and Sell 1980), Horse Mesa since the 1950s (Gibbons pers. comm.), Perkinsville since the 1960s (Rubink and Podborny 1976), and Ladders since 1962 (Floyd

Thompson, USFWS, interviewed in Forbis 1979); also the historical Tower territory was occupied as early as 1965 (Floyd Thompson, USFWS, interviewed in Forbis 1984).

The first documented Arizona bald eagle nestlings fledged from Blue Point in 1932 and 1933, and young may have fledged from Mule Hoof in 1935 (Phillips *et al.* 1964, Rubink and Podborny 1976). There are no records of productivity in the 1940s, although the Bartlett, Fort McDowell, and Mule Hoof breeding areas were occupied (Phillips *et al.* 1964, Ohmart and Sell 1980, Rubink pers. comm.). The Horse Mesa breeding area fledged young in the 1950s and 1960s (Gibbons pers. comm.), and although productivity data are unknown, Bartlett and Perkinsville were occupied (Rubink and Podborny 1976). The Ladders breeding area has been active at least since 1962 (Floyd Thompson, USFWS, interviewed in Forbis 1979), and the historical Tower territory produced young in 1965, 1966, and 1968 (Floyd Thompson, USFWS, interviewed in Forbis 1984). Two young hatched at Bartlett in 1964; however, one of the adults was shot and the other apparently abandoned the nest. One eaglet died in the nest and the other was removed by Chuck Binder (a local falconer), but later died (Rubink and Podborny 1976). The Bartlett eagles produced young again from 1966–1967, as did Fort McDowell in 1968 (Rubink and Podborny 1976). The Horse Mesa nest again fledged young in the 1970s (Gibbons pers. comm.), as did Orme (Water Treatment Plant Operators pers. comm.), and although productivity data are not known, Perkinsville (Rubink and Podborny 1976) and "76" (Haywood and Ohmart 1983) were at least occupied. Young fledged from Bartlett and Fort McDowell in 1970 and 1971 (Rubink and Podborny 1976), and also from Blue Point in 1971 (Forbis 1986).

The first consistent documentation of reproduction began in 1972, with Duane Rubink's (USFWS) nest surveys (Rubink and Podborny 1976). In addition, unpublished field notes by Duane Rubink (USFWS), Rich Glinski (AGF), Clay McCollough (AGF), and J.W. Simpson (AGF), contributed to early knowledge of nesting eagles. Productivity data at active breeding areas from 1970–1975, as well as historical data, were presented in the first USFWS status report on Arizona bald eagles (Rubink and Podborny 1976). During this same period, Stumph and Creighton (1977) of the U.S. Bureau of Reclamation wrote a report on Arizona bald eagles. Later studies supplied productivity data from 1977 (Hildebrandt and Ohmart 1978), 1977–1978 (Hildebrandt 1981), 1979–1980 (Sell 1982), 1970–1979 (Ohmart and Sell 1980), 1977–1980 (Haywood and Ohmart 1980), 1979–1980 (Haywood and Ohmart 1981), 1981 (Haywood and Ohmart 1982), and 1970–1982 (Haywood and Ohmart 1983).

The USFWS formulated a Southwestern Bald Eagle Recovery Plan in 1982 (U.S. Fish and Wildlife Service 1982), and research continued to provide productivity data from 1983 (Grubb *et al.* 1983), 1984 (Grubb 1984), and 1983–1985 (Grubb 1986a), as well as 1970–1985 (Forbis 1985) and 1970–1986 (Forbis 1986). We used each of these sources, including the current study (1987-1990), to compile the reproductive history of Arizona's bald eagles. We also used information from interviews with agency personnel, landowners, and other people knowledgeable about bald eagles in Arizona. When productivity data from the various sources conflicted, we relied on interviews with agency personnel to correct these discrepancies.

In addition to other studies, the population has been monitored since 1978 by the Arizona Bald Eagle Nest Watch Program (ABENWP). This multi-agency funded program was coordinated by Larry Forbis (USFS) from 1978 to 1985, and by Robert Mesta (USFWS) during 1986–1990. The program allows Arizona agency personnel to closely monitor individual nest sites and intervene in emergency situations. The program also contributes scientific data on nesting bald eagles, and provides valuable experience to young biologists. This program has produced an abundance of information on individual bald eagle

breeding areas in Arizona. We compiled the details and pertinent data from ABENWP reports and the aforementioned research projects for each breeding area in Section D4.

C2.5.1 Productivity 1987–1990

During our study of the ecology of bald eagles in Arizona (1987–1990), seven additional breeding areas were discovered, raising the number of known nesting territories to 28. However, the discovery of these previously unknown nest sites appeared to be the result of increased nest search efforts rather than newly established breeding areas (see Section A5.2). In the 109 known breeding area/years from 1987–1990, eagles occupied 98 nests, of which 73 pairs laid at least 125 eggs. Of 87 eaglets hatched, 71 successfully fledged at 44 breeding areas. For the four years of our study: nest success (expressed as the percentage of occupied nests producing young, Postupalsky 1974) was 45 percent; mean brood size (number of young per productive nest) was 1.6; and productivity (number of young per occupied nest) was 0.72.

C2.5.1.1 Summary of Productivity—1987. The discovery of four additional nesting territories in 1987 (Orme, Table Mountain, Alamo, and Ive's Wash), raised the number of known Arizona bald eagle breeding areas to 25. The Fort McDowell pair laid eggs during 20–30 December 1986, and ABENWP nest watchers confirmed incubation on 31 December (Collie and Knoll 1987). BioSystems biologists observed egg laying at the Pinal breeding area on 26 January. Documentation of egg laying at the remaining active nests occurred during "Occupancy and Reproduction Assessment" (ORA) flights on 2 February and 17, 23, and 27 March. We observed hatching at the East Verde breeding area on 26 February and fledging on 30 May, 93 days later. Juveniles at monitored nest sites fledged between 12 and 13 weeks of age (Table C2.5-1).

Adult bald eagles occupied 23 of the 25 known Arizona breeding areas in 1987. Only the Mule Hoof and Ash sites were unoccupied. Eagles at Cliff, Pleasant, Alamo, and Table Mountain apparently did not lay eggs, leaving 19 active nests with at least 35 eggs. Six of the active nests (Bartlett, "76", Sheep, Chino, Cedar Basin, and Lone Pine) failed in the egg stage, but the remaining 13 sites hatched 23 young. Twenty of these young fledged from 11 breeding areas; three eaglets died at two nest sites prior to fledging (see Section C3.2). Nest success for 1987 was 47.8 percent, mean brood size was 1.8, and productivity was 0.87 young.

C2.5.1.2 Summary of Productivity—1988. The discovery of two additional nesting territories in 1988 (Pinto and Devil's Post), increased to 27 the number of known Arizona bald eagle breeding areas. The earliest nesters, the Alamo pair, laid eggs the last week of December, as confirmed by ABENWP nest watchers' observations of incubating adults on 1 January (Newbold and Newbold 1988). The Lone Pine pair were last, laying eggs around 8 March, with the young fledging about 6 July. Hatching occurred from early February to mid-April, with juveniles leaving the nests from May to July at 10–13 weeks of age (Table C2.5-2). Premature fledging at some nests was believed due to adverse circumstances, such as extraordinary heat and nest parasites (see sections C3.5 and C3.4).

Bald eagles occupied 23 of the 27 known Arizona breeding areas in 1988; the known nest locations at Ash, Chino, Mule Hoof, and Pleasant remained unoccupied. Eagles at Cibecue, Devil's Post, and Pinto apparently did not lay eggs. The remaining 20 active nests produced at least 33 eggs. Four active breeding areas (Cedar Basin, Fort McDowell, Sheep, and Table Mountain) failed in the egg stage, with 26 young hatching at the remaining 16 sites. Of these 26 eaglets, 24 fledged and 19 likely survived to independence (see Section C3.2 for data on mortality of juveniles). Nest success was 65.2 percent, mean brood size was 1.6, and productivity was 1.0 young.

Table C2.5-1. Arizona bald eagle breeding area productivity 1987.

Breeding Area	Status[1]	Nest No.	Incubation Date[2]	No. Eggs	Hatch Date	No. Young Hatched	Fledge Date	No. Young Fledged	Fledge Age (Weeks)	Comments
Alamo	Occupied	1	—	—	—	—	—	—	—	Adults building nest 1 on 1 Dec. 1986.
Ash	Unoccupied	—	—	—	—	—	—	—	—	
Bartlett	Failed	2	<2 Feb	?	—	0	—	0	—	Failed 19 February.
Blue Point	Successful	6	~30 Jan	3+	~5 Mar	3	1 June	3	12	Nest 6 discovered 16 March. One young died post-fledging.
Canyon	Successful	5	<2 Feb	1+	?	1+	<6 May	1+	?	
Cedar Basin	Failed	4	<17 Mar	3	—	0	—	0	—	Failed prior to 14 April.
Chino	Failed	2	<27 Mar	2	—	0	—	0	—	Failed prior to 15 April. Nest branch fell prior to 15 May.
Cibecue	Failed	3	~9 Feb	1+	14 Mar	1	—	0	—	Adult female disappeared 20 April. Floater near-adult male attacking resident male and eaglet. Nestling died 8-11 May.
Cliff	Occupied	4	—	—	—	—	—	—	—	
Coolidge	Successful	1	~2 Feb	2+	10 Mar	2	?	2	?	
East Verde	Successful	6	~21 Jan	2	26 Feb	1	30 May	1	13.5	One young froze while pipping during a snow storm.
Fort McDowell	Successful	11	~23 Dec	1+	26 Jan	1	1 May	1	13.5	
Horse Mesa	Successful	2	~13 Jan	2+	18 Feb	2	9,12 May	2	12	Adult male died 11 April.
Horseshoe	Successful	1	~20 Jan	3+	25 Feb	3	16,20, 21-25 May	3	12	
Ive's Wash	Successful	1	?	1+	?	1+	5-6 May	1+	?	Nest 1 discovered 6 May.
Ladders	Failed	3	~26 Jan	2+	1 Mar	2	—	0	—	Young died 5 and 7 May.
Lone Pine	Failed	2	<17 Mar	1+	—	?	—	0	—	Failed prior to 6 May.
Mule Hoof	Unoccupied	—	—	—	—	—	—	—	—	
Orme	Successful	1	~30 Dec	2+	~2 Feb	2	3,5 May	2	13	Nest 1 discovered 27 March.
Pinal	Successful	2	26 Jan	2+	7 Mar	2	25,29 May	2	12	
Pleasant	Occupied	?	—	—	—	—	—	—	—	Two adults perched near nest 2 in June.
Redmond[3]	Successful	4,5	~13 Feb	3+	~18 Mar	2	?	2	?	Eggs (1+) laid in nest 4 and 2+ in nest 5. Young raised in nest 5.
76	Failed	3	<23 Feb	3	—	0	—	0	—	Failed 13 March. Photographers near nest may have caused egg breakage. Top of eggs crushed.
Sheep	Failed	1	<17 Mar	1+	—	0	—	0	—	Failed 31 March.
Table Mountain	Occupied	1	—	—	—	—	—	—	—	Nest 1 discovered 9 April.

Table C2.5-1. (Continued)

Summary

No. Breeding Areas	25
No. Occupied Breeding Areas	23
No. Active Nests	19
No. Failed	8
No. Successful	11
No. Eggs	35 +
No. Young Hatched	23
No. Young Fledged	20

$$\text{Nest Success} = \frac{\text{No. of occupied nests producing young}}{\text{No. of occupied nests}} = \frac{11}{23} = 47.83\%$$

$$\text{Mean Brood Size} = \frac{\text{No. of young produced}}{\text{No. of successful nests}} = \frac{20}{11} = 1.82$$

Productivity = Nest Success x Mean Brood Size = 0.87

1. Unoccupied status indicates unoccupied at known nest sites.
2. Approximate dates are based on 35 day incubation period.

< Indicates adults were incubating prior to survey date.

3. First documented incidence double-clutching in Arizona bald eagles.

Table C2.5-2. Arizona bald eagle breeding area productivity 1988.

Breeding Area	Status[1]	Nest No.	Incubation Date[2]	No. Eggs	Hatch Date	No. Young Hatched	Fledge Date	No. Young Fledged	Fledge Age (Weeks)	Comments
Alamo	Successful	2	~31 Dec	1+	3 Feb	1	3 May	1	13	Fell out of nest 20 April. Returned 23 April. Fishing lure removed from tongue.
Ash	Unoccupied	—		—	—	—	—	—	—	
Bartlett	Successful	2	~24 Jan	2	27,29 Feb	2	13,15 May	2	11	
Blue Point	Successful	6	~28 Jan	3+	~2 Mar	3	14,16 May	3	11	Three young died prior to 23 May. JD33 broke neck on maiden flight.
Canyon	Successful	6	?	1+	<16 Mar	1	~26 May	1	?	
Cedar Basin	Failed	4	<16 Mar	1+	—	0	—	0	—	Failed prior to 12 May.
Chino	Unoccupied	—	—	—	—	—	—	—	—	
Cibecue	Occupied	1,2,3	—	—	—	—	—	—	—	Adults working on 3 known nests.
Cliff	Successful	4	~4 Feb	2+	~9 Mar	2	27 May	2	11	Eye infections (Avian pox) in both young. Fishing hook removed from toe of JI26.
Coolidge	Successful	3	~31 Jan	2+	~5 Mar	2	<28 May	2	?	Nest 3 discovered 15 April.
Devil's Post	Occupied	4	—	—	—	—	—	—	—	Discovered 23 February. Adults building nest 4.
East Verde	Successful	6	<12 Feb	2+	<16 Mar	2	<7 May	2	?	
Fort McDowell[3]	Failed	13	<24 Jan	1+	—	0	—	0	—	Failed in nest 13 prior to 11 February.
		11	9 Mar	1+	—	0	—	0	—	Second clutch laid in nest 11 on 9 Mar, but failed prior to 27 April. Disturbance from farming activity, wood-cuting, and vehicles may have contributed to failure.
Horse Mesa	Successful	2	?	1+	<16 Mar	1	<29 Apr	1	?	
Horseshoe	Successful	8	~27 Jan	1+	~1 Mar	1	2 Jun	1	13	
Ive's Wash	Successful	1	27 Jan	1+	6 Mar	1	14 May	1	10	Prefledged 14 May.
Ladders	Successful	4	19 Jan	2	20,21 Feb	2	14,16 May	2	12	JP22 died 10 June.
Lone Pine	Successful	4	~8 Mar	2+	~12 Apr	2	~6 Jul	2	?	Nest 4 discovered 28 April.
Mule Hoof	Unoccupied	—		—	—	—	—	—	—	Adult in nest 1 on 1 February.
Orme	Successful	1	~18 Jan	1+	~21 Feb	1	7 May	1	11	
Pinal	Failed	3	—	2	<16 Mar	1	—	0	—	Young died prior to 13 April. Entangled in monofilament.
Pinto	Occupied	2	—	—	—	—	—	—	—	Copulation and nest building with Pinal male.
Pleasant	Unoccupied	—	—	—	—	—	—	—	—	Four adults sighted during March carp spawn.
Redmond	Successful	6	~31 Jan	2+	~5 Mar	2	<18 May	1	11	Both young died prior to 19 May. JV38 in nest, JV39 post-fledging.

Table C2.5-2. (Continued)

Breeding Area	Status[1]	Nest No.	Incubation Date[2]	No. Eggs	Hatch Date	No. Young Hatched	Fledge Date	No. Young Fledged	Fledge Age (Weeks)	Comments
76	Successful	3	12 Feb	2+	17 Mar	2	10 Jun	2	12	Telemetered 14 May. JW31 fell with part of nest on 21 May. Returned 25 May. JW31 fell again on 28 May. Returned 29 May. Nest fell between 15 and 25 June.
Sheep	Failed	1	28 Feb	2+	—	0	—	0	—	Failed prior to 8 April.
Table Mountain	Failed	2	<18 Mar	1+	—	0	—	0	—	Failed prior to 13 May.

Summary

Number of breeding areas	27
Number of occupied breeding areas	23
Number of active nests	20
Number failed	5
Number successful	15
Number of eggs	33 +
Number of young hatched	26
Number of young fledged	24

Nest Success = $\frac{\text{No. of occupied nests producing young}}{\text{No. of occupied nests}} = \frac{15}{23} = 65.22\%$

Mean Brood Size = $\frac{\text{No. of young produced}}{\text{No. of successful nests}} = \frac{24}{15} = 1.60$

Productivity = Nest success x mean brood size = 1.04

1. Unoccupied status indicates unoccupied at known nest sites.
2. Approximate dates are based on 35-day incubation period.
< Indicates adults were incubating prior to survey date.
3. Second documented incident of double-clutching in Arizona bald eagles.

The status of the Ash breeding area remained questionable. Adults have not been seen since 1985 at the two known nest sites west of Highway 60; however, adults were observed in 1986 and 1987 at the Highway Tanks, 2.5 km to the east (Hughes pers. comm.). These observations, supported by sighting of two juvenile bald eagles perched north of the known nest sites in late May 1986 (Hughes pers. comm.), strongly suggest the breeding area is active at a new but unknown nest location.

Four adults were sighted in the Pleasant breeding area during a March carp spawn (T. Gatz pers. comm.), and an adult was observed perched in the Mule Hoof pinnacle nest on 1 February (R. Mesta pers. comm.), although known nest locations remained unoccupied at these sites.

C2.5.1.3 Summary of Productivity—1989. The discovery of a new nest in an historical nesting territory (Perkinsville) on 6 June 1989, increased to 28 the number of known Arizona bald eagle breeding areas. The Perkinsville site has not been occupied since the late 1960s or early 1970s (see sections D4 and D5 for details on active and historical nest sites). At least one member of the pair was in near-adult plumage (ca. 4 years old). The earliest nesters, the Alamo pair, laid eggs the first week of January, as confirmed by ABENWP nest watchers, observations of incubating adults on 8 January (Moller *et al.* 1989). The Cliff and Pinto pairs were last to lay, doing so around the end of February. Hatching occurred from February to early April, with juveniles leaving the nests in May and June at 10–13.5 weeks of age (Table C2.5-3).

Bald eagles occupied 25 of the 28 known Arizona breeding areas in 1989; known nest locations remained unoccupied at Ash, Chino, and Mule Hoof. Eagles apparently did not lay eggs at Coolidge, Devil's Post, Lone Pine, Orme, Perkinsville, Pleasant, "76", and Sheep. The remaining 17 active nests yielded at least 31 eggs. Four active breeding areas (Cedar Basin, Horse Mesa, Pinto, and Table Mountain) failed in the egg stage, with 23 young hatching at the remaining 13 sites. Of these 23 eaglets, only 13 fledged (see Section C3.2 for data on mortality of juveniles). Nest success in 1989 was 36.0 percent, mean brood size was 1.4, and productivity was 0.5 young.

One young at the Ive's Wash breeding area was removed from the nest on 11 April, after ABENWP personnel noted it could not swallow food and had not eaten in several days. The dehydrated nestling was taken to Liberty Wildlife Foundation, where Dr. Kathy Ingram removed a fish bone (spine and fin rays) which had lodged in the esophagus. Dr. Ingram restored the eaglet to health, and on 17 April we returned it to the nest where it fledged successfully on 9 May.

C2.5.1.4 Summary of Productivity—1990. No new nesting territories were discovered in 1990 and the number of known Arizona bald eagle breeding areas remained at 28. The early pairs, Fort McDowell and Alamo, laid eggs the second week of January, while incubation at several sites was not confirmed until late March, due to weather problems with ORA flights. Hatching occurred from February to early April, with juveniles leaving the nests in May and June at 10-13 weeks of age (Table C2.5-4). Logistical problems with ORA flights resulted in a lack of nestling data at Cedar Basin, East Verde, Lone Pine, and Table Mountain, although the amount of excrement present at the Table Mountain nest suggests at least one young survived to an advanced stage of development (R. Mesta pers. comm.).

Bald eagles occupied 26 of 28 known Arizona breeding areas in 1990; known nest locations remained unoccupied at Ash and Chino. A pair of adults were observed perched in the Mule Hoof pinnacle nest on 5 February, although no further sightings occurred during the nesting season. Eagles at Blue Point, Cliff, Coolidge, Devil's Post, Mule Hoof, Perkinsville, Pinto, Pleasant, and Sheep apparently did not lay

Table C2.5-3. Arizona bald eagle breeding area productivity 1989.

Breeding Area	Status[1]	Nest No.	Incubation Date[2]	No. Eggs	Hatch Date	No. Young Hatched	Fledge Date	No. Young Fledged	Fledge Age (Weeks)	Comments
Alamo	Successful	2	8 Jan	2+	17 Feb	1	5 May	1	11	New female-banded on right tarsus.
Ash	Unoccupied	—	—	—	—	—	—	—	—	
Bartlett	Successful	2	18-20 Jan	3	22,24 Feb	3	10,11 May	2	11	One young died in nest 9 May. Recovered 30 June. Two young captured post fledging.
Blue Point	Failed	1	~1 Feb	2+	8 Mar	2	—	0	—	Two young died 16-19 March. Adult pair fighting with third adult. Dry riverbed resulted in many human disturbances.
Canyon	Successful	6	~9-16 Feb	1+	13-20 Feb	1	?	1	?	
Cedar Basin	Failed	3	?	1+	—	0	—	0	—	Failed prior to 1 May.
Chino	Unoccupied	—	—	—	—	—	—	—	—	
Cibecue	Successful	3	~6 Feb	2+	~13 Mar	2	5-12 Jun	1	12-13	Twelve-week-old young seen in nest 5 June. One young died in nest at 5 weeks old. New adult male.
Cliff	Failed	4	<27 Feb	3+	~5 Apr	1	—	0	—	One young died in nest prior to 12 April. Adults incubated eggs until 15 May.
Coolidge	Occupied	2	—	—	—	—	—	—	—	
Devil's Post	Occupied	—	—	—	—	—	—	—	—	
East Verde	Successful	6	~26 Jan—2 Feb	2+	2-9 Mar	2	<27 May	2	12	Nest fell prior to 4 June.
Fort McDowell	Successful	11	~20 Jan	2+	24 Feb	2	20-22 May	2	12	New female-banded on left tarsus.
Horse Mesa	Failed	2	<6 Feb	1+	—	0	—	0	—	One crushed egg collected.
Horseshoe	Failed	8	~3 Feb	2+	~10 Mar	1	—	0	—	One young decapitated 1-2 April. Apparently great horned owl predation.
Ive's Wash	Successful	1	~13 Jan	2+	17 Feb	2	9 May	1	11.5	J241 removed 11 April - fish bone lodged in esophagus, dehydrated. Returned 17 April. Both young jumped 19 April. J241 climbed to nest. J242 on ledge - jumped 20 April. J242 recovered 23 April with broken left radius and ulna, dehydrated - died 25 April.
Ladders	Successful	3	~30 Jan	2+	6,8 Mar	2	25 May, 9 Jun	2	11.5, 13.5	Adult male died 6-10 May of head injury from peregrine falcon.
Lone Pine	Occupied	—	—	—	—	—	—	—	—	

Table C2.5-3. (Continued)

Breeding Area	Status[1]	Nest No.	Incubation Date[2]	No. Eggs	Hatch Date	No. Young Hatched	Fledge Date	No. Young Fledged	Fledge Age (Weeks)	Comments
Mule Hoof	Unoccupied	—	—	—	—	—	—	—	—	
Orme	Occupied	?	—	—	—	—	—	—	—	Near-adult female. Old eggshell fragments in nest 1.
Perkinsville	Occupied	2	—	—	—	—	—	—	—	Near adult feathers in and below nest. Nest found 6 June.
Pinal	Successful	1	~16 Feb	2+	23 Mar	2	30 May	1	10	One young died in nest at 4-7 days of age.
Pinto	Failed	2	<28 Feb	1+	—	0	—	0	—	Copulation and nest building with Pinal male. Failed prior to 13 March. Pinal male did not assist in incubation.
Pleasant	Occupied	—	—	—	—	—	—	—	—	
Redmond	Failed	5	~20 Feb	2	~27 Mar	2	—	0	—	Both young died in nest on 6 or 7 April.
76	Occupied	3	—	—	—	—	—	—	—	Three adults in area.
Sheep	Occupied	1	—	—	—	—	—	—	—	New adult male.
Table Mountain	Failed	3	<28 Feb	1+	—	0	—	0	—	Nest 3 found 7 March. Old eggshell fragments.

Summary

No. Breeding Areas	28
No. Occupied Breeding Areas	25
No. Active Nests	17
No. Failed	8
No. Successful	9
No. Eggs	31 +
No. Young Hatched	23
No. Young Fledged	13

$$\text{Nest Success} = \frac{\text{No. of occupied nests producing young}}{\text{No. of occupied nests}} = \frac{9}{25} = 36.00\%$$

$$\text{Mean Brood Size} = \frac{\text{No. of young produced}}{\text{No. of successful nests}} = \frac{13}{9} = 1.44$$

Productivity = Nest Success x Mean Brood Size = 0.52

1. Unoccupied status indicates unoccupied at known nest sites.
2. Approximate dates are based on 35-day incubation period.

< Indicates adults were incubating prior to survey date.

Table C2.5-4. Arizona bald eagle breeding area productivity 1990.

Breeding Area	Status[1]	Nest No.	Incubation Date[2]	No. Eggs	Hatch Date	No. Young Hatched	Fledge Date	No. Young Fledged	Fledge Age (Weeks)	Comments
Alamo	Successful	2	~13 Jan	2+	17 Feb	2	16 May	2	12.5	New male - banded on right tarsus. Adults building nest 3 on 20 December 1989.
Ash	Unoccupied	—	—	—	—	—	—	—	—	
Bartlett[3]	Failed	2	<5 Feb	1+	—	0	—	0	—	Failed in nest 2 on 12 February.
		1	14 Mar	2+	—	0	—	0	—	Began building up nest 1 on 12 February. Laid second clutch in nest 1 on 14 March. Second nest attempt failed 22 March.
Blue Point	Occupied	—	—	—	—	—	—	—	—	New female - subadult (ca. 3 years old), performing courtship flights with male.
Canyon	Successful	6	<21 Mar	2+	?	2	?	2	?	Two young in nest 1 June.
Cedar Basin	Failed	3	<21 Mar	1+	—	?	—	0	—	Failed between 26 April and 1 June.
Chino	Unoccupied	—	—	—	—	—	—	—	—	
Cibecue	Failed	2	~26 Feb-1 Mar	1+	2-5 Apr	1+	—	0	—	Failed 14 April. Female carried fuzzy object away from nest on that date.
Cliff	Occupied	4	—	—	—	—	—	—	—	Much disturbance and shooting. Near-adult male chasing resident male off food and perching with female.
Coolidge	Occupied	2	—	—	—	—	—	—	—	Two pair of adults (one female a near-adult) sighted on San Carlos reservoir in January.
Devil's Post	Occupied	4	—	—	—	—	—	—	—	Adults working on nest 4. Both birds observed on two occasions with grease or oil smears on head and tail.
East Verde	Failed	6	<5 Feb	1+	—	?	—	0	—	Failed between 5 February and 9 May.
Fort McDowell	Failed	11	<13 Jan	1+	—	0	—	0	—	Female laid very small "runt" egg. Nest failed 29 March.
Horse Mesa	Successful	2	~3-6 Jan	2+	7-10 Feb	2	<11 May	2	12-13	
Horseshoe	Successful	8	~28 Jan	2+	~4 Mar	2	14-17,22 May	2	10,11	Adults built nest 9 from Nov-Dec 1989. Hunting blinds within 300 meters of nest 9.
Ive's Wash	Failed	2	<21 Jan	1+	—	0	—	0	—	Lots of disturbance from hunting, fishing, and camping. Closure put up 6 March, but nest failed prior to 25 February (35-day incubation period).
Ladders	Failed	4	24 Jan	2	—	0	—	0	—	New male - banded on right tarsus. Another pair of adults defending river upstream of West Clear Creek.
Lone Pine	Failed	1	<21 Mar	1+	—	?	—	0	—	Failed between 21 March and 1 June.
Mule Hoof	Occupied	1	—	—	—	—	—	—	—	Pair in nest 1 on 5 February.

Table C2.5-4. (Continued)

Breeding Area	Status[1]	Nest No.	Incubation Date[2]	No. Eggs	Hatch Date	No. Young Hatched	Fledge Date	No. Young Fledged	Fledge Age (Weeks)	Comments
Orme	Successful	3	~12-15 Feb	2	19-22 Mar	1	9 Jun	1	11.5	Nest 3 found 22 Feb. Four adults in area.
Perkinsville	Occupied	2	—	—	—	—	—	—	—	Near-adult pair. Female banded on right leg.
Pinal	Successful	3	~5 Feb	2+	12,13 Mar	2	2,3 Jun	2	11.5	Monofilament, lure, and weight in nest.
Pinto	Occupied	3	—	—	—	—	—	—	—	Female copulating and building nest 3 with Pinal male.
Pleasant	Occupied	2	—	—	—	—	—	—	—	New pair, male near-adult, female banded on left tarsus. Pair working on nest 2.
Redmond	Successful	5	~21 Feb	1+	28-29 Mar	1	6 Jun	1	10	
76	Successful	3	15 Feb	1+	21 Mar	1	18 Jun	1	12.5	Osprey foot and feathers in nest - prey item.
Sheep	Occupied	1	—	—	—	—	—	—	—	
Table Mountain	Successful	4	<20 Mar	1+	—	1+	<1 Jun	1+	?	Nest 4 found 20 March. Lots of mute at nest on 1 June, indicating the presence of young.

Summary

No. Breeding Areas	28
No. Occupied Breeding Areas	26
No. Active Nests	17
No. Failed	8
No. Successful	9
No. Eggs	26 +
No. Young Hatched	15 +
No. Young Fledged	14 +

Nest Success = $\frac{\text{No. of occupied nests producing young}}{\text{No. of occupied nests}} = \frac{9}{26} = 34.62\%$

Mean Brood Size = $\frac{\text{No. of young produced}}{\text{No. of successful nests}} = \frac{14}{9} = 1.56$

Productivity = Nest Success x Mean Brood Size = 0.54

1. Unoccupied status indicates unoccupied at known nest sites.
2. Approximate dates are based on 35-day incubation period.
< Indicates adults were incubating prior to survey date.
3. Third documented incidence of double-clutching in Arizona bald eagles.

eggs. The remaining 17 active nests produced at least 26 eggs. Four active breeding areas (Bartlett, Fort McDowell, Ive's Wash, and Ladders), and possibly three more (Cedar Basin, East Verde, and Lone Pine), failed in the egg stage, with 15 young hatching at the remaining 10 sites. Of these 15 eaglets, 14 fledged from nine nests (see Section C3.2 for data on mortality of juveniles). Nest success in 1990 was 34.6 percent, mean brood size was 1.6, and productivity was 0.5 young.

C2.5.2 Reproductive History

As discussed previously, historical records, literature, past reports, and interviews with agency personnel and other people knowledgeable about bald eagles in Arizona revealed one known breeding area in the 1920s, two by the 1930s, four by the 1940s, five by the 1950s, six by the 1960s, and eight by 1970. At least partly a result of increased search efforts, 13 breeding areas were documented as of 1975, 16 by 1980, 23 by 1985, and 28 by 1990. At least 381 eggs have been recorded, hatching 276 known young, and resulting in 232 fledged eaglets (see Table C2.5-5). Of the 28 known breeding areas, 26 have been active (Devil's Post and Perkinsville have not laid any known eggs), producing a population mean of 1.5 eggs, 1.1 hatched young, and 0.9 fledged eaglets per active breeding area per year.

Arizona bald eagles have produced 381 known eggs in 224 clutches, resulting in an *estimated* average clutch size of 1.7 eggs. This is low compared to the average clutch size of 1.9–1.97 reported for other bald eagle populations (Stalmaster 1987). However, due to the restricted view at most cliff nests and the warranted procedure of not flushing adults from the nest to count eggs on ORA flights, many clutch sizes in Arizona are simply estimated from the number of young hatched. This likely explains the reduced average clutch size in the data. Bald eagles usually lay 1–3 eggs in a clutch. Although clutches of four eggs have been reported, there has never been more than three young recorded in a nest (Stalmaster 1987).

Of the 224 clutches known for Arizona bald eagles, 41 percent (n = 91) contained one egg, 49 percent (n = 109) two eggs, and 11 percent (n = 24) three eggs. Similarly, of the 162 broods known, 38 percent (n = 62) consisted of one eaglet, 53 percent (n = 86) two eaglets, and 9 percent (n = 14) three eaglets. Again, this close relationship between clutch size and brood size is likely due to the fact that many clutch sizes in Arizona are estimated from the number of young hatched, and so there are likely more two- and three-egg clutches, and fewer one-egg clutches, than the data show. Some of this bias is eliminated by documenting the approximate number of eggs, through eggshell fragments collected in individual isolated locations in the nest. However, Arizona adults have been observed crushing and removing large eggshell pieces from the nest (Driscoll 1985, Poelker and Palmiotto 1985).

In a smaller sample of 43 clutches of known size, 7 percent (n = 3) contained one egg, 53.5 percent (n = 23) two eggs, and 39.5 percent (n = 17) three eggs (Figure C2.5-1). These 100 eggs from 43 Arizona clutches result in an average clutch size of 2.3 eggs, which is slightly higher than the mean for other bald eagle populations (1.9-2.0 eggs) reported by Stalmaster (1987).

In other bald eagle populations, Stalmaster (1987) found that 17 percent of clutches contained one egg, 79 percent two eggs, and 4 percent three eggs. Arizona nests had 10 percent less one-egg clutches, 25 percent less two-egg clutches, and 35 percent more three-egg clutches than the means for other bald eagle populations.

Data for the number of young in broods is not subject to the biases discussed for eggs, and can be compared directly to those for other populations. In other bald eagle populations throughout North

Table C2.5-5. Known reproductive history of Arizona bald eagle breeding areas, 1900-1990.*

Breeding Area	1900s				<1911				<1918				1920s				1930s				1930				1931				1932			
	S	E	Y	F	S	E	Y	F	S	E	Y	F	S	E	Y	F	S	E	Y	F	S	E	Y	F	S	E	Y	F	S	E	Y	F
Alamo		—				—				—				—				—				—				—				—		
Ash		—				—				—				—				—				—				—				—		
Bartlett		—				—				—				—				—				—				—				—		
Blue Point		—				—				—				—				—			O	?	?	?	O	?	?	?	S	1+	1+	1+
Canyon		—				—				—				—				—				—				—				—		
Cedar Basin		—				—				—				—				—				—				—				—		
Chino		—				—				—				—				—				—				—				—		
Cibecue		—				—				—				—				—				—				—				—		
Cliff		—				—				—				—				—				—				—				—		
Coolidge		—				—				—				—				—				—				—				—		
Devil's Post		—				—				—				—				—				—				—				—		
East Verde		—				—			?	?	?	?		—				—				—				—				—		
Fort McDowell	?	?	?	?		—				—				—				—				—				—				—		
Horse Mesa		—				—				—				—				—				—				—				—		
Horseshoe		—				—				—				—				—				—				—				—		
Ive's Wash		—				—				—				—				—				—				—				—		
Ladders		—				—				—				—				—				—				—				—		
Lone Pine		—				—				—				—				—				—				—				—		
Mule Hoof		—				—				—			O	?	?	?	O	?	?	?		—				—				—		
Orme		—				—				—				—				—				—				—				—		
Perkinsville		—				—				—				—				—				—				—				—		
Pinal		—				—				—				—				—				—				—				—		
Pinto		—			?	?	?	?		—				—				—				—				—				—		
Pleasant		—				—				—				—				—				—				—				—		
Redmond		—				—				—				—				—				—				—				—		
76		—				—				—				—				—				—				—				—		
Sheep		—				—				—				—				—				—				—				—		
Table Mountain		—				—				—				—				—				—				—				—		
Summary																																
Total		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		1+	1+	1+
Active Breeding Areas			?				?				?				?				?				?				?				1		
Mean		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		1+	1+	1+
Known Breeding Areas			?				?				?				1				1				2				2				2		

* S = Breeding area status, E = No. eggs, Y = No. young, F = No. fledged.
Status: U = Unoccupied, O = Occupied, A = Active, F = Failed, S = Successful.
??? indicates there is some evidence that nesting took place, or may have taken place. (See productivity page of breeding area history for details).

Table C2.5-5. (Page 2 of 8).

Breeding Area	1933				1934				1935				1936				1937				1940s				1944				1949			
	S	E	Y	F	S	E	Y	F	S	E	Y	F	S	E	Y	F	S	E	Y	F	S	E	Y	F	S	E	Y	F	S	E	Y	F
Alamo		—				—				—				—				—				—				—				—		
Ash		—				—				—				—				—				—				—				—		
Bartlett		—				—				—				—				—			O	?	?	?		—				—		
Blue Point	S	1+	1+	1+		—			0	?	?	?	O	?	?	?		—				—				—				—		
Canyon		—				—				—				—				—				—				—				—		
Cedar Basin		—				—				—				—				—				—				—				—		
Chino		—				—				—				—				—				—				—				—		
Cibecue		—				—				—				—				—				—				—				—		
Cliff		—				—				—				—				—				—				—				—		
Coolidge		—				—				—				—				—				—				—				—		
Devil's Post		—				—				—				—				—				—				—				—		
East Verde		—				—				—				—				—				—				—				—		
Fort McDowell		—				—				—				—				—			O	?	?	?		—				—		
Horse Mesa		—				—				—				—				—				—				—				—		
Horseshoe		—				—				—				—				—				—				—				—		
Ive's Wash		—				—				—				—				—				—				—				—		
Ladders		—				—				—				—				—				—				—				—		
Lone Pine		—				—				—				—			?	?	?	?		—				—				—		
Mule Hoof		—				—			A	1+	?	?		—				—				—			O	?	?	?	O	?	?	?
Orme		—				—				—				—				—				—				—				—		
Perkinsville		—				—				—				—				—				—				—				—		
Pinal		—				—				—				—				—				—				—				—		
Pinto		—				—				—				—				—				—				—				—		
Pleasant		—				—				—				—				—				—				—				—		
Redmond		—				—				—				—				—				—				—				—		
76		—				—				—				—				—				—				—				—		
Sheep		—				—				—				—				—				—				—				—		
Table Mountain		—				—				—				—				—				—				—				—		
<u>Summary</u>																																
Total		1+	1+	1+		—	—	—		1+	?	?		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?
Active Breeding Areas		1					—				1				?				?				?				?				?	
Mean		1+	1+	1+		—	—	—		1+	?	?		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?
Known Breeding Areas		2					2				2				2				2				4				4				4	

* S = Breeding area status, E = No. eggs, Y = No. young, F = No. fledged.
Status: U = Unoccupied, O = Occupied, A = Active, F = Failed, S = Successful.
??? indicates there is some evidence that nesting took place, or may have taken place. (See productivity page of breeding area history for details).

Table C2.5-5. (Page 3 of 8).

Breeding Area	1950s S	1950s E	1950s Y	1950s F	1953 S	1953 E	1953 Y	1953 F	1960s S	1960s E	1960s Y	1960s F	1960 S	1960 E	1960 Y	1960 F	1961 S	1961 E	1961 Y	1961 F	1962 S	1962 E	1962 Y	1962 F	1963 S	1963 E	1963 Y	1963 F	1964 S	1964 E	1964 Y	1964 F
Alamo		—				—				—				—				—				—				—				—		
Ash		—				—				—				—				—				—				—				—		
Bartlett		—			O	?	?	?		—				—				—				—				—			F	2+	2	0
Blue Point		—				—				—				—				—				—				—				—		
Canyon		—				—				—				—				—				—				—				—		
Cedar Basin		—				—				—				—				—				—				—				—		
Chino		—				—				—				—				—				—				—				—		
Cibecue		—				—				—				—				—				—				—				—		
Cliff		—				—				—				—				—				—				—				—		
Coolidge		—				—				—				—				—				—				—				—		
Devil's Post		—				—				—				—				—				—				—				—		
East Verde		—				—				—				—				—				—				—				—		
Fort McDowell		—				—				—				—				—				—				—				—		
Horse Mesa	S	?	?	?		—			S	?	?	?		—				—				—				—				—		
Horseshoe		—				—				—				—				—				—				—				—		
Ive's Wash		—				—				—				—				—				—				—				—		
Ladders		—				—				—				—				—			A	?	?	?	A	?	?	?	A	?	?	?
Lone Pine		—				—				—				—				—				—				—				—		
Mule Hoof		—				—				—				—				—				—				—				—		
Orme		—				—				—				—				—				—				—				—		
Perkinsville		—				—			O	?	?	?		—				—				—				—				—		
Pinal		—				—				—				—				—				—				—				—		
Pinto		—				—				—				—				—				—				—				—		
Pleasant		—				—				—				—				—				—				—				—		
Redmond		—				—				—				—				—				—				—				—		
76		—				—				—				—				—				—				—				—		
Sheep		—				—				—				—				—				—				—				—		
Table Mountain		—				—				—				—				—				—				—				—		
Summary																																
Total		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		2+	2	0
Active Breeding Areas			1				?				1				?				?				1				1				2	
Mean		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		?	?	?		2+	2	0
Known Breeding Areas			5				5				6				6				6				7				7				7	

* S = Breeding area status, E = No. eggs, Y = No. young, F = No. fledged.
Status: U = Unoccupied, O = Occupied, A = Active, F = Failed, S = Successful.
??? indicates there is some evidence that nesting took place, or may have taken place. (See productivity page of breeding area history for details).

Table C2.5-5. (Page 4 of 8).

Breeding Area	1965 S	1965 E	1965 Y	1965 F	1966 S	1966 E	1966 Y	1966 F	1967 S	1967 E	1967 Y	1967 F	1968 S	1968 E	1968 Y	1968 F	1969 S	1969 E	1969 Y	1969 F	1970s S	1970s E	1970s Y	1970s F	1970 S	1970 E	1970 Y	1970 F	1971 S	1971 E	1971 Y	1971 F
Alamo	—				—				—				—				—				—				—				—			
Ash	—				—				—				—				—				—				—				—			
Bartlett	—				S	1+	1	1	A	1+	?	?	—				—				—				S	3	1	1	S	3	1	1
Blue Point	—				—				—				—				—				—				—				S	2+	2	2
Canyon	—				—				—				—				—				—				—				—			
Cedar Basin	—				—				—				—				—				—				—				—			
Chino	—				—				—				—				—				—				—				—			
Cibecue	—				—				—				—				—				—				—				—			
Cliff	—				—				—				—				—				—				—				—			
Coolidge	—				—				—				—				—				—				—				—			
Devil's Post	—				—				—				—				—				O	?	?	?	—				—			
East Verde	—				—				—				—				—				—				S	2+	2	2	S	1+	1	1
Fort McDowell	—				—				—				S	1+	1	1	—				S	?	?	?	—				—			
Horse Mesa	—				—				—				—				—				—				—				—			
Horseshoe	—				—				—				—				—				—				—				—			
Ive's Wash	—				—				—				—				—				—				—				—			
Ladders	A	?	?	?	A	?	?	?	A	?	?	?	A	?	?	?	A	?	?	?	A	?	?	?	A	?	?	?	A	?	?	?
Lone Pine	—				—				—				—				—				—				—				—			
Mule Hoof	—				—				—				—				—				—				—				—			
Orme	—				—				—				—				—				S	?	?	?	—				—			
Perkinsville	—				—				—				—				—				O	?	?	?	—				—			
Pinal	—				—				—				—				—				—				—				—			
Pinto	—				—				—				—				—				—				—				—			
Pleasant	—				—				—				—				—				—				—				—			
Redmond	—				—				—				—				—				—				—				—			
76	—				—				—				—				—				O	?	?	?	—				—			
Sheep	—				—				—				—				—				—				—				—			
Table Mountain	—				—				—				—				—				—				—				—			
Summary																																
Total		?	?	?		1+	1	1		1+	?	?		1+	1	1		?	?	?		?	?	?		5+	3	3		6+	4	4
Active																																
Breeding Areas		1				2				2				2				1				3				3				4		
Mean		?	?	?		1+	1	1		1+	?	?		1+	1	1		?	?	?		?	?	?		2.5	1.5	1.5		2.0	1.3	1.3
Known																																
Breeding Areas		7				7				7				7				7				10				10				10		

* S = Breeding area status, E = No. eggs, Y = No. young, F = No. fledged.
Status: U = Unoccupied, O = Occupied, A = Active, F = Failed, S = Successful.
??? indicates there is some evidence that nesting took place, or may have taken place. (See productivity page of breeding area history for details).

Table C2.5-5. (Page 5 of 8).

Breeding Area	1972 S	1972 E	1972 Y	1972 F	1973 S	1973 E	1973 Y	1973 F	1974 S	1974 E	1974 Y	1974 F	1975 S	1975 E	1975 Y	1975 F	1976 S	1976 E	1976 Y	1976 F	1977 S	1977 E	1977 Y	1977 F	1978 S	1978 E	1978 Y	1978 F	1979 S	1979 E	1979 Y	1979 F
Alamo		—				—				—				—				—				—				—				—		
Ash		—				—				—				—				—				—				—				—		
Bartlett	F	1+	?	0	S	2+	2	2	F	1+	?	0	S	1+	1	1	F	1+	0	0	S	2+	2	2	S	2+	2	1	S	1+	1	1
Blue Point	F	2+	2	0	U				U				U				U				U				U				O			
Canyon		—				—				—				—				—				—				—				—		
Cedar Basin		—			?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	S	2+	2	2	F	1+	0	0
Chino		—				—				—				—				—				—				—				—		
Cibecue		—			S	1+	1	1		—			S	1+	1	1	U				F	1+	1	0	S	3	3	2	F	1+	0	0
Cliff		—				—				—				—				—				—				—				—		
Coolidge		—				—				—				—			?	?	?	?		—				—				—		
Devil's Post		—				—				—				—				—			A	?	?	?		—				—		
East Verde		—			S	2+	2	2	S	3	3	3	S	1+	1	1	S	2+	2	2	S	2+	2	2	F	2	0	0	U			
Fort McDowell	U				S	1+	1	1	S	1+	1	1	S	2+	2	2	S	2+	1	1	S	2+	2	2	S	2+	2	2	S	2+	2	2
Horse Mesa		—				—				—				—				—			O	?	?	?		—				—		
Horseshoe		—				—				—			F	2	0	0	S	2+	2	2	F	2	0	0	F	2	0	0	F	1+	0	0
Ive's Wash		—				—				—				—				—				—				—				—		
Ladders	F	1+	0	0	S	1+	1+	1+	U				U				U				F	1	0	0	O				F	1+	0	0
Lone Pine		—				—				—				—				—				—				—				—		
Mule Hoof		—				—			S	2+	2	2	F	1+	0	0	U				U				F	1+	0	0	F	1+	0	0
Orme		—				—				—				—				—				—				—				—		
Perkinsville		—			?	?	?	?		—				—				—				—				—				—		
Pinal		—				—				—				—				—				—			S	1+	1+	1+	S	2+	2	2
Pinto		—				—				—				—				—				—				—				—		
Pleasant		—				—				—				—				—				—				—			U			
Redmond		—				—			O				F	1+	1	0	S	2+	2	2	O				S	2+	2	1	S	2+	2	1
76		—				—			O	?	?	?	O	?	?	?		—				—				—				—		
Sheep		—				—				—				—				—				—				—				—		
Table Mountain		—				—				—				—				—				—				—				—		
Summary																																
Total		4+	2	0		7+	7+	7+		7+	6+	6		9+	6	5		9+	7	7		10+	7	6		17+	12+	9+		12+	7	6
Active Breeding Areas		3				5				4				7				5				7				9				9		
Mean		1.3	0.7	0.0		1.4	1.4	1.4		1.8	1.5	1.5		1.3	0.8	0.7		1.8	1.4	1.4		1.6	1.2	1.0		1.9	1.3	1.0		1.3	0.8	0.7
Known Breeding Areas		10				12				13				14				14				14				16				17		

* S = Breeding area status, E = No. eggs, Y = No. young, F = No. fledged.
Status: U = Unoccupied, O = Occupied, A = Active, F = Failed, S = Successful.
??? indicates there is some evidence that nesting took place, or may have taken place. (See productivity page of breeding area history for details).

Table C2.5-5. (Page 6 of 8).

Breeding Area	1980s S	1980s E	1980s Y	1980s F	1980 S	1980 E	1980 Y	1980 F	1981 S	1981 E	1981 Y	1981 F	1982 S	1982 E	1982 Y	1982 F	1983 S	1983 E	1983 Y	1983 F	1984 S	1984 E	1984 Y	1984 F	1985 S	1985 E	1985 Y	1985 F	1986 S	1986 E	1986 Y	1986 F
Alamo	—					—				—				—				—				—				—				—		
Ash	—					—				—			0	?	?	?	O	?	?	?	S	2+	1	1	S	2+	2	2	U	?	?	?
Bartlett	—				S	1+	1	1	S	2+	2	2	S	2	1	1	F	3	0	0	F	3	0	0	S	2	2	1	S	1	1	1
Blue Point	—				O				S	3+	3	3	S	3+	3	3	S	3	3	3	S	2	2	2	S	2	2	1	U	?	?	?
Canyon	—					—				—				—				—				—				—			S	1+	1	1
Cedar Basin	—				U				O				O				F	1+	0	0	F	1+	0	0	F	1+	0	0	F	1+	0	0
Chino	—					—				—				—				—				—			S	2+	2	2	F	1	0	0
Cibecue	—				F	3	3	0	U				S	1+	1	1	F	2+	2	0	S	3	3	3	S	2+	2	1	S	2+	2	1
Cliff	—					—				—				—				—			F	2	2	0	S	2	2	2	F	1+	0	0
Coolidge	—					—				—				—				—				—			F	2	0	0	S	2+	1	1
Devil's Post	—					—				—				—				—				—				—				—		
East Verde	—				S	2+	2	2	S	2+	2	2	S	2+	2	2	F	1+	1	0	S	1+	1	1	S	2	2	2	S	2+	2	2
Fort McDowell	—				F	1+	0	0	S	2+	2	2	S	2+	2	2	S	3	3	3	S	3	3	3	S	3	3	3	S	2+	2	2
Horse Mesa	—					—				—			O	?	?	?	F	1+	0	0	F	2+	0	0	F	1+	0	0	S	3	2	2
Horseshoe	—				F	2	0	0	O				S	2+	2	2	S	1+	1	1	S	2+	2	2	S	2+	2	2	S	2+	2	2
Ive's Wash	—					—				—				—				—				—				—				—		
Ladders	—				S	2+	2	2	S	2+	2	2	F	2	0	0	S	2+	2	2	F	1+	0	0	S	2+	2	2	S	2+	2	2
Lone Pine	—					—				—				—				—			F	2	0	0	F	1+	0	0	S	1+	1	1
Mule Hoof	—				U				U				O				U				U				U				U			
Orme	1+	1+	?			—				—				—				—				—				—			S	?	?	?
Perkinsville	—					—				—				—				—				—				—				—		
Pinal	—				F	2+	0	0	S	2+	2	1	F	1+	1	0	S	1+	1	1	S	1+	1	1	S	1+	1	1	U			
Pinto	—					—				—				—				—				—				—			S	?	?	?
Pleasant	—				U				U				U				U				F	1+	0	0	F	1+	0	0	U			
Redmond	—				F	1+	0	0	S	2+	2	2	S	2+	2	2	S	2+	2	2	F	2+	2	0	S	2	2	2	S	1+	1	1
76	—					—			S	2+	2	2	S	1+	1	1	S	2+	2	1	S	2+	2	2	S	1+	1	1	S	1+	1	1
Sheep	—					—				—			O				F	2+	0	0	O				O				F	2+	2	0
Table Mountain	—					—				—				—				—				—			O	?	?	?	O	?	?	?
Summary																																
Total	1+	1+	?		14+		8	5	17+		17	16	18+		15	14	24+		17	13	30+		19	15	31+		25	22	25+		20	17
Active Breeding Areas	1				8				8				10				13				16				18				16			
Mean	1.0	1.0	?		1.8		1.0	0.6	2.1		2.1	2.0	1.8		1.5	1.4	1.8		1.4	1.1	1.9		1.2	0.9	1.7		1.4	1.2	1.6		1.2	1.1
Known Breeding Areas	17				17				17				19				19				21				24				26			

* S = Breeding area status, E = No. eggs, Y = No. young, F = No. fledged.
Status: U = Unoccupied, O = Occupied, A = Active, F = Failed, S = Successful.
??? indicates there is some evidence that nesting took place, or may have taken place. (See productivity page of breeding area history for details).

Table C2.5-5. (Page 7 of 8).

Breeding Area	1987 S	1987 E	1987 Y	1987 F	1988 S	1988 E	1988 Y	1988 F	1989 S	1989 E	1989 Y	1989 F	1990 S	1990 E	1990 Y	1990 F
Alamo	O				S	1+	1	1	S	2+	1	1	S	2+	2	2
Ash	U	?	?	?	U	?	?	?	U				U			
Bartlett	F	1+	0	0	S	2	2	2	S	3	3	2	F	3+	0	0
Blue Point	S	3+	3	3	S	3+	3	3	F	2+	2	0	O			
Canyon	S	1+	1+	1	S	1+	1	1	S	1+	1	1	S	2+	2	2
Cedar Basin	F	3	0	0	F	2	0	0	F	1+	0	0	F	1+	?	0
Chino	F	2+	0	0	U				U				U			
Cibecue	F	1+	1	0	O				S	2+	2	1	F	1+	1+	0
Cliff	O				S	2+	2	2	F	3+	1	0	O			
Coolidge	S	2+	2	2	S	2+	2	2	O				O			
Devil's Post	O				O				O				O			
East Verde	S	2	1	1	S	2+	2	2	S	2+	2	2	F	1+	?	0
Fort McDowell	S	1+	1	1	F	2+	0	0	S	2+	2	2	F	1+	0	0
Horse Mesa	S	2+	2	2	S	1+	1	1	F	1+	0	0	S	2+	2	2
Horseshoe	S	3	3	3	S	1+	1	1	F	2+	1	0	S	2+	2	2
Ive's Wash	S	1+	1+	1+	S	1+	1	1	S	2+	2	1	F	1+	0	0
Ladders	F	2+	2	0	S	2+	2	2	S	2+	2	2	F	2	0	0
Lone Pine	F	1+	0	0	S	2+	2	2	O				F	1+	?	0
Mule Hoof	U				U				U				O			
Orme	S	2+	2	2	S	1+	1	1	O				S	2	1	1
Perkinsville		—				—			O				O			
Pinal	S	2+	2	2	F	2	1	0	S	2+	2	1	S	2+	2	2
Pinto		—			O				F	1+	0	0	O			
Pleasant	O				U				O				O			
Redmond	S	3+	2	2	S	2+	2	1	F	2	2	0	S	1+	1	1
76	F	3	0	0	S	2+	2	2	O				S	1+	1	1
Sheep	F	1+	0	0	F	2+	0	0	O				O			
Table Mountain	O				F	1+	0	0	F	1+	0	0	S	1+	1+	1+
Summary																
Total		36+	23+	20+		34+	26	24		31+	23	13		26+	15	14+
Active Breeding Areas			19				20				18				17	
Mean		1.9	1.2	1.0		1.7	1.3	1.2		1.7	1.3	0.7		1.5	0.9	0.8
Known Breeding Areas			28				28				28				28	

* S = Breeding area status, E = No. eggs, Y = No. young, F = No. fledged.
Status: U = Unoccupied, O = Occupied, A = Active, F = Failed, S = Successful.
??? indicates there is some evidence that nesting took place, or may have taken place. (See productivity page of breeding area history for details).

Table C2.5-5. (Page 8 of 8).

Breeding Areas	Total			Total Years**			Mean		
	Eggs	Young	Fledged	Eggs	Young	Fledged	Eggs	Young	Fledged
Alamo	5+	4	4	4	4	4	1.2	1.0	1.0
Ash	4+	3	3	2	2	2	2.0	1.5	1.5
Bartlett	44+	25	20	24	21	22	1.8	1.2	0.9
Blue Point	27+	27	22–24	15	15	15	1.8	1.8	1.5–1.6
Canyon	6+	6	6	5	5	5	1.2	1.2	1.2
Cedar Basin	14+	2	2	12	11	12	1.2	0.2	0.2
Chino	5+	2	2	3	3	3	1.7	0.7	0.7
Cibecue	24+	23	11	15	15	15	1.6	1.5	0.7
Cliff	10+	7	4	7	7	7	1.4	1.0	0.6
Coolidge	8+	5	5	6	6	6	1.3	0.8	0.8
Devil's Post	0	0	0	4	4	4	0.0	0.0	0.0
East Verde	31+	27	26	17	16	17	1.8	1.7	1.5
Fort McDowell	38+	33	33	21	21	21	1.8	1.6	1.6
Horse Mesa	13+	7	7	8	8	8	1.6	0.9	0.9
Horseshoe	28+	18	17	16	16	16	1.8	1.1	1.0
Ive's Wash	5+	4	3	4	4	4	1.2	1.0	0.8
Ladders	25+	17	15	16	16	16	1.6	1.1	0.9
Lone Pine	8+	3	3	7	7	7	1.1	0.5	0.4
Mule Hoof	6+	2	2	7	6	6	0.8	0.3	0.3
Orme	6+	5	4	5	5	4	1.2	1.0	1.0
Perkinsville	0	0	0	2	2	2	0.0	0.0	0.0
Pinal	19+	16	12	12	12	12	1.6	1.3	1.0
Pinto	1+	0	0	3	3	3	0.5	0.0	0.0
Pleasant	2+	0	0	5	5	5	0.4	0.0	0.0
Redmond	27+	25	17	16	16	16	1.7	1.6	1.1
76	15+	12	11	10	10	10	1.5	1.2	1.1
Sheep	7+	2	0	9	9	9	0.8	0.2	0.0
Table Mountain	3+	1	1	4	4	4	0.8	0.2	0.2
Summary									
Total	381+	276	232	259	253	255	1.5	1.1	0.9
Active Breeding Areas	26	—	—	—	—	—	—	—	—
Mean	—	—	—	—	—	—	—	—	—
Known Breeding Areas	28	—	—	—	—	—	—	—	—

** Total occupied years with known data concerning eggs, young, and fledging.

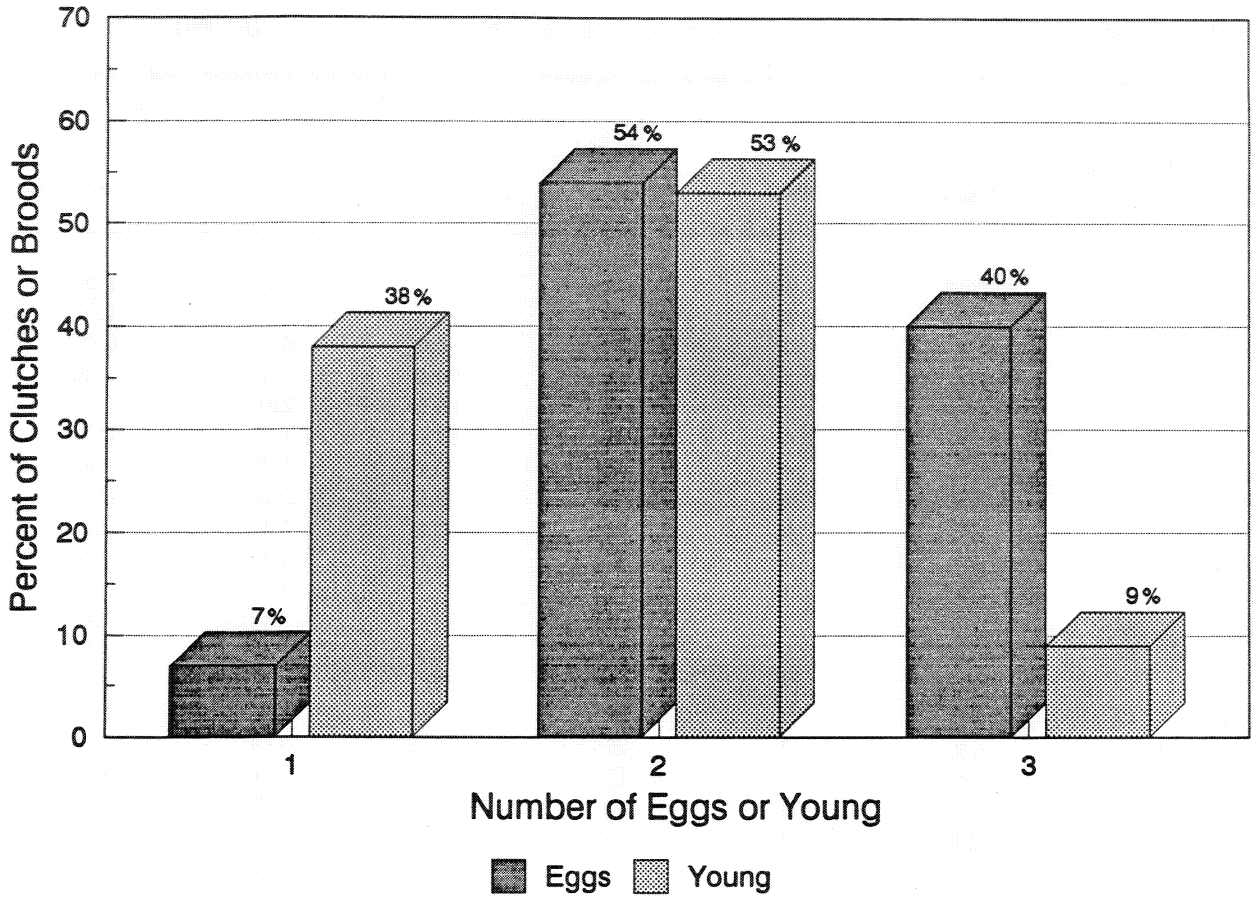


Figure C2.5-1. Percent of clutches (n = 43) and broods (n = 162) produced by Arizona bald eagles containing 1, 2, and 3 eggs or young.

America, 50 percent of broods contained one eaglet, 46 percent two eaglets, and 4 percent three eaglets (Stalmaster 1987). Arizona eagles produced 12 percent less one-eaglet broods, 7 percent more broods with two young, and 5 percent more broods with three young than the averages for other populations. Thus, the Arizona bald eagle population produces more two- and three-chick broods than the mean for other bald eagle populations. When these data are compared to clutch size, it is likely that Arizona eagles lay larger clutches and subsequently have larger broods than the mean for other bald eagle populations in North America.

A more accurate picture of the status of the Arizona bald eagle population is presented in Table C2.5-6. It is possible that more breeding areas existed in the 1960s and 1970s than we knew about, and those in remote areas, as well as some close to Phoenix, remained undiscovered for many years. For those breeding areas where known reproductive data existed, productivity, expressed as the number of young per occupied nest (Postupalsky 1974, see formulas on table) has fluctuated from 0.0 (1972) to 1.60 (1981) since 1970. However, by comparing productivity over five-year periods, a more stable picture appears, with values ranging from 0.85 to 1.11. Over the 21-year period (1970–1990), 226 known eaglets fledged, averaging 10.8 young per year (see Table C2.5-6).

Table C2.5-6. Known productivity at Arizona bald eagle breeding areas, 1970-1990.*

Year	Known Breeding Areas	Occupied Nests	Successful Nests	Young Fledged	Nest Success (%)	Mean Brood Size	Productivity
1970	2	2	2	3	100.0	1.5	1.50
1971	3	3	3	4	100.0	1.3	1.33
1972	4	3	0	0	0.0	0.0	0.00
1973	6	5	5	7	100.0	1.4	1.40
1974	8	5	3	6	60.0	2.0	1.20
1975	9	7	4	5	57.0	1.2	0.71
1976	9	5	4	7	80.0	1.7	1.40
1977	9	7	3	6	42.9	2.0	0.86
1978	11	10	6	9	60.0	1.5	0.90
1979	12	10	4	6	40.0	1.5	0.60
1980	12	9	3	5	33.3	1.7	0.56
1981	13	10	8	16	80.0	2.0	1.60
1982	14	13	8	14	61.5	1.7	1.07
1983	15	13	7	13	53.8	1.9	1.00
1984	18	17	8	15	47.1	1.9	0.88
1985	20	19	13	22	68.4	1.7	1.16
1986	21	16	12	17	75.0	1.4	1.06
1987	26	24	11	20	45.8	1.9	0.83
1988	27	23	15	24	65.2	1.6	1.04
1989	28	25	9	13	36.0	1.4	0.52
1990	28	26	9	14	34.6	1.6	0.54

SUMMARY

Five-year Period	Known Breeding Areas[1]	Young Produced Total	Young Produced Mean	% Nest Success	Mean Brood Size	Productivity
1970–1974	8	20	4.0	72.22	1.54	1.11
1975–1979	12	33	6.6	53.85	1.57	0.85
1980–1984	18	63	12.6	54.84	1.85	1.01
1985–1989	28	96	19.2	56.07	1.60	0.90
TOTAL (1970–1990)	28	226	10.8	54.37	1.65	0.90

* Nest Success = $\frac{\text{No. of occupied nests producing young}}{\text{No. of occupied nests}}$

Mean Brood Size = $\frac{\text{No. of young produced}}{\text{No. of successful nests}}$

Productivity = Nest success × mean brood size

[1] At end of five-year period.

We found it difficult to compare Arizona productivity data to that of other bald eagle populations, due to the variance in reproductive terminology. Postupalsky (1974) standardized these terms for raptors, but researchers did not always adhere to these definitions. Stalmaster (1987) reported that on average, a successful bald eagle nest contains 1.6 young. The mean brood size (number of young per successful nest) for the Arizona population from 1970–1990 was 1.65, equal to the average of other populations. The mean productivity for the Arizona population over the same period (1970–1990) was 0.90. This is equal to the average productivity (0.92) for other populations throughout North America (Stalmaster 1987).

Nest success, expressed as the percentage of occupied nests producing young (Postupalsky 1974), has fluctuated from 0–100 percent from 1970–1990 (Figure C2.5-2). However, by comparing data over five year periods, nest success appears more stable, ranging from 53.8 to 72.2 percent per period (Figure C2.5-3). Mean nest success over the 20-year period (1970–1989) was 56.64 percent, resulting in an average failure rate (100% minus nest success) of 43.36 percent. The relatively high nest success from 1970–1974 (72%) is likely an artifact of the low number of known nests during this period (n = 2–5). Nest success for the remaining three periods (1975–1979, 1980–1984, 1985–1989) was more stable (53–56%). Factors affecting nest success vary from one population to another, and areas with high

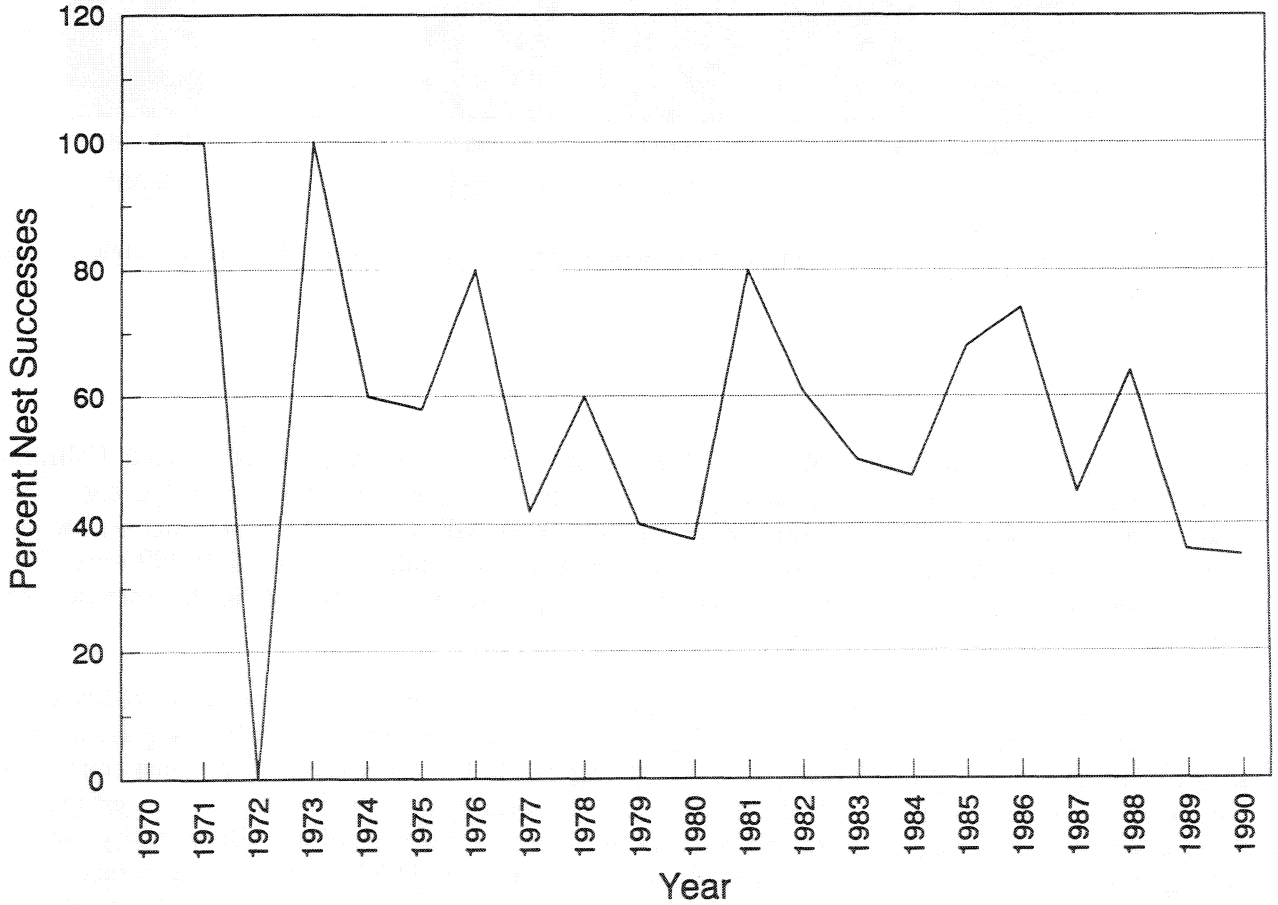


Figure C2.5-2. Percent nest success in Arizona, 1970–1990.

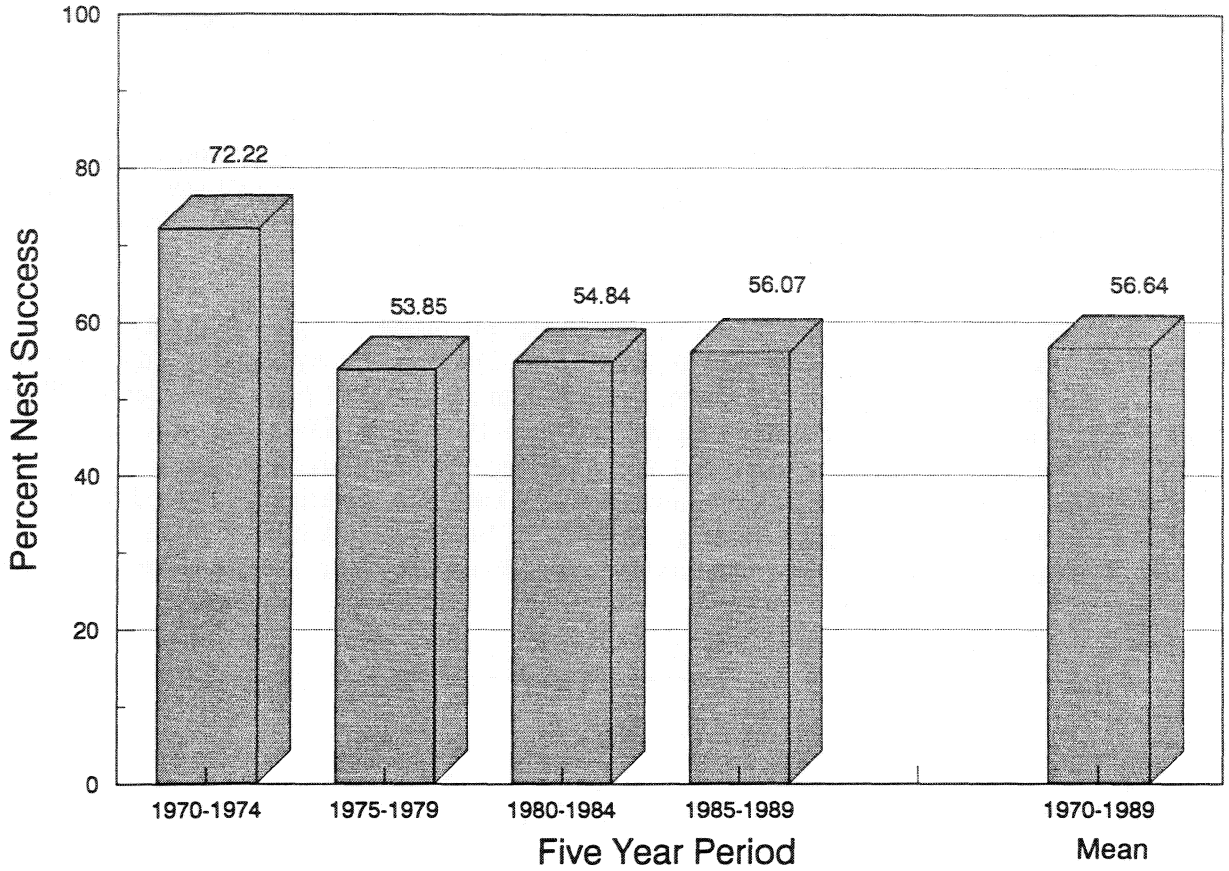


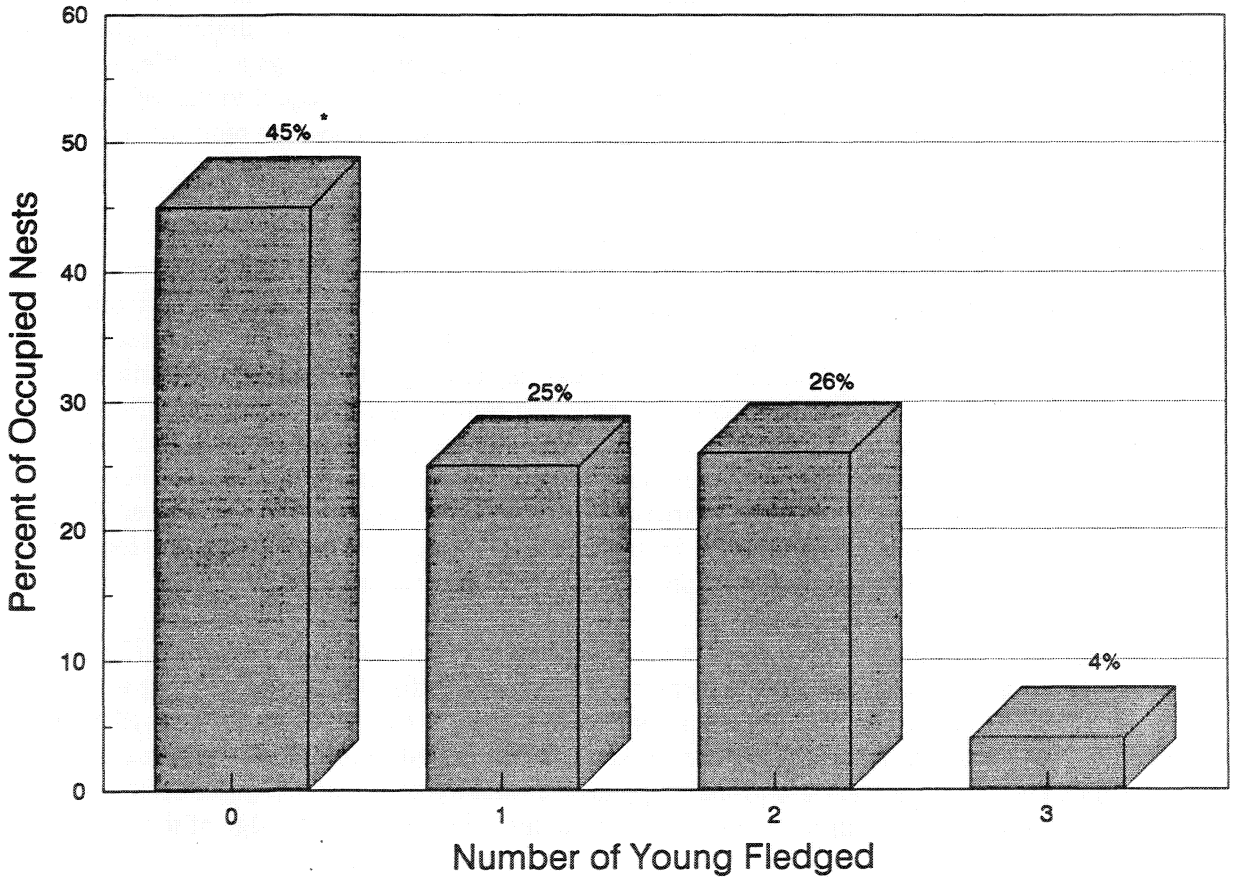
Figure C2.5-3. Percent nest success over five year periods, and mean nest success, for Arizona bald eagle breeding areas, 1970–1989.

DDT/DDE, e.g., Big Sur Coast, California (C. Himmelwright pers. comm.), Catalina Island, California (Garcelon *et al.* 1989), Great Lakes Region of the Midwest (Stalmaster 1987), or PCBs, e.g., Great Lakes Region of Midwest (National Wildlife Federation 1990), will tend to have a lower success rate than those in uncontaminated areas. Nest success for the Arizona population from 1970–1990 was 54.37 percent, which is 3.6 percent below the mean for other populations throughout North America (58%) reported by Stalmaster (1987).

It is important to note, however, that in Arizona we probably know more about the mortality of our eaglets than do researchers studying other populations. Nest success data for many populations is acquired from survey (ORA) flights when the young are 8–10 weeks old. In Arizona, due to the ABENWP and other projects, we have data on juvenile mortality prior to fledging. Thus, estimates of Arizona's nest success may decrease as a result of our greater knowledge of juvenile mortality just prior to fledging. However, the close watch we keep on Arizona nests (ABENWP) also increases survivorship by allowing us to intervene in emergency situations and save eaglets which would have otherwise perished.

The data presented in Figure C2.5-1, which describes the percent of clutches (n = 43) and broods (n = 162) produced by Arizona bald eagles containing 1, 2, and 3 eggs or young, only includes active nests (eggs laid) and does not take nestling mortality into consideration. A complete analysis of productivity in the Arizona population also needs to address the percent and number of young fledged at occupied nests (Figure C2.5-4). This method takes into account pairs that do not lay eggs, eggs that fail to hatch, and young that survived to fledge. Thus, of 258 occupied nests in Arizona for all years, 45 percent (n = 116) did not produce young, 25 percent (n = 63) fledged one eaglet, 26 percent (n = 68) produced two young, and 4 percent (n = 11) fledged three eaglets. The 45 percent (n = 116) of nests which did not produce young can be further separated into 14.3 percent (n = 37) that apparently did not lay eggs, 23.3 percent (n = 60) where the eggs failed to hatch, and 7.4 percent (n = 19) where the entire brood died prior to fledging.

In other bald eagle populations throughout North America 47 percent of occupied nests did not produce young, 27 percent fledged one eaglet, 24 percent produced two young, and 2 percent fledged three eaglets (Stalmaster 1987). The Arizona bald eagle population showed 2 percent less nest failures (or no eggs laid), had 2 percent less one-eaglet broods, 2 percent more broods with two young, and 2 percent more broods with three young than the averages for other populations.



* 14% did not lay eggs and 31% failed to hatch.

Figure C2.5-4. Percent and number of young produced at occupied bald eagle nests in Arizona.

Arizona bald eagles have produced 381 known eggs, of which 276 (72%) hatched nestlings, and 28 percent died or were infertile. Of course, the actual number of eggs from those nests was likely greater than 381. Egg numbers in Arizona are often estimated from the number of young hatched (see above); thus, the actual egg mortality rate is likely higher than 28 percent. Of the 276 eaglets hatched, 232 (84%) fledged, and 16 percent died. Stalmaster (1987) presented data on 451 eggs from other bald eagle populations throughout North America, of which 75 percent hatched and 25 percent died; of 433 young, 85 percent fledged and 15 percent died. Although the comparison hints that the Arizona population has a higher rate of egg (at least 3%, but likely more) and nestling (1%) mortality, the difference was not significant by Chi-Square.

In summary, the Arizona bald eagle population produces more two- and three-chick broods than the mean for other bald eagle populations throughout North America. When these data are compared to clutch size (using known or estimated Arizona clutch size data), Arizona eagles lay larger clutches, resulting in larger broods than the mean for other populations. However, nestling survival rates in Arizona are similar to those in other populations.

Nest-bound eaglets do not have access to free water, and Arizona has less precipitation and higher temperatures, than other populations which likely results in an increased incidence of heat stress (see Section C3.5). In addition, nest parasites, which appear to be more common in cliff-nesting raptors (Platt 1975, Grubb 1986b), including bald eagles (Section C3.4), may also contribute to slightly higher levels of nestling mortality than other populations experience. Although Arizona nestlings are subjected to heat stress and Mexican chicken bugs, the nestling mortality in Arizona is roughly equal to that of other bald eagle populations in North America. See Section C3.2 for further details on nestling mortality in Arizona bald eagles.

C2.5.3 Analysis of Reproduction at Breeding Areas

Productivity at an individual nest site in any one year is the result of a multitude of factors including, but not restricted to: (1) stability of nesting structure; (2) changes in the adult pair; (3) fertility of adults; (4) nesting and foraging experience of adults; (5) food availability; (6) climate (e.g., heat, cold, precipitation, flooding, wind)(Section C3.5); (7) human disturbance and impact, e.g., monofilament (Section C3.3), poisoning, shooting, black-market feather trade, farming and ranching practices (Sections C3 and C4); (8) intraspecific and interspecific interactions (predation, territorial disputes) (Section D7); and, (9) nest parasites (Section C3.4). Therefore, the productivity of the population is not merely the species' general capability to reproduce, but its evolutionary predisposition to adapt and survive in an ever-changing ecosystem. The matter is further compounded by the bald eagles' location at the top of the food chain, where it may be impacted by how its prey adapts to similar environmental changes.

C2.5.3.1 Occupancy. Little was known about breeding bald eagles in Arizona prior to 1972 when the USFWS began monitoring the population (Rubink and Podborny 1976). Only two breeding areas were known to agency personnel in 1970, eight nest sites had been located by 1974, 12 by 1979, 18 by 1984, and 28 by 1989. The number of breeding areas in Arizona is expected to increase as nest search efforts continue. Some new breeding areas are probably pioneer efforts by an expanding population, but many contain multiple nests, indicating they were probably occupied prior to our knowledge of their existence.

An occupied breeding area, as defined by Postupalsky (1974), is an area containing a nest in which:

a. Young were raised;
b. Eggs were laid;
c. An adult was observed sitting low in the nest, presumably incubating;
d. Two adults were observed perched on or near the nest;
e. An adult and a bird in immature plumage were observed at or near the nest, if courtship behavior occurred; or,
f. Recent repairs (fresh sticks or lining), mute, or feathers were visible at or near the nest.

Therefore, an unoccupied breeding area is an area containing a nest at which none of the above indicators is observed. An active nest is a nest in which eggs have been laid. A failed nest is an active nest in which eggs did not hatch, or young died before reaching an advanced stage of development. A successful nest is an active nest in which at least one young survived to an advanced stage of development (Postupalsky 1974).

Historical reports of occupancy exist for several bald eagle breeding areas in Arizona, some dating to the early 1900s (sections D3 and D5). When discussing breeding area occupancy, it is important to note that a nest site recorded as unoccupied in any one year, simply means no eagles were seen at *known* nest sites. Throughout this study, we have discovered previously unknown nest locations at many breeding areas (Blue Point, Canyon, Coolidge, Lone Pine, Orme, Pinal, Redmond, Table Mountain). In most cases the nests existed prior to discovery, and several contained old eggshell fragments (Coolidge, Orme, Pinal, Table Mountain). The presence of eggshells indicates the eagles nested in a year when the breeding area was either recorded as unoccupied or was as yet undiscovered.

Of the 28 known breeding areas in Arizona, 11 have been recorded as unoccupied. Since Rubink and Podborny (1976) began documenting Arizona bald eagle nesting activity in the early 1970s, six sites have shown apparent occupancy problems. Mule Hoof has the highest percentage of unoccupied years (65%, n = 11 years), followed by Pleasant (58%, n = 7), Ash (56%, n = 5), Chino (50%, n = 3), Blue Point (35%, n = 7), and Ladders (16%, n = 3). Of the remaining five breeding areas, Cibecue was recorded as unoccupied for two years, and Cedar Basin, Pinal, East Verde, and Fort McDowell were reported unoccupied for one year each.

Mule Hoof Breeding Area. The Mule Hoof breeding area, first known active in 1935 (Phillips *et al.* 1964), fledged two young in 1974 (Rubink and Podborny 1976). The pair laid eggs in three other years (1975, 1978, 1979), but failed. Nest 2 was refurbished by the eagles in 1982 (Haywood and Ohmart 1983) and a pair of adults were observed on nest 1 in 1990. In the other 11 years since 1974, the territory has remained unoccupied at known nest locations, although one adult was sighted on Nest 1 in 1988. Hypotheses on the lack of occupancy at Mule Hoof are discussed in Section D4.19.

Pleasant Breeding Area. The Pleasant breeding area was discovered in 1979, however, it was not known to be active until 1984. The Pleasant pair, a full adult female and a near-adult male, laid eggs in 1984 and 1985, which failed to hatch (U.S. Bureau of Reclamation 1984b, Berger and Droege 1985). The two known nests were unoccupied in 1986, although one adult was in the nest area from January to February (Berger *et al.* 1986). A pair of adults were observed near the nest cliffs on 25 November 1986 (Walchuk 1986), and a pair was perched near the cliff nest on 2 June 1987 (T. Gatz pers. comm.), indicating the pair may have nested in an unknown location in 1987. The two known nests were unoccupied in 1988,

however, four adults were sighted in the nest area during a carp spawn in March (T. Gatz pers. comm.). Adults were sighted in the area in 1989, although no nest activity occurred. In 1990, a new pair occupied the cliff nest, a near-adult male (ca. 4 years old), and a female with a USFWS band on her left tarsus (M. Cross pers. comm.). It is possible the Pleasant eagles are nesting in unknown nest locations, due to their sporadic appearance in the area. The two known nest sites have been unoccupied for seven of the 12 years we have known about the breeding area, and (to our knowledge) the pair has never been successful.

Ash Breeding Area. The two Ash nests were reported in 1982 (B. Jackson pers. comm.), although the breeding area was not found by agency personnel until 1984. The Ash eagles fledged one young in 1984, and two in 1985 (Grubb 1986a). The two known nest locations have remained unoccupied since 1986, however, adults have been observed at the Highway Tanks, 2.5 km to the east, in 1986 and 1987 (Hughes pers. comm.). These observations, supported by the sighting of two juvenile bald eagles perched north of the known nest sites in late May 1986 (Hughes pers. comm.) strongly suggest the breeding area is active at a new nest location.

The Ash breeding area is located in the mountains south of the Salt River, on an intermittent stream (Ash Creek). However, the pair delivered suckers to the nest as prey when the creek was dry in 1985 (Driscoll 1985b) and therefore must have traveled to the Salt River for at least some foraging. It is interesting that the two known Ash nests are 11.0 km (by air) from the Salt River at Mule Hoof Bend (Km 191) and 11.5 km (by air) from the Salt River at Black Rock Rapid (Km 159— just below Gleason Flat). Thus, in nesting there, the Ash pair could access either section of the river.

Chino Breeding Area. The Chino breeding area was discovered in 1985, when it fledged two young. The eggs failed to hatch in 1986, however, two young were fostered into the nest from the inundated Horseshoe nest site, and fledged. In December 1986, the Chino female (or pair) moved to 7.5 Km downstream and built a nest on the north shore of Alamo Reservoir (see Section D4.1). A new female (or pair) built a nest in a snag just upstream of the 1985/1986 nest at Chino in 1987 and laid two eggs. The eggs failed to hatch and the limb and nest fell in May 1987. The breeding area has been unoccupied at known nest locations since 1988. The Big Sandy River is dry during part of the year, and the Chino pair utilized the reservoir on all occasions when observations were made there in 1986 (Sudar and Morgan 1986). The Alamo and Ive's Wash pairs already have nests on upper Alamo Reservoir, and it is possible that the available habitat cannot support three bald eagle breeding areas on this section of the Big Sandy, Santa Maria, and Bill Williams rivers.

Blue Point Breeding Area. The Blue Point breeding area, with early records dating to the 1930s (Phillips *et al.* 1964), was reported as unoccupied from 1973–1978. Our current knowledge of the Blue Point pair and their extensive use of Saguaro Reservoir (see, Section B4.2), indicate that the pair may possibly have nested in one of the side canyons off the reservoir during this period. In 1987, we discovered the eagles, with three young, in a previously unknown nest on a side canyon off Willow Springs Cove on Saguaro Reservoir. Nests situated inland from water sources (Blue Point, Orme) are difficult to locate, which may account for the eagles' choice of location. Both of these breeding areas experience an extraordinary amount of human recreation pressure.

Ladders Breeding Area. The Ladders breeding area has been active since 1962, but it was not discovered by management agencies until 1972, and has since produced at least 25 eggs, hatching 17 young, of

which 15 have fledged (Section D4.17). The nest site has no apparent problems (see Section B4.3), however, the known nests were unoccupied from 1974–1976 (Rubink and Podborny 1976).

C2.5.3.2 Egg Production. There are several Arizona bald eagle breeding areas which are occupied year to year, but fail to lay eggs. Possible reasons why a pair of eagles would not lay eggs in a given year might include mate replacement, infertile or contaminated adults, or stress induced by disturbance. Breeding areas which may have egg-laying problems in Arizona include Sheep, Devil's Post, Cliff, Coolidge, Pleasant (see above), Pinto, and Perkinsville.

The Sheep breeding area, on Tonto Creek, has been occupied each of the nine years since its discovery in 1982. The eagles have laid seven eggs in four years, two of which hatched, but the nestlings died at 1–2 days of age. The Sheep adults apparently did not lay eggs in the remaining five years. Food habits data indicate the Sheep breeding area may have a prey availability problem.

The Devil's Post breeding area on Burro Creek has been occupied at least since the early 1970s, but was not discovered by management agencies until 1987. The adult pair has been present each year since, but they have apparently never laid eggs. On two separate occasions in 1990, both adults were observed with what appeared to be grease or oil smears on their heads and tails (R. Hall and M. Cross pers. comm.).

Both Cliff adults were already banded when the breeding area was discovered in 1984 and have occupied the site since; however the pair did not lay eggs in 1987 or 1990. Failure to lay eggs in 1990 may have been related to disturbance in the breeding area (see Section D4.9).

The Pinto breeding area is an interesting case, involving a polygynous relationship with the Pinal male (see Section D4.23). The Pinto female and Pinal male have built nests and copulated each year since we discovered the site in 1987. The Pinto female apparently did not lay eggs in 1988 or 1990. In 1989, at least one egg was laid, but the Pinal male did not assist in incubation, and the Pinto female had to leave the egg(s) to forage.

The Coolidge pair was discovered in 1985 and the eagles have laid at least eight eggs, fledging five young from 1985–1988. The pair apparently did not laid eggs in 1989 or 1990. Gila River flows were terminated below Coolidge dam during the early part of the 1990 breeding season; however, we do not know if this affected egg laying.

The Perkinsville breeding area was at least occupied (may have been active) in the 1960s and early 1970s, but remained unoccupied from 1973–1988. A pair of eagles, at least one of which was a near-adult (ca. four-years-old), built a nest at Perkinsville in 1989, although apparently no eggs were laid. A near-adult pair (ca. five years old) (female banded on right tarsus) did not lay eggs again in 1990.

C2.5.4 Trends In Productivity

Of 295 *known* nests (territory/years) from 1970–1990, only 15 percent were unoccupied; 85 percent were occupied, 73 percent active (laid eggs), and 46 percent successfully fledged young (Figure C2.5-5). This nest occupancy rate for Arizona bald eagles was 14 percent higher than that for other populations throughout North America, which Stalmaster (1987) noted was 71 percent. Similarly, Arizona nests were active 5 percent above the average for other populations (68%), and were successful 3 percent more often than the mean for other populations (43%)(Stalmaster 1987).

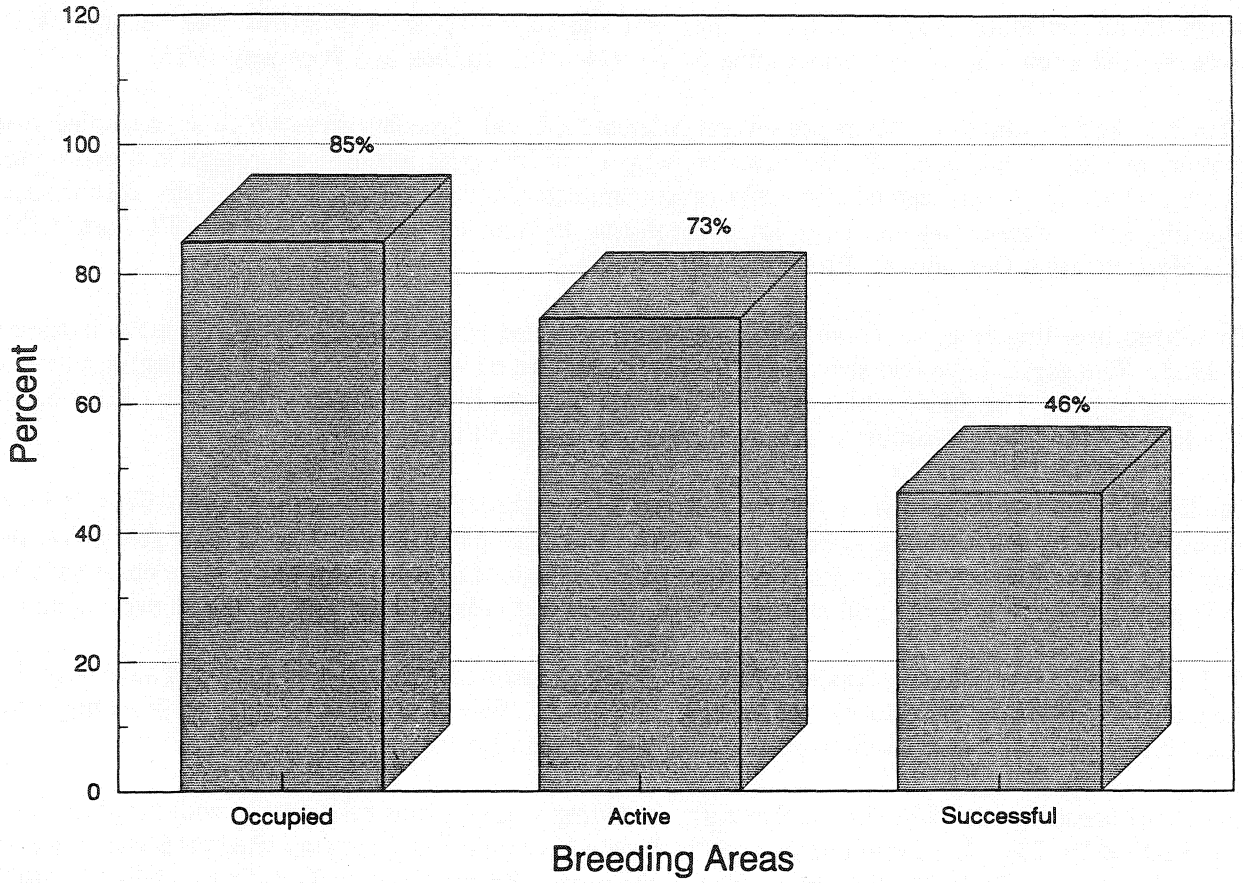


Figure C2.5-5. Percent of known Arizona bald eagle breeding areas which were occupied, active, and successful, from 1970–1990.

Although the Arizona eagles occupy, lay eggs, and fledge young at a higher percentage of *known* breeding areas relative to other populations, the decreasing percentage differences (14 to 5 to 3) indicates that fewer Arizona pairs that occupy breeding areas lay eggs and fledge young. From 1970–1990, Arizona eagles attempted to breed (laid eggs) at 85 percent (215) of the occupied nests (252), but only 54 percent (137) of the occupied nests successfully fledged young (Figure C2.5-6). Of the 85 percent (215) which laid eggs, 64 percent (137) successfully fledged eaglets. Arizona adults did not lay eggs at 15 percent of the *known* occupied breeding areas from 1970–1990. The number of known *occupied* bald eagle breeding areas in Arizona has increased from two in 1970, to five by 1974, 10 by 1979, 17 by 1984, and 26 by 1990 (Table C2.5-7).

Arizona bald eagles laid eggs at *occupied* breeding areas 4 percent less than the mean for other populations throughout North America (89%), and fledged young at *occupied* sites 4 percent less than the average for other populations (58%) reported by Stalmaster (1987). Of pairs which laid eggs, Arizona eagles fledged young from 2 percent more nests than the mean for other populations throughout North America (Stalmaster 1987). However, as explained in the first section (D4.8) many of these nest sites suffered brood reductions prior to fledging.

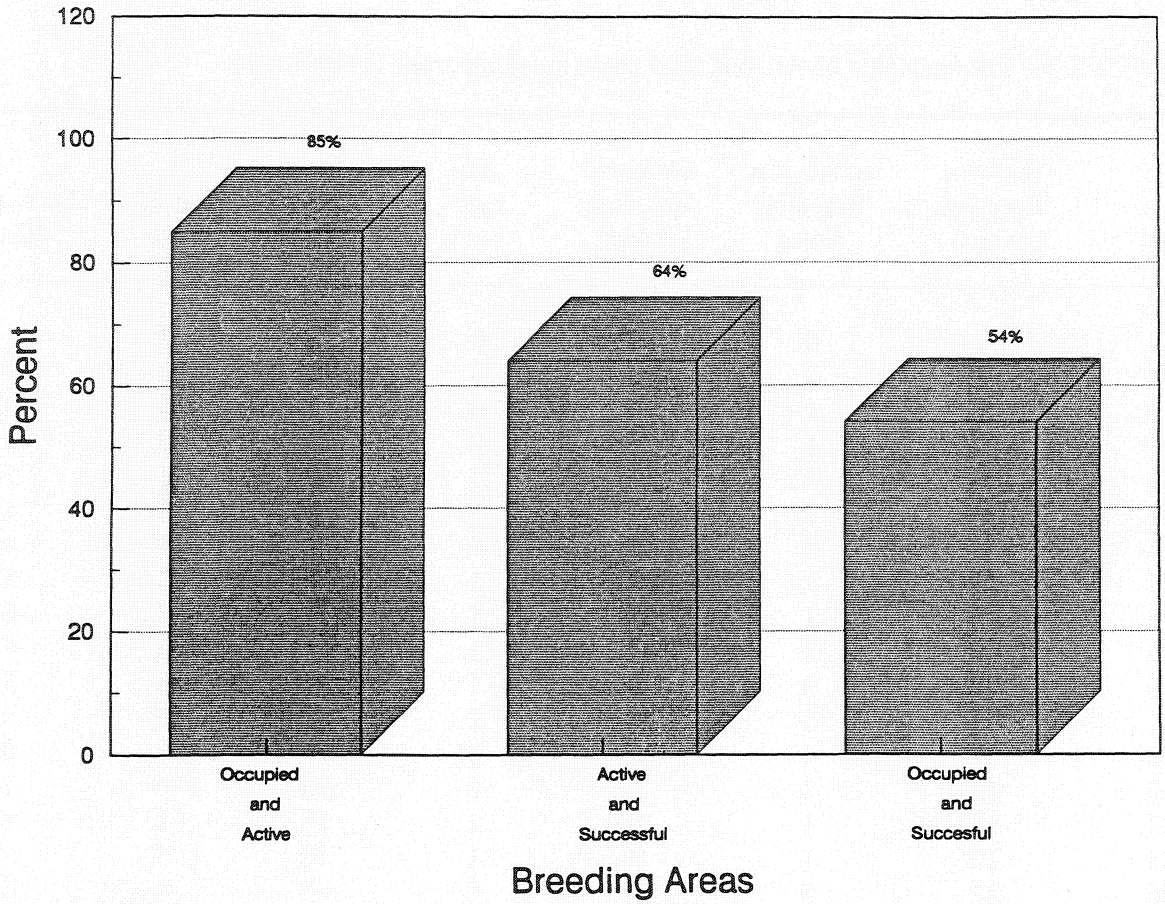


Figure C2.5-6. Percent of known Arizona bald eagle nests which were occupied and active, active and successful, and occupied and successful, from 1970–1990.

When the Southwest Bald Eagle Recovery Plan was written in 1982, eight of 13 occupied nests were successful, fledging 14 young for a productivity index of 1.07. The number of successful nests peaked at 15 (of 23 occupied sites) in 1988, fledging a record 24 young, although productivity remained stable at 1.04. In 1988 we observed near-adult bald eagles (ca. 4 years old) in four pairs, and replacements at an additional five nest sites (see sections A5.2 and C3.7). In 1989, as temperatures rose during the early nesting season (Section C3.5), the number of successful nests plunged to nine, fledging only 13 young, and productivity fell to 0.52. We observed an additional near-adult in a pair and four replacements in 1989. In 1990, nine nests fledged 14 young and productivity was 0.54, similar to 1989. We recorded four near-adults in breeding pairs in 1990, and two more replacements.

Such a high rate of change in adult tenure at Arizona bald eagle breeding areas suggests factors other than natural mortality are at work, such as shooting. However, some replacements may be due to increased altercations with other eagles seeking breeding status. Although partially due to a greater knowledge of nest locations, the number of young fledged ranged from less than 10 per year prior to 1980, to 16 in 1981, 22 in 1985, 24 in 1988, and then 13 in 1989 and 14 in 1990.

Table C2.5-7. Known status of Arizona bald eagle breeding areas, 1970–1990.

Year	Known Breeding Areas	Unoccupied Breeding Areas	Occupied Breeding Areas	No Eggs Laid	Active Nests	Failed Nests	Successful Nests
1970	2	0	2	0	2	0	2
1971	3	0	3	0	3	0	3
1972	4	1	3	0	3	3	0
1973	6	1	5	0	5	0	5
1974	8	3	5	1	4	1	3
1975	9	2	7	0	7	3	4
1976	9	4	5	0	5	1	4
1977	9	2	7	1	6	3	3
1978	11	1	10	1	9	3	6
1979	12	2	10	1	9	5	4
1980	12	3	9	1	8	5	3
1981	13	3	10	2	8	0	8
1982	14	1	13	3	10	2	8
1983	15	2	13	0	13	6	7
1984	18	1	17	1	16	8	8
1985	20	1	19	1	18	5	13
1986	21	5	16	0	16	4	12
1987	26	2	24	5	19	8	11
1988	27	4	23	3	20	5	15
1989	28	3	25	8	17	8	9
1990	28	2	26	9	17	8	9
Total	295	43 +	252	37 +	215	78 +	137
Sum Total		295		252		215	
Percent		15 +	85	15 +	85	36 +	64
Sum Percent		100		100		100	

Even with the large increase in fledged young over the years, Arizona still lacks a substantial floating population of non-breeding adults. This is apparent by the number of breeding pairs containing near-adult eagles each year. Normally, the floating population of full-adult eagles would be expected to increase as surviving cohorts accumulate or after the nesting population reaches carrying capacity and eventually a stable age-distribution. On the other hand, the values of natality and mortality may have changed in

recent years. As Stalmaster (1987) points out, "A population may be reproducing at a maximum rate, but if the survival of full-grown birds is poor, the population can rapidly become extinct!"

Wet Cycles. It has been hypothesized in the past that wet cycles (periods of increased precipitation) in Arizona result in increased bald eagle productivity and population growth. Two factors which complicate this analysis include differential rainfall (or snow) at each breeding area and the seasonality of rain. Most precipitation in Arizona comes with the "monsoons" (storms from the Gulf of Mexico in July and August) and during the winter months. The greatest annual precipitation (measured at Sky Harbor Airport in Phoenix) was 19.73 in. in 1905, and the least was 2.82 in. in 1956. Mean annual precipitation is 7.11 in. (Office of State Climatologist 1990). Peaks in rainfall occurred in 1978 (16 in.), 1983 (13.5 in.), and 1984 (15 in.) (Table C2.5-8). In the same years, nest success was 60.0, 53.8, and 47.1 percent, respectively. Low precipitation levels occurred in 1975 (4 in.), 1977 (3 in.), 1979 (6.5 in.), 1980 (6 in.), and 1989 (5 in.). Nest success in these years was 57.0, 42.9, 40.0, 33.3, and 36.0 percent, respectively.

It is interesting that 1989 (4.94 in.) was the driest year since 1977 (3.16 in.) and had 143 days of temperatures in excess of 100° F; nest success dropped to 36.0 percent. Nest success was also low in 1990 (34.6%) when precipitation levels were slightly above normal (7.73 in.) and in 1980 (33.3%) when annual rainfall was 6 in.. Therefore, nest success does not appear to fluctuate directly with annual rainfall.

Annual rainfall also showed no direct apparent relationship to the discovery of "new" breeding areas or the number of young produced. In 1980, when agency personnel knew of 12 breeding areas, annual rainfall in Phoenix was 6 inches. Precipitation increased each year (7.5 in. in 1981, 10 in 1982, 13 in 1983) to a high of 15 in. in 1984. From 1985–1990, annual rainfall remained at 7.5–8.5 in., excluding 1989 when it fell to 5.0 in. (U.S. National Oceanic and Atmospheric Administration). During the period 1980–1985, the number of known breeding areas rose from 12 to 20, and fledged young increased from 5 to 22. As precipitation returned to normal levels from 1985–1990, the number of known breeding areas continued to rise (partially due to increased nest search efforts) to 28 in 1989 (see Section C2.0). The number of young fledged dropped to 17 in 1986, rose to 20 in 1987, peaked at 24 in 1988, then declined to 13 in 1989 and 14 in 1990.

In an effort to discover a pattern in the data, we plotted annual precipitation and nest success from 1975-1990 (we removed the pre-1975 data because of possible bias associated with the low number of known breeding areas). The regressions showed no relationship between nest success and precipitation in the same calendar year, the previous calendar year, or a 5-year moving average of precipitation. Although Arizona bald eagle nest success, the number of young produced, and the discovery of "new" breeding areas did not appear to fluctuate with annual precipitation, other factors such as extended periods of high temperatures, or flood conditions creating high and turbid river flows, may obscure any relationship.

C2.5.5 Ranking of Breeding Areas

Of the 297 total nest-years of known productivity data, Arizona breeding areas successfully fledged young in 46 percent of nest-years, failed in 26 percent, were occupied but did not lay eggs in 12 percent, remained unoccupied 14 percent, and status was unknown (site not checked) in 1 percent of nest-years (Table C2.5-9).

We ranked the 28 Arizona bald eagle breeding areas based on the total known number of young produced over the years (in the case of a tie, we considered number of successful years, percent of successful years

Table C2.5-8. The relationship of nest success and the number of known Arizona bald eagle breeding areas to annual precipitation in Phoenix.*

Year	Precipitation (inches)	Nest Success	Known Breeding Areas
1965	11.0	—	—
1966	7.0	—	—
1967	8.0	—	—
1968	5.5	—	—
1969	7.0	—	—
1970	7.5	100.0	2
1971	3.5	100.0	3
1972	11.0	0.0	4
1973	6.0	100.0	7
1974	8.0	60.0	8
1975	4.0	57.0	10
1976	7.5	80.0	10
1977	3.0	42.9	10
1978	16.0	60.0	11
1979	6.5	40.0	12
1980	6.0	33.3	12
1981	7.5	80.0	13
1982	10.0	61.5	14
1983	13.5	53.8	15
1984	15.0	47.1	18
1985	7.5	68.4	20
1986	7.5	75.0	21
1987	8.0	45.8	26
1988	7.5	65.2	27
1989	5.0	36.0	28
1990	7.7	34.6	28

* Precipitation data from U.S. National Oceanic and Atmospheric Administration.

Table C2.5-9. Status of bald eagle breeding areas in Arizona since discovery or the first year of recorded data.*

Breeding Area	Year**	Successful	Failed	Occupied	Unoccupied	Total Unknown	Years
Alamo	1987	3 (75)	—	1 (25)	—	—	4
Ash	1984	2 (29)	—	—	5 (71)	—	7
Bartlett	1970	14 (67)	7 (33)	—	—	—	21
Blue Point	1971	8 (40)	2 (10)	3 (15)	7 (35)	—	20
Canyon	1986	5 (100)	—	—	—	—	5
Cedar Basin	1978	1 (8)	9 (69)	2 (15)	1 (8)	—	13
Chino	1985	1 (17)	2 (33)	—	3 (50)	—	6
Cibecue	1973	8 (44)	6 (33)	1 (6)	2 (11)	1 (6)	18
Cliff	1984	2 (29)	3 (43)	2 (29)	—	—	7
Coolidge	1985	3 (50)	1 (17)	2 (33)	—	—	6
Devil's Post	1987	—	—	4 (100)	—	—	4
East Verde	1973	14 (78)	3 (17)	—	1 (6)	—	18
Fort McDowell	1968	18 (78)	3 (13)	—	1 (4)	1 (4)	23
Horse Mesa	1983	4 (50)	4 (50)	—	—	—	8
Horseshoe	1975	9 (56)	6 (38)	1 (6)	—	—	16
Ive's Wash	1987	3 (75)	1 (25)	—	—	—	4
Ladders	1972	8 (42)	7 (37)	1 (5)	3 (16)	—	19
Lone Pine	1984	2 (29)	4 (57)	1 (14)	—	—	7
Mule Hoof	1974	1 (6)	3 (18)	2 (12)	11 (65)	—	17
Orme	1987	3 (75)	—	1 (25)	—	—	4
Perkinsville	1989	—	—	2 (100)	—	—	2
Pinal	1978	9 (69)	3 (23)	—	1 (8)	—	13
Pinto	1988	—	1 (33)	2 (67)	—	—	3
Pleasant	1979	—	2 (17)	3 (25)	7 (58)	—	12
Redmond	1974	11 (65)	4 (24)	2 (12)	—	—	17
76	1981	8 (80)	1 (10)	1 (10)	—	—	10
Sheep	1982	—	4 (44)	5 (56)	—	—	9
Table Mountain	1987	1 (25)	2 (50)	1 (25)	—	—	4
Total		138 (46)	78 (26)	37 (12)	42 (14)	2 (1)	297

* Number represents years at indicated status. Value in parenthesis is percent of years at status.
** Year of discovery or first year of recorded productivity data.

since a site's discovery or first recorded data, and the mean number of young produced per known occupied year (Table C2.5-10). Overall, the Fort McDowell territory has been the most productive site, fledging 33 young in 18 successful years since 1968, with a mean of 1.6 young per occupied year. The East Verde breeding area ranked second, fledging 26 young in 14 successful years since 1973, with a mean of 1.5 young per occupied year. Blue Point was third, fledging 22–24 young in 8 successful years since 1971, with a mean of 1.5–1.6 young per occupied year.

The Canyon eagles have successfully fledged young each year since the breeding area's discovery in 1986, but is ranked 12th due to the low number of young produced (6) overall. The Coolidge eagles have fledged five young since 1985, but is ranked 17th, below more recently discovered sites which have fledged a higher number of mean young per year. The Cliff breeding area is ranked 18th for similar reasons.

The Sheep breeding area was the least productive site. Although eggs were laid in four of the nine occupied years at Sheep; two young have hatched, but none fledged. Although Sheep is the least productive site, the Cedar Basin breeding area has experienced the most nest failures. The Cedar Basin eagles have laid at least 14 eggs in 12 years; however, only two known young have hatched and fledged.

In order to determine the aquatic habitat type containing the most productive bald eagle breeding areas in Arizona, we used the percent of successful years (since each breeding area's discovery or the first recorded productivity data) and mean number of young produced (in occupied years with known productivity data) at territories where the eagles forage on: (1) regulated rivers only (below dams); (2) regulated rivers and reservoirs; (3) reservoirs only; (4) free-flowing rivers and reservoirs; (5) free-flowing rivers only; and, (6) free-flowing creeks. For this comparison, we included the Ash and Canyon eagles (which nest about 13 km north and south of the upper Salt River) in the free-flowing creek category. Ash Creek is intermittent, remaining dry most of the year, and although foraging data are largely lacking on these pairs, it is suspected they travel to the Salt River to forage (see sections D4.2 and D4.5). Similarly, although the Orme breeding area includes a small run-of-river reservoir behind the Granite Reef Diversion Dam (Maxwell Reservoir) the breeding area was categorized as regulated river only, since the habitat features (and likely the fishery) of the "reservoir" more closely resemble a river. For the East Verde Breeding Area, although the eagles often forage in the artificially supplemented East Verde River, we included the territory in the category of free-flowing rivers. The reason is that the East Verde River exhibits the characteristics of a free-flowing stream. Note that, for ranking, we used data on the total number of years since discovery so as to consider occupancy problems possibly stemming from habitat quality.

Arizona breeding areas on regulated rivers were the most productive, having been successful in 78 percent of years, with a mean of 1.5 young (Table C2.5-11). Pairs foraging on regulated rivers and reservoirs ranked second, and were successful in 52 percent of years, with a mean of 1.0 young produced. Eagles on reservoirs ranked third, having been successful in 50 percent of years, with a mean of 0.9 young. Fourth ranked were eagles that forage on free-flowing rivers and reservoirs, which were successful in 41 percent of years, with a mean of 0.8 young produced. Following closely behind were pairs that forage only on free-flowing rivers, which were successful in 40 percent of years, producing a mean of 0.8 young. Breeding areas on free-flowing creeks ranked sixth, successful in 43 percent of years, with a mean of 0.7 young produced.

Table C2.5-10. Arizona bald eagle breeding areas ranked by productivity and nest success.*

Rank	Breeding Area	Year**	Successful Years No.	Successful Years %	Total Young Produced	Occupied Years with Known Data	Mean Young Produced
1	Fort McDowell	1968	18	78	33	21	1.6
2	East Verde	1973	14	78	26	17	1.5
3	Blue Point	1971	8	40	22-24	15	1.5-1.6
4	Bartlett	1970	14	67	20	22	0.9
5	Redmond	1974	11	65	17	16	1.1
6	Horseshoe	1975	9	56	17	16	1.1
7	Ladders	1972	8	42	15	16	0.9
8	Pinal	1978	9	69	12	12	1.0
9	76	1981	8	80	11	10	1.1
10	Cibecue	1973	8	44	11	15	0.7
11	Horse Mesa	1983	4	50	7	8	0.9
12	Canyon	1986	5	100	6	5	1.2
13	Alamo	1987	3	75	4	4	1.0
14	Orme	1987	3	75	4	4	1.0
15	Ash	1984	2	29	3	2	1.5
16	Ive's Wash	1987	3	75	3	4	0.8
17	Coolidge	1985	3	50	5	6	0.8
18	Cliff	1984	2	29	4	7	0.6
19	Chino	1985	1	17	2	3	0.7
20	Lone Pine	1984	2	29	3	7	0.4
21	Mule Hoof	1974	1	6	2	6	0.3
22	Table Mountain	1987	1	25	1+	4	0.2
23	Cedar Basin	1978	1	8	2	12	0.2
24	Perkinsville	1989	0	—	0	2	0.0
25	Pinto	1988	0	—	0	3	0.0
26	Devil's Post	1987	0	—	0	4	0.0
27	Pleasant	1979	0	—	0	5	0.0
28	Sheep	1982	0	—	0	9	0.0
Total	297	138	46	232	255	0.9	

* Ranking based on number of young produced, number of successful years, percent of successful years, and mean number of young produced.

** Year of discovery or first year of recorded productivity data.

Table C2.5-11. Aquatic habitat types ranked by the productivity and nest success of Arizona bald eagle breeding areas.*

Rank	Breeding Area	Year**	Successful Years No.	Successful Years (%)	Total Young Produced	Occupied Years With Known Data	Mean Young Produced
Regulated River							
1	Fort McDowell	1968	18	(78)	33	21	1.6
14	Orme	1987	3	(75)	4	4	1.0
1	2	27	21	(78)	37	25	1.5
Regulated River and Reservoir							
3	Blue Point	1971	8	(40)	22-24	15	1.5-1.6
4	Bartlett	1970	14	(67)	20	22	0.9
16	Ive's Wash	1987	3	(75)	3	4	0.8
17	Coolidge	1985	3	(50)	5	6	0.8
18	Cliff	1984	2	(29)	4	7	0.6
2	5	58	30	(52)	55	54	1.0
Reservoir							
11	Horse Mesa	1983	4	(50)	7	8	0.9
3	1	8	4	(50)	7	8	0.9
Free-Flowing River and Reservoir							
6	Horseshoe	1975	9	(56)	17	16	1.1
8	Pinal	1978	9	(69)	12	12	1.0
13	Alamo	1987	3	(75)	4	4	1.0
19	Chino	1985	1	(17)	2	3	0.7
25	Pinto	1988	0	0	—	3	0.0
27	Pleasant	1979	0	0	—	5	0.0
4	6	54	22	(41)	35	43	0.8

Table C2.5-11. (Continued)

Rank	Breeding Area	Year**	Successful Years No.	Successful Years (%)	Total Young Produced	Occupied Years With Known Data	Mean Young Produced
Free-Flowing River							
2	East Verde	1973	14	(78)	26	17	1.5
5	Redmond	1974	11	(65)	17	16	1.1
7	Ladders	1972	8	(42)	15	16	0.9
10	Cibecue	1973	8	(44)	11	15	0.7
20	Lone Pine	1984	2	(29)	3	7	0.4
21	Mule Hoof	1974	1	(6)	2	6	0.3
22	Table Mountain	1987	1	(25)	1+	4	0.2
23	Cedar Basin	1978	1	(8)	2	12	0.2
24	Perkinsville	1989	0	—	0	2	0.0
5	9	115	46	(40)	77	95	0.8
Free-Flowing Creek							
9	"76"	1981	8	(80)	11	10	1.1
12	Canyon	1986	5	(100)	6	5	1.2
15	Ash	1984	2	(29)	3	2	1.5
26	Devil's Post	1987	0	—	0	4	0.0
28	Sheep	1982	0	—	0	9	0.0
6	5	35	15	(43)	20	30	0.7

* Ranking of individual breeding areas based on number of young produced, number of successful years, percent of successful years, and mean number of young produced.

Ranking of aquatic habitat types based on percent of successful years and mean number of young produced, to eliminate bias resulting from the selection and number of habitat categories and the number of breeding areas within each habitat type.

** Year of discovery or first year of recorded productivity data.

By comparing the percent of successful years and mean number of young produced, we removed any bias from separating breeding areas into habitat groups. For example, free-flowing rivers contained the most breeding areas (9) and produced the most young (77) of the six categories. However, if we combined the nest sites into two groups, those foraging on natural streams produced 97 young at 14 sites in 125 occupied nest-years for a mean of 0.8 young, and those using habitats altered by dam construction produced 134 young at 14 sites in 130 years for a mean of 1.0 young. Although eagle pairs in altered habitats produced more young than natural habitats, the difference is not significant by Chi-Square.

By using all 28 known bald eagle breeding areas in Arizona, the above comparison of productivity in various habitats may be somewhat biased by including infertile pairs, or pairs which do not fledge young for reasons that are not linked to habitat quality. To eliminate this bias, we used the same habitat categories, but compared only those breeding areas successfully fledging at least one young since 1980. However, this created an additional bias by removing pairs which may not be able to produce young due to insufficient habitat characteristics (i.e., prey base) at individual nest sites.

For the 21 breeding areas successfully fledging at least one young since 1980, a much different scenario of productivity in various habitat types developed (Table C2.5-12). Regulated rivers were again the most productive habitat, having been successful in 78 percent of years, with a mean of 1.5 young. Pairs on free-flowing creeks ranked second, and were successful in 68 percent of years, with a mean of 1.2 young produced. Eagles foraging on free-flowing rivers and reservoirs ranked third, having been successful in 56 percent of years, with a mean of 1.0 young. Fourth ranked were eagles that forage only on free-flowing rivers, which were successful in 53 percent of years, with a mean of 1.0 young produced. Following closely behind were pairs that forage on regulated rivers and reservoirs, which were successful in 52 percent of years, producing a mean of 1.0 young. Breeding areas on reservoirs ranked sixth, having been successful in 50 percent of years, with a mean of 0.9 young produced.

In the second comparison (of the 21 breeding areas fledging at least one young since 1980), free-flowing systems ranked higher in productivity among the various aquatic habitat types than in the first comparison (of all 28 nest sites). Pairs on free-flowing creeks increased from a ranking of sixth, to second, and eagles foraging only on free-flowing rivers moved from fifth to fourth. Also, pairs foraging on free-flowing rivers and reservoirs changed from ranking fourth to third. Eagles foraging only on regulated rivers ranked first in both comparisons; however, pairs on reservoirs dropped from third to sixth, and those foraging on regulated rivers and reservoirs fell from second to fifth.

Although free-flowing systems increased in importance when comparing only the 21 breeding areas fledging at least one young since 1980, aquatic habitats altered by man were still more productive when grouped. Combining the nest sites into two groups, those foraging on natural streams produced 93 young at 9 sites in 92 occupied nest-years for a mean of 1.0 young, and those using habitats altered by dam construction produced 134 young at 12 sites in 122 years for a mean of 1.1 young. Thus, in both comparisons of habitat types (at all 28 breeding areas, and at only those nest sites [n = 21]) fledging at least one young since 1980) eagle pairs in habitats altered by dam construction were more productive than those in natural habitats; however, the difference was not significant by Chi-square.

We also ranked the five drainages supporting breeding bald eagles in Arizona. The Verde River system ranked first, with nine breeding areas producing 120 eaglets in 109 occupied nest-years, for a mean of 1.1 young (Table C2.5-13). The Salt drainage followed, with 14 breeding areas producing 101 eaglets in 124 occupied nest-years, for a mean of 0.8 young. The Gila drainage only contains one known

Table C2.5-12. Aquatic habitat types ranked by the productivity and nest success of Arizona bald eagle breeding areas successfully fledging at least one young since 1980.*

Rank	Breeding Area	Year**	Successful Years No.	Successful Years (%)	Total Young Produced	Occupied Years With Known Data	Mean Young Produced
Regulated River							
1	Fort McDowell	1968	18	(78)	33	21	1.6
14	Orme	1987	3	(75)	4	4	1.0
1	2	27	21	(78)	37	25	1.5
Free-Flowing Creek							
9	"76"	1981	8	(80)	11	10	1.1
12	Canyon	1986	5	(100)	6	5	1.2
15	Ash	1984	2	(29)	3	2	1.5
2	3	22	15	(68)	20	17	1.2
Free-Flowing River and Reservoir							
6	Horseshoe	1975	9	(56)	17	16	1.1
8	Pinal	1978	9	(69)	12	12	1.0
13	Alamo	1987	3	(75)	4	4	1.0
19	Chino	1985	1	(17)	2	3	0.7
3	4	39	22	(56)	35	35	1.0
Free-Flowing River							
2	East Verde	1973	14	(78)	26	17	1.5
5	Redmond	1974	11	(65)	17	16	1.1
7	Ladders	1972	8	(42)	15	16	0.9
10	Cibecue	1973	8	(44)	11	15	0.7
20	Lone Pine	1984	2	(29)	3	7	0.4
21	Table Mountain	1987	1	(25)	1+	4	0.2
4	6	83	44	(53)	73	75	1.0

Table C2.5-12. (Continued)

Rank	Breeding Area	Year**	Successful Years No.	Successful Years (%)	Total Young Produced	Occupied Years With Known Data	Mean Young Produced
Regulated River and Reservoir							
3	Blue Point	1971	8	(40)	22-24	15	1.5-1.6
4	Bartlett	1970	14	(67)	20	22	0.9
16	Ive's Wash	1987	3	(75)	3	4	0.8
17	Coolidge	1985	3	(50)	5	6	0.8
18	Cliff	1984	2	(29)	4	7	0.6
5	5	58	30	(52)	55	54	1.0
Reservoir							
11	Horse Mesa	1983	4	(50)	7	8	0.9
6	1	8	4	(50)	7	8	0.9

* Ranking of individual breeding areas based on number of young produced, number of successful years, percent of successful years, and mean number of young produced.

territory (Coolidge), but ranked third, fledging five nestlings in six occupied years for a mean of 0.8 young. The Bill Williams drainage ranked fourth, with four nest sites producing nine eaglets in 15 occupied years, for a mean of 0.6 young. The Agua Fria drainage ranked fifth, and contains only one known breeding area (Pleasant) which has not hatched any known young in the five occupied years since its discovery in 1979.

Similar to our comparison among the aquatic habitat types, we also ranked the five drainages supporting breeding bald eagles in Arizona based on only the 21 breeding areas fledging at least one young since 1980. In this comparison, the Verde River system again ranked first, with eight breeding areas producing 120 eaglets in 107 occupied nest-years, for a mean of 1.1 young (Table C2.5-14). The Salt drainage followed, with 10 breeding areas producing 97 eaglets in 94 occupied nest-years, for a mean of 1.0 young. The Bill Williams drainage ranked third, with three nest sites producing nine eaglets in 11 occupied years, for a mean of 0.8 young. The Gila drainage ranked fourth, with one known territory (Coolidge) fledging five nestlings in six occupied years for a mean of 0.8 young.

In this comparison (of the 21 breeding areas fledging at least one young since 1980), the Salt River, although still ranking second, was much closer to the productivity values of the Verde River than in the first comparison (of all 28 nest sites). The Bill Williams drainage moved from a ranking of fourth in the

Table C2.5-13. Arizona drainages ranked by productivity and nest success at bald eagle breeding areas.*

Rank	Breeding Area	Year**	Successful Years No.	Successful Years (%)	Total Young Produced	Occupied Years With Known Data	Mean Young Produced
Verde River							
1	Fort McDowell	1968	18	(78)	33	21	1.6
2	East Verde	1973	14	(78)	26	17	1.5
4	Bartlett	1970	14	(67)	20	22	0.9
6	Horseshoe	1975	9	(56)	17	16	1.1
7	Ladders	1972	8	(42)	15	16	0.9
14	Orme	1987	3	(75)	4	4	1.0
18	Cliff	1984	2	(29)	4	7	0.6
22	Table Mountain	1987	1	(25)	1+	4	0.2
24	Perkinsville	1989	0	—	0	2	0.0
1	9	115	69	(60)	120	109	1.1
Salt River							
3	Blue Point	1971	8	(40)	22–24	15	1.5–1.6
5	Redmond	1974	11	(65)	17	16	1.1
8	Pinal	1978	9	(69)	12	12	1.0
9	"76"	1981	8	(80)	11	10	1.1
10	Cibecue	1973	8	(44)	11	15	0.7
11	Horse Mesa	1983	4	(50)	7	8	0.9
12	Canyon	1986	5	(100)	6	5	1.2
14	Orme	1987	3	(75)	4	4	1.0
15	Ash	1984	2	(29)	3	2	1.5
20	Lone Pine	1984	2	(29)	3	7	0.4
21	Mule Hoof	1974	1	(6)	2	6	0.3
23	Cedar Basin	1978	1	(8)	2	12	0.2
25	Pinto	1988	0	—	0	3	0.0
28	Sheep	1982	0	—	0	9	0.0
2	14	151	62	(41)	101	124	0.8
Gila River							
17	Coolidge	1985	3	(50)	5	6	0.8
3	1	6	3	(50)	5	6	0.8

Table C2.5-13. (Continued)

Rank	Breeding Area	Year**	Successful Years No.	Successful Years (%)	Total Young Produced	Occupied Years With Known Data	Mean Young Produced
Bill Williams River							
13	Alamo	1987	3	(75)	4	4	1.0
16	Ive's Wash	1987	3	(75)	3	4	0.8
19	Chino	1985	1	(17)	2	3	0.7
26	Devil's Post	1987	0	—	0	4	0.0
4	4	18	7	(39)	9	15	0.6
Agua Fria River							
27	Pleasant	1979	0	—	0	5	0.0
5	1	12	0	(—)	0	5	0.0

* Ranking based on number of young produced, number of successful years, percent of successful years, and mean number of young produced.

** Year of discovery or first year of recorded productivity data.

first comparison, to third in the second, fledging 11 young compared to six for the Gila River, which dropped from third to fourth.

C2.6 FOSTERED YOUNG

Fostering young from one breeding area into a nest in another territory is used in emergencies when eaglets face certain death. Timing is crucial, and ideally the eaglets are placed at a site where the nesting attempt has recently failed, but the adults are still incubating or attached to the nest following the death of their own eggs or young. If circumstances are favorable, the new adults readily accept the fostered young as their own and begin brooding and delivering prey immediately. This method removes the eaglets from the threatening situation, yet keeps them within the wild population.

There have been three instances where eaglets were removed from Arizona nests and fostered into the nest of another breeding area. In 1982, one eaglet was removed from the "76" nest following the disappearance of the adult female, and fostered into the Pinal nest, where the young had disappeared.

Table C2.5-14. Arizona drainages ranked by the productivity and nest success of bald eagle breeding areas successfully fledging at least one young since 1980.*

Rank	Breeding Area	Year**	Successful Years No.	Successful Years (%)	Total Young Produced	Occupied Years With Known Data	Mean Young Produced
Verde River							
1	Fort McDowell	1968	18	(78)	33	21	1.6
2	East Verde	1973	14	(78)	26	17	1.5
4	Bartlett	1970	14	(67)	20	22	0.9
6	Horseshoe	1975	9	(56)	17	16	1.1
7	Ladders	1972	8	(42)	15	16	0.9
14	Orme	1987	3	(75)	4	4	1.0
18	Cliff	1984	2	(29)	4	7	0.6
22	Table Mountain	1987	1	(25)	1+	4	0.2
1	8	113	69	(61)	120	107	1.1
Salt River							
3	Blue Point	1971	8	(40)	22-24	15	1.5-1.6
5	Redmond	1974	11	(65)	17	16	1.1
8	Pinal	1978	9	(69)	12	12	1.0
9	"76"	1981	8	(80)	11	10	1.1
10	Cibecue	1973	8	(44)	11	15	0.7
11	Horse Mesa	1983	4	(50)	7	8	0.9
12	Canyon	1986	5	(100)	6	5	1.2
14	Orme	1987	3	(75)	4	4	1.0
15	Ash	1984	2	(29)	3	2	1.5
20	Lone Pine	1984	2	(29)	3	7	0.4
2	10	109	60	(55)	97	94	1.0
Bill Williams River							
13	Alamo	1987	3	(75)	4	4	1.0
16	Ive's Wash	1987	3	(75)	3	4	0.8
19	Chino	1985	1	(17)	2	3	0.7
3	3	14	7	(50)	9	11	0.8
Gila River							
17	Coolidge	1985	3	(50)	5	6	0.8
4	1	6	3	(50)	5	6	0.8

* Ranking based on number of young produced, number of successful years, percent of successful years, and mean number of young produced.

** Year of discovery or first year of recorded productivity data.

Also in 1982, two eaglets were removed from the Horseshoe nest prior to its inundation by the rising reservoir, and fostered into the Ladders breeding area, where the eggs did not hatch. Similarly, in 1986, two eaglets were removed from the Horseshoe nest prior to its inundation by the rising reservoir, and fostered into the Chino breeding area, where the egg did not hatch.

C2.6.1 "76" Breeding Area—1982

The "76" pair hatched one eaglet in 1982; however, the adult female disappeared following an aggressive altercation with a golden eagle. In the same time frame, the young had disappeared from the nest in the nearby Pinal breeding area. The 3.5-week-old "76" eaglet was removed from the nest and fostered into the Pinal nest. The eaglet jumped from the nest during a banding attempt, but was returned to the nest and later fledged (Haywood and Ohmart 1983, Forbis 1985). A new adult female occupied the "76" breeding area in 1983.

C2.6.2 Horseshoe Breeding Area—1982 and 1986

Nest inundation problems, due to fluctuating reservoir levels, have prompted the removal of young from the Horseshoe nest on two occasions. In 1982, the nest was inundated and the tree fell. The two young were removed prior to the nests flooding, and were fostered into the Ladders breeding area. The two eggs laid at Ladders in 1982 failed to hatch, and were collected for analysis (Haywood and Ohmart 1983).

In 1986, two eaglets hatched at Horseshoe on 11 and 13 March. At this time, the snag nest was in danger of being inundated by the rising reservoir. On 17 March 1986, the two Horseshoe eaglets were taken from the nest to the Phoenix Zoo. During this same time period, the Chino nest (on the Big Sandy River above Alamo Reservoir) had failed. The addled egg, which should have hatched by 1 March, was still being incubated by the Chino adults. On 21 March the two Horseshoe eaglets were flown to the Chino breeding area and placed in the nest, and the unhatched Chino egg was removed. The Chino adults accepted the eaglets, which subsequently fledged on 1 and 3 June. In the interim, the Horseshoe nest was at reservoir level on 28 March, and completely inundated on 29 March 1986 (Mesta 1986).

C3 MORTALITY

Mortality is an issue of great significance in assessing the status of a wildlife population, but obtaining data on mortality in a species as wide ranging as the bald eagle is difficult. If nests are monitored annually, recording nestling mortality is relatively simple, but once the eaglet leaves the nest, the chances of recovering data on its whereabouts are minimal. Also, the hot climate of Arizona promotes rapid decomposition of carcasses, which minimizes the chance of successfully determining the cause of death during necropsies. In light of these factors, banding and telemetry become valuable techniques in the study of bald eagle mortality and the estimation of nestling survivorship to breeding age.

In Section C2.5, we discussed Arizona bald eagle breeding areas with low rates of occupancy and sites with poor egg production. Each territory was ranked by productivity and nest success. Reviewing Table C2.5-9, the least productive and least successful breeding areas may be the result of poor egg production, but may also indicate chronic egg mortality and nest failure in the egg stage. By documenting juvenile deaths at each nest site, we gain insight into natural mortality factors such as predation, nest parasites, and heat stress, as well as human induced mortality like monofilament fishing line and disturbance. Such knowledge will aid in developing specific management criteria for each breeding area.

C3.1 EGG MORTALITY

When viable eggs are lost due to known human disturbance, the loss to the population is equal to juvenile mortality minus the "natural" death rate between the two life-history stages. Egg mortality may be difficult to define and to identify. For example, for a mortality to have occurred, the egg had to be fertile, containing a living, growing embryo. But how do we define, in mortality terms, the case of a pair of eagles who have raised young in the past, but do not lay eggs one year due to excessive human disturbance near the nest (e.g., Cliff 1990)? Often, we do not know if the eggs are fertile. If the eggs are broken or otherwise lost, their status remains unknown. If a pair lays a second clutch after early failure of the first clutch, the first clutch may go totally unrecorded (see Section C2.4).

We can be fairly certain, however, that if a pair has been successful in previous nesting attempts, and there has been no change in adult tenure at the nest site, failure (including failure to lay eggs) may be linked to adverse circumstances rather than genetic causes or environmental contamination. Among the multitude of possible reasons for nest failure are: (1) human disturbance; (2) interactions with other animal species; (3) climate—heat, cold, wind, precipitation, etc.; (4) nest parasites; (5) lack of available prey; and, (6) other events causing stress or forcing the adults off the nest. The exact reason for nest failure often cannot be determined, but circumstances which may have contributed to the egg's demise are occasionally discovered.

C3.1.1 Embryo Mortality

Twenty six whole eggs have been collected from Arizona bald eagle nests (see Section C2.3), and embryos were detected in only four (15%) of these. Grubb and Rubink (1978) noted ca. 27-day-old embryos in two eggs collected from a fallen nest tree at the Horseshoe breeding area in 1977. We found an embryo about 12 days old in the 1989 Alamo egg, and a 26-day-old embryo in the 1986 Horse Mesa

egg (see Section C2.3). We found the Horse Mesa egg on 3 July 1986, buried under 15-20 cm of soft nest material, after two young had successfully fledged on 8 May. The egg-laying date at Horse Mesa was 6 January 1986, so the egg was about 181 days old (26 weeks) it was discovered; it survived 88 days with two eaglets in the nest. The Horse Mesa egg may have died due to neglect by the adults after the two eaglets hatched. We observed a similar situation at East Verde in 1987 where one eaglet hatched on 26 February. The second eaglet was pipping on 26 February during a snow storm, but the adults left part of the egg exposed when brooding the hatched young, and the pipping eaglet died.

C3.1.2 Incidents Linked To Egg Mortality, 1987-90

During 1987-1990, bald eagles laid at least 125 eggs in known Arizona bald eagle nests and hatched 87 young. Of the 38 eggs which did not hatch, we could make inferences about the cause of failure in only six cases (11 eggs).

"76" Breeding Area—1987. Three eggs were laid at the "76" breeding area in 1987, but the adults were flushed off the eggs daily by two photographers who erected a blind less than 30 m from the nest at nest level. ABENWP personnel discovered photographer William E. Barcus near the "76" nest on 4 March 1987, and he informed them of his partner William L. West. ABENWP personnel told one of the photographers to leave, but the photographers returned later. The nest failed and was abandoned by the birds. In photos confiscated by USFWS, the adult appeared very stressed and was looking at the camera and vocalizing in most incidents. This long disturbance at such a crucial period in the nesting cycle (early incubation) no doubt caused the nest failure. After the adults abandoned the nest, we recovered two eggs with the tops crushed and a separate set of eggshell fragments (3 eggs). See Section D4.26 for more details on the 1987 nest failure at "76."

Fort McDowell Breeding Area—1988. Two clutches of eggs were laid at the Fort McDowell breeding area in 1988 (see Section C2.4). Cotton was planted in the field adjacent to (within 50 m of) the nest trees, and helicopters sprayed herbicides and insecticides on the crop. Wood-cutters were also in the area, cutting much of the mesquite bosque below and surrounding the nest trees. A dirt road running past the nest trees and down to the river, provided waterfront access to fishermen and partiers. It is likely that both clutches (2+ eggs) failed because of disturbance during incubation. One whole egg was collected from the second clutch following abandonment by the adults.

Pinto Breeding Area—1989. An interesting situation has existed at least since 1988 at the Pinto breeding area. The Pinto female copulates and builds nests with the Pinal male. However, the Pinal male also copulates and builds nests with the Pinal female, 11.2 Km upstream. When eggs are laid, the Pinal male assists in incubation duties at the Pinal nest site, but does not help the Pinto female incubate. Therefore, the Pinto female must leave the eggs to eat. In 1989, the Pinto female laid at least one egg which did not hatch.

Bartlett Breeding Area—1990. Two clutches of eggs were laid at the Bartlett breeding area in 1990 (see Section C2.4). During an ORA flight on 5 February, USFWS, Reclamation, and AGF biologists observed incubation in nest 2. BioSystems accompanied ABENWP biologists to the nest site on 9 February. The closure gate was open (broken) and appeared to have been rammed by a truck. Multiple sets of tire tracks led to the closure fence, which had been cut. The tracks continued up the road which runs immediately behind the nest cliff. At this point, the adults were still incubating in nest 2. On 12 February, the pair abandoned the eggs (1+) in nest 2 and began refurbishing nest 1. The eagles laid a second clutch of eggs (2+) in nest 1 on 14 March. The second nest attempt failed on 22 March when

the adults stopped incubating (Kime and Upton 1990). It is likely that too much disturbance during incubation caused the failure of the 1990 Bartlett nest.

Fort McDowell Breeding Area—1990. This mortality was a result of the unusually small "runt" egg laid at the Fort McDowell breeding area in 1990. Although lab results are not available at this time, the egg appeared to be infertile, lacking 85–90 percent of its interior contents (see Section C2.3).

Ive's Wash Breeding Area—1990. The Ive's Wash pair laid at least one egg in the Woody's Cove tree nest prior to 21 January 1990. Woody's Cove is a popular camping and fishing spot, with a road running down to the shore of Alamo Reservoir, 20–25 m from the nest tree. There was substantial disturbance at this site, with 74 percent due to fishermen (Theisfeldt and Linskens 1990). The adults were forced off the egg(s) many times by boats fishing directly beneath the nest (Theisfeldt and Linskens 1990, B. Bock pers. comm.). The egg(s) should have hatched prior to 25 February (35-day incubation period). One whole egg was collected following abandonment by the adults. It is almost certain that disturbance during incubation caused the death of the Ive's Wash egg. Theisfeldt and Linskens (1990) stated, "The failure of this nest is undoubtedly due to numerous human disturbances."

The Army Corps of Engineers manages Alamo Reservoir, BLM manages the surrounding land, and AGF manages the wildlife. Robert Mesta, USFWS, and Robert Hall, BLM, attempted to erect a closure at the Woody's Cove area immediately following confirmation of incubation, but the erection of the closure was delayed until 6 March, nine days after the nest had failed. The closure consisted of a saw-horse blocking the road into Woody's Cove and buoys placed in a 100-m circumference around the nest tree to deter boats from the area. See Section D4.16 for more details on the 1990 nest failure at Ive's Wash.

Cliff Breeding Area—1990. The Cliff pair have occupied the breeding area at least since its discovery in 1984 (both adults are banded) and have laid at least 10 eggs, hatching seven young and successfully fledging four. The pair apparently did not lay eggs in 1987 and 1990. The Cliff territory is located on the Verde River, below Horseshoe Dam, and receives considerable use from recreationists. Four-wheel-drive vehicles, fishermen, campers, and people shooting automatic, semi-automatic, and other types of firearms frequently use the nest area. The Cliff nest site is within a legally designated Bald Eagle Breeding Area Closure, although the closure was not enforced in 1990. Mehling and Kershaw (1990) describe numerous accounts of vehicles and gunshots within the closure in February, and throughout the nesting season. Nest watchers suggested the gate at the cattle guard be locked, restricting vehicle entrance to the nest area, but their recommendations were not implemented. It is likely that too much disturbance in January and February deterred the eagles from nesting in 1990. See Section D4.9 for further details on the 1990 nest failure at Cliff.

Summary of Incidents Linked To Egg Mortality. While a certain amount of egg mortality in a bald eagle population is to be expected (snow is a factor in northern climes), it is evident from the above cases that human disturbance during incubation contributes to egg mortality among Arizona bald eagles.

C3.1.3 Nest Failure In The Egg Stage

Breeding areas which consistently fail to hatch eggs may have productivity problems linked to other factors within their home range. These factors may include human disturbance, polygynous relationships, deficient prey base, unavailability of prey, infertile adults, contaminated adults, adult mortality, or other unknown causes. We ranked Arizona bald eagle breeding areas based on the number and percent of years failed in the egg stage, and the number and percent of unhatched eggs (Table C3.1-1). Cedar Basin

Table C3.1-1. Arizona bald eagle breeding areas ranked by failures in the egg stage.*

Rank	Breeding Area	Total Occupied Years	Years Failed in Egg Stage No.	Years Failed in Egg Stage %	Total Failed Years	Minimum Total Eggs	Unhatched Eggs No.	Unhatched Eggs %	Young Hatched	Young Fledged
1	Cedar Basin	12	9	75.0	9	14	12	85.7	2	2
2	Lone Pine	7	4	57.1	4	8	5	62.5	3	3
3	Horse Mesa	8	4	50.0	4	13	6	46.2	7	7
4	Mule Hoof	7	3	42.9	3	6	4	66.7	2	2
5	Ladders	16	6	37.5	7	25	8	32.0	17	15
6	Horseshoe	16	5	31.3	6	28	10	35.7	18	17
7	Bartlett	24	7	29.2	8	44	19	43.2	25	20
8	Chino	3	2	66.7	2	5	3	60.0	2	2
9	Table Mountain	4	2	50.0	2	3	2	66.7	1	1
10	Pleasant	5	2	40.0	2	2	2	100.0	0	0
11	Sheep	9	3	33.3	4	7	5	71.4	2	0
12	Pinto	3	1	33.3	1	1	1	100.0	0	0
13	Ive's Wash	4	1	25.0	1	5	1	20.0	4	3
14	Coolidge	6	1	16.7	1	8	3	37.5	5	5
15	Cliff	7	1	14.3	3	10	3	30.0	7	4
16	Fort McDowell	21	3	14.3	3	38	5	13.2	33	33
17	East Verde	17	2	11.8	3	31	4	12.9	27	26
18	"76"	10	1	10.0	1	15	3	20.0	12	11
19	Pinal	12	1	8.3	3	19	3	15.8	16	12
20	Cibecue	15	1	6.7	6	24	1	4.2	23	11
21	Redmond	16	1	6.3	4	27	2	7.4	25	17
22	Ash	2	0	—	0	4	1	25.0	3	3
23	Alamo	4	0	—	0	5	1	20.0	4	4
24	Orme	5	0	—	0	6	1	16.7	5	4
25	Devil's Post	4	0	—	0	0	0	—	0	0
26	Perkinsville	2	0	—	0	0	0	—	0	0
27	Canyon	5	0	—	0	6	0	—	6	6
28	Blue Point	15	0	—	2	27	0	—	27	22–24
	Total	259	60	23.2	79	381	105	27.6	276	232

* Ranking based on the number and percent of years breeding area failed in the egg stage, and the number and percent of unhatched eggs.

ranked first, failing to hatch eggs in nine (75%) of 12 years of occupancy, with 12 (85.7%) of 14 eggs not hatching. The Lone Pine breeding area ranked second, failing to hatch eggs in four (57%) of seven years of occupancy, with five (62.5%) of eight eggs not hatching. It is interesting that these two nests are the uppermost sites on the Salt River, where the Salt River Canyon is narrow and the white-water is so treacherous that it is rarely, if ever, navigated by raft or kayak. The consistent failure to hatch eggs at these two breeding areas may be linked to a lack of prey availability, since both sites have fledged young in the past. Other breeding areas with high rates of failure in the egg stage include Horse Mesa, Mule Hoof, Ladders, Horseshoe, Bartlett, Chino, Table Mountain, Pleasant, and Sheep.

Cedar Basin Breeding Area. The breeding area ranked first in nest failures during the egg stage was Cedar Basin, which has failed to hatch eggs in nine (75%) of 12 years of occupancy, with 12 (85.7%) of 14 eggs not hatching. Possible reasons for this phenomenon include: (1) one of the adults (most likely the female) is contaminated with pesticides, leading to thin eggshells or dead or deformed embryos; (2) one of the adults has become infertile or has been replaced by an infertile adult since 1978 (when two young hatched); (3) one of the adults (most likely the male) is part of another breeding pair and does not assist in incubation duties (see Section D4.23); or, (4) the prey base in the nest area cannot support the pair through incubation, and both adults must leave the nest area to forage.

We collected eggshell fragments at Cedar Basin in 1986 and 1987 and retrieved a whole egg in 1988. Analysis of the whole egg revealed Cedar Basin had the lowest DDE concentration of any egg collected in Arizona from 1986–1989, with levels of 31 ppm lipid, and 2.3 ppm wet weight (see Section E4). Some breeding areas in Arizona with DDE levels of 100 ppm (lipid weight) are still productive. Also, historical (pre-1946, pre-DDT) eggshell thickness in the southwest was 0.591 mm (samples from Baja California). Eggshells collected at Cedar Basin measured 10 percent *thicker* than historical records, at 0.651 mm (see Section E5). These data likely rule out the hypothesis of pesticide contamination.

No embryo was visible in the contents of the whole egg collected in 1988, therefore it may be possible that one of the adults at Cedar Basin is infertile. It is also possible that one adult is part of another breeding pair and does not assist in incubation duties, therefore, the other adult must leave the eggs to forage. This phenomenon has been occurring at the Pinto breeding area since 1988.

Although data on the prey base of the Cedar Basin pair is limited, there may be periods of reduced fish availability due to fast and muddy river conditions following rains. In other Arizona breeding areas, mammalian prey are usually utilized in periods when fish become unavailable (see Section B4), and non-fish prey have been found in the Cedar Basin nest (see Section D4.6). Carrizo Creek is located 7 Km upstream from the Cedar Basin area and attracts a congregation of eagles in February. Carrizo Creek carries warmer water into the Salt River, due to geothermal activity, which could create early spawning runs in the creek. It may be that a lack of prey availability throughout the nesting season is limiting productivity at Cedar Basin; however, there are no data on this point.

In summary, hypothesis 2, 3, or 4 could be acting to suppress reproduction at Cedar Basin. The remote location and rugged terrain of the Cedar Basin breeding area limits the collection of nest data to ORA helicopter flights. Thus, adult replacements would be difficult to document, and mortality information is largely lacking. To accurately address the productivity problems, further data are needed on the ecology of the Cedar Basin eagles and their prey base.

Lone Pine Breeding Area. The Lone Pine breeding area ranked second in nest failures during the egg stage. Eggs failed to hatch in four (75%) of seven years of occupancy, with five (62.5%) of eight eggs not hatching. Eagles at Lone Pine have only nested successfully in two years (1986 and 1988), fledging three young, and the adults apparently did not lay eggs in 1989. The sporadic nest failures at Lone Pine tend to indicate the breeding area may have insufficient prey availability. Human disturbance is not likely a problem at Lone Pine, due to its remote location. The hazardous white-water in this section of the Salt River also precludes river traffic. Even rafts and kayaks rarely (if ever) venture above the Highway 60 bridge when running the Salt River. The fact that the pair do occasionally raise young suggests that contamination is not a problem. The remote location and rugged terrain of the Lone Pine breeding area limits the collection of nest data to ORA helicopter flights. Thus, adult replacements would be difficult to document, and mortality information is lacking. Prey remains data suggest use of fish, waterfowl, mammals, and carrion (elk, domestic cow). To accurately address the productivity problems, further data are needed on the ecology of the Lone Pine eagles and their prey base.

Horse Mesa Breeding Area. The Horse Mesa breeding area, which ranked third, failed to hatch eggs in four of eight years of occupancy, with six (46.1%) of 13 eggs not hatching. The failures at Horse Mesa were possibly linked to an infertile or contaminated adult. The pair failed to hatch eggs in the first three years following the nest's discovery (1983–1985). A new adult female (near-adult) entered the pair in 1986 (Driscoll and Buckley 1986), after which the site fledged young (1986–1988 and 1990), but failed in 1989. In 1986, when two young fledged, we collected a whole egg with a 26-day-old embryo in it. As mentioned in Section C3.1.1, the egg may have been neglected by the adults once the two other young hatched.

Mule Hoof Breeding Area. The Mule Hoof territory has a high vacancy rate as discussed in Section C2.5. Mule Hoof has a high rate of egg failure as well (ranked fourth): failing in three of seven occupied years, with four of six known eggs not hatching. Productivity problems at Mule Hoof may be linked to human disturbance or food resources, and are discussed in sections C2.5.2 and D4.19.

Ladders Breeding Area. Another breeding area with a high rate of failure in the egg stage was Ladders (ranked fifth), failing to hatch eggs in six of 16 years of occupancy, with eight of 25 eggs not hatching. Nest failure at Ladders has been sporadic (1972, 1977, 1979, 1982, 1984, and 1990), and the territory was also unoccupied during 1974–1976 and apparently did not lay eggs in 1978. The factors causing intermittent nest failure at Ladders are perplexing, but may be linked to human disturbance, changes in the adult pair, or low prey availability during years with high and turbid flows.

Horseshoe Breeding Area. Horseshoe ranked sixth in egg failures (five of 16 years of occupancy, with 10 of 28 eggs not hatching). The problems with nest failure at Horseshoe are relatively easy to surmise; the breeding area has been plagued by nest inundation. The eggs failed to hatch in 1975, but no direct cause of nest failure was determined. In 1976, the Horseshoe pair fledged two young from a cliff nest. The nest tree fell in 1977, with two eggs containing embryos. High and turbid flows in 1978, when two eggs failed to hatch, may have caused prey availability problems or otherwise contributed to nest failure. The Horseshoe pair laid at least one egg in an artificial tripod nest structure (constructed by Teryl Grubb, USFS) in 1979; however, the structure was not built above high water levels, and the rising reservoir inundated the nest and egg(s). The tripod structure was moved in September 1979, and the eagles built onto the nest in 1980. Once again the tripod was not above high water levels, and the rising reservoir threatened to inundate the structure. A super-structure was added to the tripod, which the eagles

accepted, refurbished their nest, and laid at least two eggs. However, for the third time the structure was not above the high water level, and the nest and eggs were inundated.

The Horseshoe pair apparently did not lay eggs in 1981. In 1982, the eagles built a nest in a willow tree and hatched two young; however, the tree was inundated by the rising reservoir, and the young were fostered into another breeding area. One eaglet fledged from the cliff nest in 1983, but had to be rescued from the reservoir after a premature flight. In 1984, a nest branch broke and two eaglets fell to the ground. The nest was rebuilt, and the young were returned to the new nest and fledged. Two eaglets fledged again in 1985 from the cliff nest. The Horseshoe adults built a new nest in a willow snag in 1986 and hatched two young; however, the rising reservoir inundated the nest, and the young were fostered into another breeding area. Three eaglets fledged from the cliff nest in 1987, and two from another cliff nest fledged in 1988. In 1989, one egg did not hatch, and the one eaglet was decapitated in the nest at three weeks of age, apparently by a great horned owl. Two young fledged from a cliff nest in 1990.

Thus, if the Horseshoe eagles nest on the cliff they are more successful, while tree nests are usually inundated by the reservoir. Four artificial nesting structures have been built at Horseshoe (two tripods and two towers) all of which have been consistently inundated, and have fallen. Only one suitable nest tree, which contains nest 9 (see Section D4.15), still exists on Horseshoe Reservoir. In the past, artificial nest structures have encouraged the eagles to nest closer to the reservoir, resulting in nest inundation. Artificial nesting structures should therefore probably not be built in the future so that the eagles will nest on the cliff, high above the adverse effects of rising water.

Bartlett Breeding Area. Bartlett ranked seventh in egg failures, failing in seven of 24 years, with 19 of 44 eggs not hatching). Even though 43.2 percent of the Bartlett eagle's eggs have not hatched, the pair has still fledged 20 young, and the territory ranks fourth in productivity and nest success. The Bartlett eagles have laid more known eggs than any other breeding area in Arizona. Food resources are obviously not a problem at Bartlett; prey is abundant and available (see Section B4.1). However, Bartlett has a mortality problem (e.g., shooting), ranking third in adult mortality and fourth in nestling mortality (see sections C3.2 and C3.7). The high rate of egg failure at Bartlett is likely due to the multitude of recreational disturbance in the nest area (see Section D4.3). This hypothesis is somewhat supported by the sporadic incidence of failure (1972, 1974, 1976, 1983, 1984, 1987, 1990) in between which the nest fledged young.

Chino Breeding Area. The Chino breeding area ranked eighth in nest failures during the egg stage. This site also has a low rate of occupancy, as discussed in Section C2.5. Chino has failed to hatch eggs in two of three years of occupancy, with three of five eggs not hatching. The Chino eagles fledged two young in 1985. The one egg laid in 1986 did not hatch, and the two Horseshoe young were fostered into Chino when the Horseshoe nest was inundated (see above). The Chino female or pair moved to Alamo Reservoir in December 1986, and a new pair moved into the Chino territory (see Section D4.7). The new pair laid two eggs in 1987, which did not hatch, and the nest later fell. Throughout this time frame (1985–1987), Alamo Reservoir has been receding. In 1985, the reservoir was backed up to the origin of the Bill Williams River, at the confluence of the Big Sandy and Santa Maria rivers, where the three rivers and the reservoir formed a large estuary. This habitat is now gone, and the Big Sandy is dry for a large portion of the year. Cattle grazing had eliminated the regeneration of cottonwoods and willows, and the riparian habitat was seriously degraded. A moratorium on cattle grazing was enacted for this area, and young cottonwoods are now sprouting on the upper reservoir and along the Big Sandy River. Habitat loss has no doubt contributed to the Chino breeding area's demise. If reservoir levels are

increased in the future, Chino may become an active breeding area again; however, the Alamo and Ive's Wash eagles also nest on the upper end of the reservoir. These two pairs will likely defend the prime foraging habitat they now share on the northern end of Alamo Reservoir. In fact, the two pairs have been observed teaming up to drive off intruding eagles (see Section D4.1 and D4.16).

Table Mountain Breeding Area. The Table Mountain breeding area has failed in two of four years of occupancy, hatching one of three known eggs; it ranks ninth in nest failures during the egg stage. The Table Mountain eagles apparently did not lay eggs in 1987; however, old eggshell fragments have been found in newly discovered nests, suggesting the breeding area has been active prior to our knowledge of its existence. Since Table Mountain was only discovered in 1987, and failed in 1988 and 1989, we have little data on the breeding area and the factors influencing nest failure. Table Mountain is in a remote location on the Verde River, so human disturbance is not likely a major problem. Two known nests are in willow trees, and hikers and rafting groups could easily disturb the eagles by disembarking to camp or picnic near the nest trees.

Pleasant Breeding Area. The Pleasant breeding area is unique in that it ranks high in unoccupancy (second) (see Section C2.5), low in egg production when occupied, and when eggs were laid (two of five years of occupancy) the eggs (two) did not hatch. Pleasant ranks tenth in nest failures during the egg stage, but since the eagles have not hatched any known young, there is virtually no data on the factors influencing nest failure. AGF has conducted fisheries studies on the lake, so data on the prey base are available. Large runs of spawning white bass and carp have been observed during February and March in the Agua Fria River near the nest cliff (see Section D4.24). Pleasant Reservoir also attracts fairly large numbers of waterfowl and American coots in winter and spring. Thus bald eagle prey appears to be abundant and available. It is possible that the Pleasant eagles are nesting in an unknown location; capturing them for radio-tagging would supply answers to many of the questions regarding this pair.

Sheep Breeding Area. The Sheep breeding area ranks eleventh in egg failures, and the site also has an egg production problem (see Section C2.5). The only two young, known to have hatched from at least seven eggs laid in four years at Sheep, died at 1–2 days of age in 1986. The eagles apparently did not lay eggs in five other years of occupancy. There are six possible hypothesis which may explain the productivity problems at Sheep: (1) the adults have an unknown nest location they use in years of occupancy when apparently no eggs are laid; (2) one of the adults is infertile; (3) the prey base in the Sheep breeding area cannot support the eagles through incubation; (4) the Sheep male is involved in a polygynous relationship with a female at an unknown breeding area, and does not completely assist the Sheep female in incubation duties; (5) one or both of the adults is contaminated with pesticides; or, (6) human disturbance during incubation keeps the adults away from the eggs, resulting in nest failure.

It is possible that the adults have an unknown nest location (1), but this does not appear to be the case, since both adults have been observed in the known nest tree during the breeding season. Fertility in the adults (2) is not likely a problem, since the eggs did hatch in 1986. The "76" and Sheep eagles use more non-fish prey than other Arizona bald eagle pairs, and a lack of prey availability may be hampering nest success (3). However, we have observed suckers, carp, and channel catfish in pools within both breeding areas. The Sheep and "76" eagles were not radio-tagged, so data on the foraging ecology of the Tonto Creek eagles is limited to visual observations and prey remains collected at the nest. It is also possible that the Sheep male is part of another breeding pair, and involved in a polygynous relationship (4). ABENWP personnel noted normal incubation and nest exchanges in years when eggs were laid

(Chadbourne 1983, Nahstoll and Webster 1986, Tocco and Brashear 1987, Krueger *et al.* 1988), which reduces the likelihood of this scenario.

Another possibility involves pesticide contamination of the adults (5). However, the eggshell thickness of the Sheep eggs in 1988 was within the range of other Arizona bald eagle nests (see Section E5). Human disturbance during incubation could also cause nest failure (6), although ABENWP personnel have reported a virtual lack of human activity near the nest (Chadbourne 1983, Nahstoll and Webster 1986, Tocco and Brashear 1987, Krueger *et al.* 1988). Thus, at this point it appears more data are needed on the foraging ecology of the Sheep eagles and prey availability within the breeding area to determine aspects of bald eagle ecology possibly missing from this territory.

Summary of Nest Failure In The Egg Stage. There are a variety of factors, both natural and human induced, which can cause a nest to fail in the egg stage, and these factors vary between breeding areas. Some of these causes (or combinations) are presented in the above discussions on sites with high percentages of nest failures in the egg stage. The lowest ranking sites in terms of egg failures are a mixture of breeding areas with egg production problems (no eggs laid, therefore no egg failure—Devil's Post, Perkinsville) and nests that have not failed in the egg stage during years of occupancy (young have hatched each year eggs were laid—Ash, Alamo, Orme, Canyon, Blue Point). Of the latter five breeding areas, Ash, Alamo, and Orme have all laid at least one egg that did not hatch, although another egg in the clutch hatched, so the nest did not fail. Canyon and Blue Point are the only nest sites which have not experienced any known egg mortality. Although Canyon was only discovered in 1986, the nest site has produced six young in those five years. The Blue Point breeding area has produced 27 eggs in 15 years of occupancy, hatching 27 young, and fledging 22–24 young.

C3.1.4 Summary of Egg Mortality

Bald eagle populations throughout North America have a mean hatch rate of 75 percent and a 25 percent egg mortality rate. Once the young hatch, they have a better chance for survival (85%), with a mean nestling mortality rate of 15 percent (Stalmaster 1987). As a population, Arizona eagles have produced 381 known eggs, of which 105 (27.6%) failed to hatch, resulting in a hatch rate of 72.4 percent. Of the 276 eggs which hatched young, 232 (84.1%) survived to fledging, resulting in a nestling mortality rate of 15.9 percent. Thus, the Arizona population shows a 2.6 percent higher egg mortality rate and a 0.9 percent higher nestling mortality rate than the mean for other bald eagle populations throughout North America; however, the difference is not significant by Chi-Square.

Although the Arizona population has a slightly higher egg mortality rate than other bald eagle populations throughout North America, Arizona's egg mortality rate is likely even higher than the data indicate. Egg numbers in Arizona are often estimated from the number of young hatched, due to the restricted view at most cliff nests and the warranted procedure of not flushing adults from the nest to count eggs on ORA flights. Thus, the actual egg mortality rate is likely higher than 27.6 percent, and the number of eggs hatching is less than 72.4 percent. There are likely more two- and three-egg clutches, and less one-egg clutches, than the data show. Some of this bias is eliminated by documenting the approximate number of eggs, through eggshell fragments collected in individual isolated locations in the nest. However, Arizona adults have been observed crushing and removing large eggshell pieces from the nest (Driscoll 1985, Poelker and Palmiotto 1985).

The chances of a nest failing are greater during the early stages of nesting. In 259 nest-years of occupancy, Arizona nests have failed in 60 nest-years (23.2%) in the egg stage, and 19 nest-years (7.3%) in the nestling stage, resulting in a nest success rate of 69.5 percent.

C3.2 JUVENILE MORTALITY

Juvenile bald eagle mortality is fairly easy to document when young are confined to the nest. However, once the eaglets fledge, monitoring their movements and survivorship becomes increasingly difficult. Juvenile mortality in Arizona has been relatively well documented, due to the efforts of the ABENWP and previous studies by Duane Rubink (USFWS), Robert Ohmart (ASU), and Teryl Grubb (USFS), although earlier records are scarce. Since 1964, 57 juvenile mortalities have been recorded: 27 died in the nest, 8 disappeared from nests, 9 fell from nests, 11 died post-fledging, 1 disappeared post-fledging, and 1 died in captivity (Table C3.2-1). Of the 12 known post-fledging mortalities, 10 were documented because the young were telemetered or banded.

Plate C9. Nestling bald eagles (6 weeks old) at the Blue Point breeding area, April 1991 (photo by D. Driscoll).

The first known juvenile bald eagle mortality in Arizona was recorded in 1964 at the Bartlett breeding area. One of the adults was shot, and the other apparently abandoned the nest. One eaglet died in the nest, and the other was taken into captivity by Chuck Binder (a local falconer), but the eaglet later died (Rubink and Podborny 1976). At the Redmond breeding area, one young died in the nest in 1975, resulting in nest failure (Rubink and Podborny 1976). In 1977, one eaglet disappeared from the nest at

Table C3.2-1. Known Arizona juvenile bald eagle mortalities.

Year	Breeding Area	No.	Comments
1964	Bartlett	2	One adult shot, other abandoned nest. One young died in nest. One young taken into captivity, but later died.
1975	Redmond	1	Died in nest.
1977	Cibecue	1	Disappeared from nest.
	Fort McDowell	1	Died post-fledging. Displaced at perch by sibling and fell to river. Broken left humerus inspired water into left lung, drowning bird.
1978	Bartlett	2	One died post-fledging and was eaten by a mammalian predator. One fell from nest.
	Redmond	2	One fell from nest. One fledged to ledge below nest, but died 1–2 days later.
	Cibecue	1 or 2	One fell from nest. One disappeared post-fledging (telemetered).
1979	Redmond	1	Fell from nest.
1980	Cibecue	3	One disappeared from nest. One died in nest from intestinal ulcer and hemorrhage. One fell during banding attempt.
1981	Bartlett	1	Died post-fledging.
	Pinal	1	Died in nest. Cannibalized by sibling.
	Blue Point	1	Died post-fledging.
1982	Pinal	1	Disappeared from nest.
1983	East Verde	1	Died in nest.
	76	1	Died in nest. Sibling aggression — impact to head, emaciation, trauma.
	Cibecue	2	Disappeared from nest.
1984	Redmond	2	Died in nest. Mexican chicken bugs. Photographer may have induced late laying.
	Cliff	2	Disappeared from nest. One later found dead below nest.
1985	Blue Point	1	Died in nest. Helicopter disturbances may have contributed.
	Bartlett	1	Fell from nest.
	Cibecue	1	Died in nest.
1986	Cibecue	1	Fell from nest.
	Sheep	2	Died in nest.
≤1986	Orme	1	Fell from nest. Skeleton found below nest 13 May 1990.
1987	East Verde	1	Died while pipping out of egg in snowstorm.
	Ladders	2	Died in nest. Mexican chicken bugs.
	Cibecue	1	Died in nest. Mexican chicken bugs. Attacked by floater near adult.
	Blue Point	1	Died post-fledging. Found near dead redtail hawk.
1988	Pinal	1	Died in nest. Entangled in monofilament.
	Blue Point	3	Died post-fledging.
	Redmond	2	One died post-fledging. One died in nest. Mexican chicken bugs.
	Ladders	1	Died post-fledging. Apparently killed by great horned owl.
1989	Blue Point	2	Died in nest. Dry riverbed resulted in many disturbances.
	Pinal	1	Died in nest.
	Horseshoe	1	Died in nest. Decapitated—apparently killed by great horned owl.
	Redmond	2	Died in nest. Mexican chicken bugs.
	Cliff	1	Died in nest.
	Ive's Wash	1	Fell from nest. Broken left radius and ulna.
	Bartlett	1	Died in nest.
	Cibecue	1	Died in nest.
1990	Cibecue	1	Disappeared from nest 14 April. Adult female may have removed dead eaglet from nest. Photographers may have contributed.

SUMMARY		
Died in Nest	27	
Disappeared from nest	8	
Fell from nest	9	
Died post-fledging	11	(Nine found by telemetry or band returns)
Disappeared post-fledging	1	(Telemetered)
Died in captivity	1	
Total known mortalities	57	

the Cibecue breeding area, and one radio-tagged juvenile died post-fledging at Fort McDowell. The Fort McDowell eaglet died shortly after fledging when it was displaced at a perch by its sibling. The juvenile fell to the river, breaking its left humerus, which inspired water into the left lung, drowning the bird (Hildebrandt 1981).

Five, and likely six, young died in 1978. One Bartlett eaglet fell from the nest, and the other (which was radio-tagged) died shortly after fledging and was eaten by a mammalian predator. Similarly, one Cibecue eaglet fell from the nest, and the second (which was telemetered) disappeared shortly after fledging (Hildebrandt 1981). This radio-tagged nestling apparently was only out of the nest a few days and likely not capable of dispersing. Since the young was telemetered, either the juvenile departed the nest area, the transmitter stopped functioning, or the eagle was shot and removed from the area, and the transmitter was destroyed. Two eaglets died at the Redmond breeding area in 1978, apparently of heat stress (see Section C3.5). One young fell from the nest (presumably while seeking shade) (Hildebrandt 1981) and the other fledged to a ledge just below the nest, but died 1–2 days later (Grubb 1986a). One young fell from the nest again in 1979 at Redmond, and heat stress was suspected (Hildebrandt 1981).

Three nestlings died at the Cibecue breeding area in 1980; one fell from the nest, one died in the nest of an intestinal ulcer and hemorrhage, and the third fell from the nest during a banding attempt (Haywood and Ohmart 1980). Three eaglets also died in 1981. A Bartlett juvenile died shortly after fledging, and was found in the area by USFS personnel. The eagle was identified by its USFWS band number. One Pinal young died in the nest and was cannibalized by its sibling. A 1981 Blue Point eaglet died of unknown causes shortly after fledging (Haywood and Ohmart 1982). In 1982, the Pinal nestling disappeared from the nest (Haywood and Ohmart 1983).

Four juvenile bald eagle mortalities were documented in 1983. An East Verde eaglet died in the nest, and two Cibecue young disappeared from the nest. A "76" nestling was killed by its sibling, apparently of repeated blows to the head from its nestmate (Grubb *et al.* 1983). Four juveniles again died in 1984. The two Cliff eaglets disappeared from the nest between 31 May and 5 June 1984. One nestling was found dead below the nest cliff on 6 June, but the other was not located (Grubb 1984). The two 1984 Redmond nestlings apparently died from a severe infestation of Mexican chicken bugs (see Section C3.4). In 1985, one young died in the nest at Cibecue (DeCandido 1985), one fell from the nest at Bartlett (Senger and Senger 1985), and one died in the nest at Blue Point. The Blue Point mortality may have been linked to reduced prey deliveries, caused by helicopter disturbances (Collie *et al.* 1985).

One eaglet fell from the nest at the Cibecue breeding area in 1986 (Hein and Nahstoll 1986), and two died in the nest at 1–2 days of age at Sheep (R. Mesta pers. comm., D. Driscoll unpublished field notes). In addition, we found the skeleton of a nestling below Orme nest 3 in 1990, that would have been from 1986 or earlier (see Section D4.20). During 1987–1990, we documented 23 juvenile bald eagle mortalities, which are discussed below.

C3.2.1 Juvenile Mortality—1987

Five juvenile mortalities, four nestlings and one fledgling, were documented at Arizona bald eagle breeding areas in 1987. One eaglet at East Verde died while pipping from its egg in a snow storm. Nest parasites likely contributed to the deaths of three nestlings (see Section C3.4), although one (Cibecue) was also attacked by a near-adult bald eagle and likely stressed. One of the Blue Point juveniles was found dead along the Salt River, below Stewart Mountain Dam, three weeks after fledging.

Two eggs were laid at the East Verde breeding area in 1987. The first egg hatched on 26 February, during a snow storm. The second eaglet was pipping on 26 February, but the egg was left partially exposed as the adults devoted their attention to the newly hatched eaglet. The pipping nestling died from the exposure.

At the Cibecue territory, ABENWP biologists P. Carroll and A. Housser last observed the adult female (one eaglet in nest) on 18 April being chased downstream by a supernumerary near-adult male (not part of the nesting pair) with brown feathers in its white head and tail (ca. 4 years old). On 19 April, the near-adult began interacting with the resident adult male. The two eagles entered into several aggressive altercations per day. On 29 April, the intruding male entered the nest and attacked the eaglet. The resident male returned to the area during the attack and drove the floater adult away from the nest; no observations of the floater male occurred from 5 to 8 May. Carroll and Housser were absent during 8 and 9 May, but returned on 10 May to find the eaglet dead in the nest and the near-adult interacting with the resident male. Only bones and feathers remained when the nestling was retrieved on 13 May amid a heavy infestation of Mexican chicken bugs (see Section C3.4).

Two nestlings at the Ladders breeding area (JP08 and JP09) died on 5 and 7 May. ABENWP biologists observed a floater adult interacting with the resident adults on 4 May and shortly after sighted the resident adults and both young in the nest. No nest observations took place on 5 May. On 6 May, biologists sighted one dead eaglet in the nest and the other on a ledge approximately 10 m south of the nest (Sudar pers. comm.). BioSystems and USFWS biologists retrieved the dead nestling, JP08, on 7 May, but could not locate JP09 on the nest cliff. The same day we found prefledged JP09 at the Chasm Creek confluence and returned the eaglet to the nest. The nestling appeared to die four minutes after it was returned to the nest, but the U.S. Forest Service requested it be left there for the remainder of the day. The nest climb on 7 May and retrieval of JP09 on 8 May revealed a heavy infestation of Mexican chicken bugs (see Section C3.4) which likely caused premature fledging and contributed to the eaglets' demise. Cause of death could not be determined from necropsies.

A juvenile bald eagle from the Blue Point breeding area (JD10) was found dead in the vicinity of Bulldog Cliffs on 19 June. A dead red-tailed hawk, located approximately 3 m from JD10, suggested that the birds may have injured each other in an altercation, or were possibly shot or poisoned. The state of decomposition of the two carcasses precluded positive determination of the cause of death.

C3.2.2 Juvenile Mortality—1988

Seven known juvenile mortalities occurred during the 1988 season, two in the nest and five post-fledging. The Pinal nestling died after becoming entangled in monofilament fishing line. Nest parasites and unusually high temperatures were assumed to have caused or contributed to the death of two eaglets at the Redmond breeding area. The three Blue Point young died shortly after fledging, probably as a result of heat stress, and one post-fledging juvenile was apparently killed by a great horned owl at Ladders.

During a nest check at the Pinal breeding area on 13 April, BioSystems biologists noticed the eaglet, which hatched prior to 16 March, appeared to be dead and was laying at the back of the nest. We climbed the pinnacle on 26 April, and found that the eaglet had become entangled in monofilament fishing line and died at about two weeks of age. The nestling's feet were unusually small, which led to the assumption that the monofilament had cut off circulation to the legs several days before the eaglet actually died (K. Ingram pers. comm.). See Section C3.3 for more details on monofilament in Arizona bald eagle nests.

The Redmond eagles raised two young in a new nest on a west-facing cliff on the east side of Redmond Flat in 1988. We climbed the nest to band the 10-week-old eaglets on 12 May. Both young were perched on the northern most end of the nest ledge, approximately 2 m away from the nest as we approached the cliff. The west-facing cliff was hot to the touch and the sun's heat was noticeably burning the climbers already tan skin. Upon entering the nest, Mexican chicken bugs scurried up the climber's legs. The bugs were noted crossing the bare rock ledge to access the perched eaglets. By 19 May, both young had died, one in the nest and one after fledging to the talus slope 50 m west of the nest. Nest parasites and heat stress likely contributed to the death of both nestlings (see Section C3.4 and C3.5).

Three juveniles at the Blue Point breeding area left the nest on 14 and 16 May at 11 weeks of age. One of the three, (JD32) appearing much younger than his siblings, left first and remained on a vegetated ledge 10 m above the ground, directly below the nest. The other two eaglets left the nest two days later. One (JD34) flew to an open hillside north of the nest. The last nestling (JD33) soared in a wide circle, returned toward the nest, and flew into the face of the pinnacle, trying to perch. It then tumbled down the pinnacle face, breaking its neck. We entered the area on 23 May to retrieve the dead fledgling (JD33) and found all three young dead. Heat stress was believed to have contributed to the deaths of these eaglets (see Section C3.5).

The Ladders juveniles also fledged on 14 and 16 May at 12 weeks of age. Both of these young had been telemetered in the nest and we monitored their post-fledging movements. On 9 June, 4 weeks after leaving the nest, JP22 roosted on the nest cliff as usual. On the morning of 10 June, the juvenile was found on the ground below the nest cliff. The bird had been decapitated and its breast muscle eaten, apparently by a raptorial bird. Since the incident happened during the night, a great horned owl was the suspected predator. Great horned owls are known to decapitate prey, and this is commonly recognized as their signature.

C3.2.3 Juvenile Mortality—1989

Ten known juvenile mortalities occurred during the 1989 season. Nine eaglets died in the nest and one fell from the nest ledge, breaking its wing. Human disturbance and altered habitat may have contributed to the death of the two Blue Point nestlings, while eaglets at Pinal, and Cibecue died of unknown causes. The Horseshoe eaglet was apparently killed by a great horned owl. Nest parasites and unusually high temperatures were assumed to have caused or contributed to the death of two eaglets at the Redmond breeding area. High temperatures also appear to have been related to the death of one eaglet at Cliff, one at Bartlett, and one at Ive's Wash.

At the Blue Point breeding area in 1989, hatching occurred on 8 March, and at least one young was seen on 11 March, although feeding behavior indicated the presence of two eaglets (Bond *et al.* 1989). The eaglets died 16–19 March at about one week of age. The Salt River was largely without flow below Stewart Mountain Dam through the nesting season in 1989 and consisted of isolated pools (see Section C4.4). The dry riverbed allowed recreationists on the lower Salt River to access the nest cliff. People hiked under and attempted to climb the nest cliff (A. Day pers. comm.) and in one instance approached within 50–100 m of the nest (four days prior to hatching) and began throwing rocks (Bond *et al.* 1989). It is likely that too much disturbance near the nest, during a crucial period (just after hatching), and the lack of foraging opportunities (reducing prey availability) in the dry riverbed, contributed to the loss of the two eaglets.

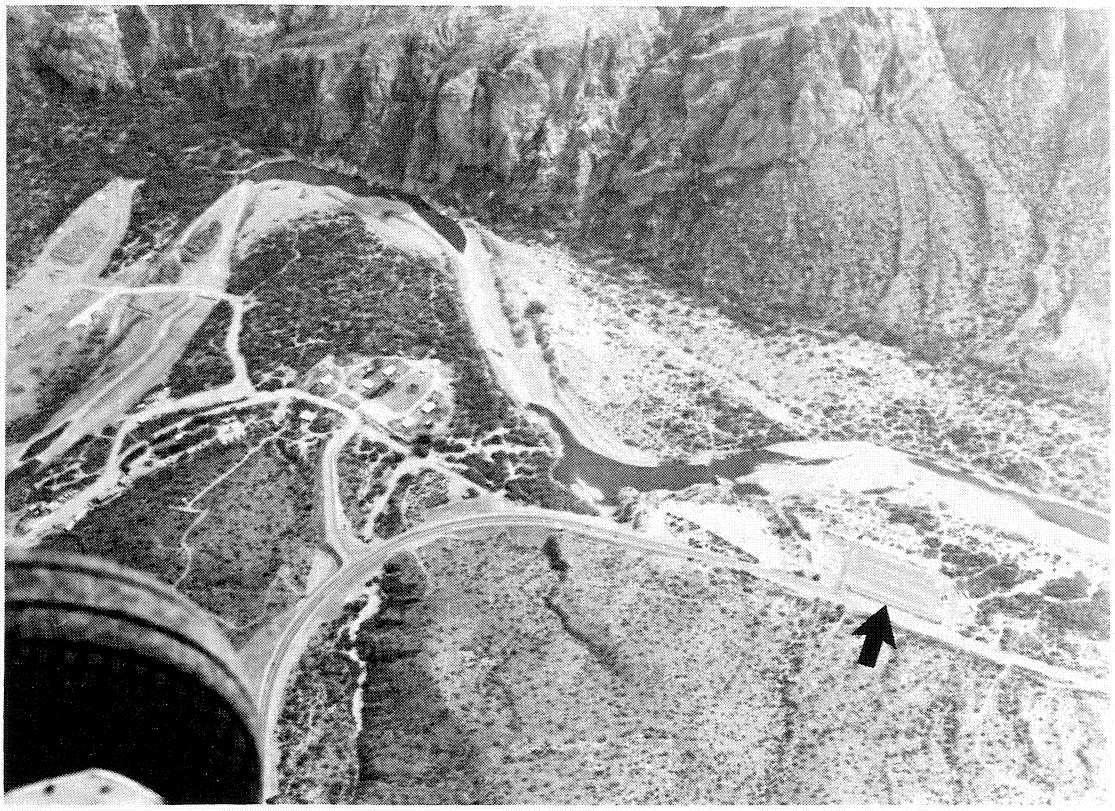


Plate C10. Blue Point (Bulldog) nest cliffs along the regulated Salt River, below Stewart Mountain Dam, February 1989. The cliffs contain nests 1 and 5, which have been used by bald eagles since at least the 1930s. This photograph was taken when water flow was shut off (0 cfs from January through March) during the bald eagle breeding season. The isolated pools disappeared in most sections of the river prior to the release of water from the dam. The parking area (indicated by arrow) was built by the U.S. Forest Service in 1988, directly across the river from nest 1, to serve as a starting point for recreationists tubing down the river (photo by D. Driscoll).

At the Pinal nest site, the remains of a week-old eaglet were found in the nest while banding the surviving juvenile. The young hatched on 23 March; therefore we estimated that the nestling died about 27–30 March. The remaining juvenile fledged successfully.

The Horseshoe adults reared one healthy eaglet to about three weeks of age in 1989. During a routine nest check on 2 April, BioSystems biologists found the eaglet was dead. We climbed the nest on 3 April and found the eaglet had been decapitated, a common practice of the great horned owl. The young had not undergone rigor mortis, which led us to believe the eaglet was killed 1–2 April.

Two eaglets died at the Redmond breeding area on 6–7 April, at 1.5 weeks of age, during a period of unusually high temperatures (see Section C3.5). A low density of Mexican chicken bugs was found in the nest when climbed on 13 April (see Section C3.4). The above-average heat and the nest parasites likely contributed to the death of both juveniles.

At the Cliff nest site, one eaglet died prior to 12 April at less than one week of age. The adults continued incubating the unhatched eggs until 15 May. We climbed the nest on 16 May and collected

one whole egg and two sets of eggshell fragments. The eaglet at this unshaded nest may have been another victim of the above-average temperatures during this period (see Section C3.5).

Breeding activity remained unknown at Cibecue until 5 June when an approximately 12-week-old juvenile was seen in the nest. A wildlife officer for the White Mountain-Fort Apache tribe had monitored the nest through the season, and told BioSystems biologists that one of the young died around 17 April at about five weeks of age. The Cibecue eaglet's death may have been linked to high temperatures (see Section C3.5), although we do not have enough information to be certain.

The Ive's Wash nest site was a flurry of activity in 1989. We climbed the nest to band the eaglets on 25 March. On 10 April, ABENWP biologists reported one of the young had been regurgitating its food for three days and apparently could not swallow. We removed the nestling (J241) on 11 April and transported it to Dr. Kathy Ingram at Liberty Wildlife Foundation. Dr. Ingram removed a fish bone (spine and fin rays) that had lodged in the eaglets esophagus, blocking the throat. The juvenile was nursed back to health and returned to the nest on 17 April.

Both of the Ive's Wash young jumped from the nest on 19 April, at nine weeks of age, during unusually high temperatures (see Section C3.5). One eaglet (J241) climbed back to the nest, while J242 remained on a ledge overnight. On 20 April J242 jumped from the ledge into the canyon below the nest. The juvenile was not sighted, nor did the adults take it food by 22 April. ABENWP biologists and USFWS biologist Robert Mesta found the young eagle on 23 April with a broken left radius and ulna (wing) and severely dehydrated. The juvenile was transported to Liberty Wildlife Foundation where it died of dehydration and shock on 25 April.

The Bartlett adults raised three nestlings to 11 weeks of age in 1989. On 9 May, during a period of unusually high temperatures, one eaglet died in the nest (see Section C3.5). The remaining two young fledged on 10 and 11 May. The two fledglings remained on the ground for several days before flying to safer perches. We did not retrieve the dead eaglet, because the nest climb requires a helicopter and the adults remained in or close to the nest to watch the two fledglings.

C3.2.4 Juvenile Mortality—1990

Only one known juvenile mortality was documented in 1990 when the Cibecue eaglet died on 14 April, at 1.5 weeks of age. Two river rafting guides, who are also professional photographers, photographed the nest and adults in early March. The river rafting guides "blazed a trail" up the backside of the nest cliff, and once again photographed the adults and nest on 5 April when the nest watchers were on their days off. The photographers later informed ABENWP personnel that the adults were circling and vocalizing on each occasion (Kershaw and Mehling 1990). An army helicopter flew within 200 m of the nest twice on 24 March, and an air force jet passed the nest at a distance of 300 m on 27 March.

On 10 and 11 April, an air force jet flew within 400 m of the nest, 81 vehicles passed below the nest, 12 hikers walked below the nest, and 12 rafts floated passed the nest (Kershaw and Mehling 1990). The photographers (and other disturbances), at a crucial point in the nesting cycle (just after hatching), may have contributed to the eaglet's demise. Photographers have been associated with nest failures at two other breeding areas in Arizona (see sections D4.25 and D4.26). We have also observed commercial rafting fliers that advertised "Hike to an eagle nest" as part of the paid trip.

C3.2.5 Summary of Juvenile Mortality

The 57 juvenile mortalities documented in Arizona have occurred at only 14 of the 28 known bald eagle breeding areas (Table C3.2-2). The Cibecue breeding area ranked first in juvenile mortality, with 13 deaths (56.5%) of 23 young hatched. Redmond ranked second, losing 10 (40.0%) of 25 eaglets hatched, followed by Blue Point, where eight young died (29.6%) of 27 hatched. The Bartlett nest site ranked fourth, with seven juvenile mortalities (28.0%) of 25 nestlings hatched. Pinal ranked fifth, followed by Cliff, Ladders, and Sheep.

Table C3.2-2. Arizona bald eagle breeding areas ranked by juvenile mortality.

Rank	Breeding Area	Total Occupied Years	Young Hatched	Nestling And Post-Fledging Mortalities	Percent
1	Cibecue	15	23	13	56.5
2	Redmond	16	25	10	40.0
3	Blue Point	15	27	8	29.6
4	Bartlett	24	25	7	28.0
5	Pinal	12	16	4	25.0
6	Cliff	7	7	3	42.9
7	Ladders	16	17	3	17.6
8	Sheep	9	2	2	100.0
9	East Verde	17	27	2	7.4
10	Ive's Wash	4	4	1	25.0
11	Orme	5	5	1	20.0
12	"76"	10	12	1	8.3
13	Horseshoe	16	18	1	5.6
14	Fort McDowell	21	33	1	3.0
	Other Sites	72	35	0	—
Total		259	276	57	20.7

Of the 276 known young hatched in Arizona, 232 (84.1%) survived to fledge, and 44 died, resulting in a 15.9 percent nestling mortality rate. We know of 13 additional eaglets which died prior to departing on migration, for a total of 57 known juvenile mortalities, resulting in a 20.7 percent juvenile mortality rate prior to departing the natal area. It is important to note that this number represents a minimum mortality figure, since it is difficult to keep track of post-fledging juveniles, and most data collection (by the ABENWP) ceases when the eaglets leave the nest. Actually witnessing the mortality of a fledged juvenile, or finding a carcass (before scavengers do so) in the vast expanse of the desert is rare, unless the eaglet was radio-tagged.

In other bald eagle populations throughout North America, an average of 85 percent of hatched young survive to fledging resulting in a mean nestling mortality rate of 15 percent (Stalmaster 1987). Thus, the Arizona population may suffer a 0.9 percent higher nestling mortality rate, and in turn, a 0.9 percent lower nestling survival rate, than the mean for other bald eagle populations throughout North America, although this difference was not significant by Chi-Square analysis. Also, the Arizona population experienced an additional 4.8 percent mortality rate prior to the juveniles departing on migration.

It is important to note, however, that in Arizona we know more about the mortality of our eaglets than in other populations. Mortality data in many populations is acquired from ORA surveys when the nestlings are 8–10 weeks old. In Arizona, due to the ABENWP and other projects, we have data on juvenile mortality prior to and after fledging. However, the close watch we keep on Arizona nests (ABENWP) also increases survivorship, by allowing us to intervene in emergency situations and save eaglets which would have otherwise perished.

The potential sources of juvenile bald eagle mortality are numerous, including natural (health related) factors, nest predation, human disturbance, monofilament fishing line (see Section C3.3), nest parasites (see Section C3.4), heat stress (see Section C3.5), prey abundance and availability, weather, and likely many more. Details on juvenile mortalities at individual bald eagle breeding areas in Arizona are provided in Section D4.

C3.3 MONOFILAMENT IN NESTS

Although monofilament fishing line has been used for decades, it has only recently been recognized as a mortality factor in bald eagles. None of the previous reports on Arizona bald eagles mention monofilament in the nests, although Grubb (1984) found a fishing stringer in the Lone Pine nest. The first documented incident in Arizona involving monofilament and fish hooks occurred at the Horse Mesa breeding area in 1986. The adult female returned to the nest with a fishing hook lodged in her tongue and monofilament hanging from her beak. The female had difficulty feeding the eaglets and herself, and dropped much of the food into the nest. She shook her head violently on many occasions throughout the day, but the hook remained imbedded in her tongue. The bird had dislodged the hook within 24 hours. Later in the season both eaglets had monofilament protruding from their beaks, but it was absent later the same day (Driscoll and Buckley 1986).

From 1986–1990, we found fishing paraphernalia in 22 (40%) of 55 examined nests which contained broods (Table C3.3-1). During nest climbs in 1986, monofilament, fishing hooks, weights, and fishing lures were found in four nests. Four sites contained fishing paraphernalia in 1987, eight in 1988, and five in 1989. Fishing tackle was only found in one nest in 1990; however nests were only climbed to band young, so not all sites were checked. At the Bartlett breeding area in 1989, monofilament was attached to prey delivered to the nest on two occasions. Monofilament also occurred in one of three bald eagle nests we climbed on the Rio Yaqui, Sonora, Mexico (Brown and Olivera 1988).

A fishing lure with three treble hooks was removed from the Alamo nestling's tongue on 23 April 1988 when we returned her to the nest after she was blown out in a storm. The hook at one end of the lure was lodged in her tongue, while the hook at the opposite end held a dead white-faced ibis brought in as prey. We also removed a fishing hook from the foot of a juvenile at Cliff when we captured it for radio-tagging shortly after it fledged.

Table C3.3-1. Occurrence of fishing paraphernalia in Arizona bald eagle nests containing broods, which we examined during 1986–1990.[1]

Breeding Area	1986	1987	1988	1989	1990
Alamo	—	—	ML[3]	MH	0
Bartlett	—	—	—	M[6]	—
Blue Point	—	0	MH	0	—
Canyon	0	—	—	0	—
Chino	MHL	—	—	—	—
Cibecue	0	0	—	—	—
Cliff	—	—	MH3[4]	0	—
Coolidge	0	0	M	—	—
East Verde	MW	0	0	0	—
Fort McDowell	M	M	—	M	—
Horse Mesa	MH[2]	MH	0	—	0
Horseshoe	—	0	0	0	0
Ive's Wash	—	0	MH3	MHL	—
Ladders	0	0	M	0	—
Lone Pine	—	—	0	—	—
Orme	—	M	0	—	0
Pinal	—	MHW	MH[5]	H	MLW
Redmond	0	0	MS	0	0
"76"	0	—	0	—	0

[1] **M** monofilament, **H** hook, **L** lure, **W** weight, **S** stringer.
[2] Hook lodged in adult female's tongue. Out within 24 hours. Both young with monofilament protruding from beak. Lost same day.
[3] Lure lodged in nestling's tongue. Removed on nest climb next day.
[4] Hook removed from juvenile's foot when captured for radio-tagging.
[5] Nestling died at age two weeks. Entangled in monofilament.
[6] Monofilament attached to prey delivered to nest on two occasions.
— Not climbed or did not contain a brood.
0 No fishing paraphernalia found.

The Pinal nestling died at two weeks of age in 1988. We climbed the nest to retrieve the eaglet and found it entangled in monofilament fishing line. A hook was lodged against its left leg, and the monofilament line lay in multiple wraps around both legs, also entangling the wings and upper body. The nestling's feet appeared abnormally small in relation to its body size. Necropsy revealed the monofilament had cut off circulation to the legs, prohibiting growth in the last 3–4 days of the eaglet's life (K. Ingram pers. comm.).

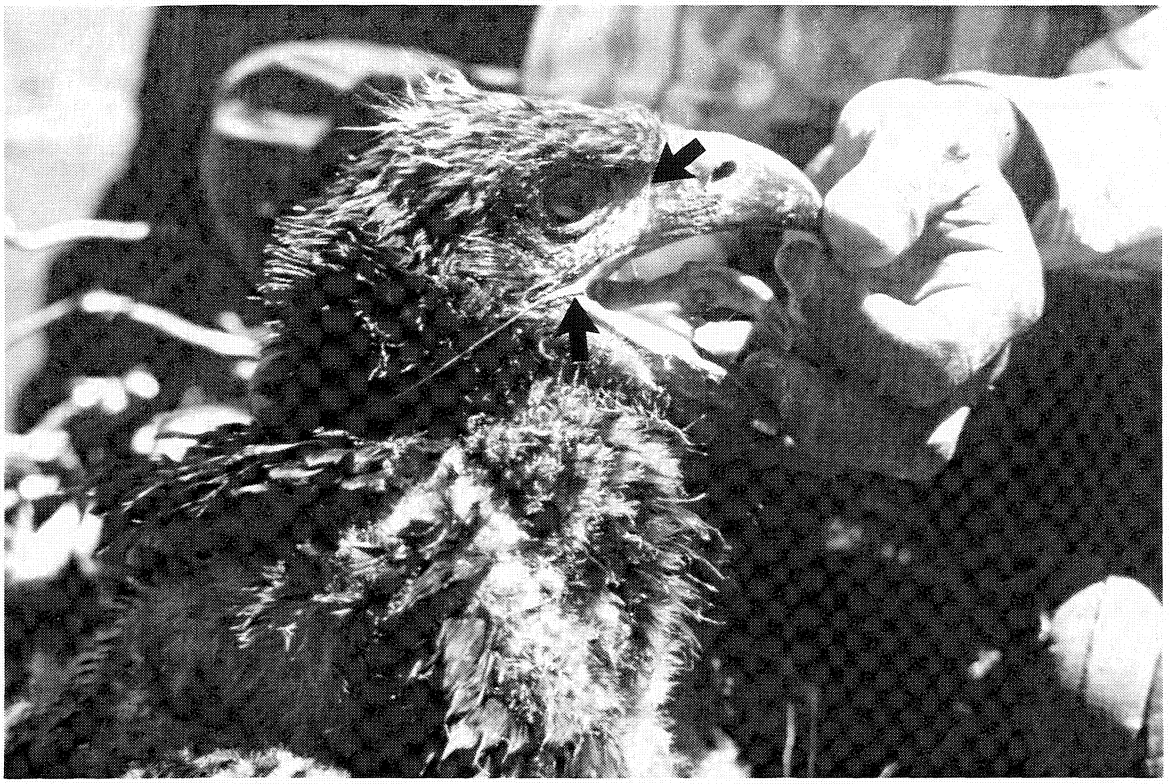


Plate C11. Nestling bald eagle entangled in monofilament at the Horse Mesa breeding area, March 1991. Note the fish hook lodged in the eaglet's mouth (arrow). The monofilament was wrapped around the eaglet many times, then attached to the nest, so the eaglet could not move. The fishing line can also be seen in front of the nestling's eye (arrow), in a loop over the beak and under the tongue (lacerating the underside of the tongue) which likely prevented eating, by holding the tongue against the roof of the eaglet's beak (photo by D. Driscoll).

A similar incident occurred in the Greater Yellowstone Ecosystem where a six-week-old eaglet died after becoming entangled in monofilament (A. Harmata pers. comm.). Also, a six-week-old eaglet was found tied to the nest (entangled in monofilament) in southeast Alaska in 1988. The young eagle, still alive, was removed from the nest, nursed to health, and released in a hacking program (P. Schempf pers. comm.). In Washington, an approximately nine-week-old eaglet was found hanging from a nest tree in 1988, with a monofilament gill net around its neck. The gill net was also tangled in the tree branches, and held part of a steelhead (salmon). It appeared that an adult carried the fish (which was caught in the net) to the nest; then the eaglet became entangled in the net and fell, strangling itself when the net was caught in the tree (Watson 1989). Although fishing paraphernalia appears to have only recently become a factor in nestling bald eagle mortality, it may be that in earlier decades it occurrence was overlooked, since Broley (1947) noted finding a fish plug and a 70 foot line with hook attached in a Florida bald eagle nest.

Nestling bald eagles are not the only victims of waste monofilament and fishing tackle. The Horse Mesa adult female had a hook lodged in her tongue (see above). In a similar incident, an adult bald eagle in California had a fishing hook lodged in its naris (nasal opening). While trying to remove the hook, the eagle caught one talon in its naris, fell off its perch, and drowned (Zimmerman 1976). We also found

a dead raven in the East Verde breeding area with monofilament protruding from its beak. Two oriole nests made almost entirely of monofilament were found at the confluence of the Salt and Verde rivers in the Orme bald eagle nesting territory. In this same location, M. Cross (AGF) found a live common moorhen with a hook in its stomach and the attached monofilament tangled amongst the riparian brush. In another oriole nest made of monofilament, the female oriole hung itself in a loop of it (Mather 1987). Brown pelicans have also died from becoming entangled in monofilament fishing line (National Wildlife Federation 1988). For a discussion of angler litter, see Edwards and Cryer (1987).

Other foreign matter found in Arizona bald eagle nests included white plastic bags, melted plastic, white gauze, white string, comforter material with stuffing attached, white jean material, red sock material, blue and black string, wire, styrofoam, cattle feces, unidentified mammal feces, ringtail scat, rocks, cardboard, yellow nylon rope, a Budweiser beer can, and a Grandma's cookie package (fudge chocolate chip). Shotgun shells, rifle cartridges, and beer cans were frequently found near nests. A metal measuring tape and pop rivet were found in the 1989 Blue Point nest, obviously left during a previous eagle study. In an interesting observation, the Bartlett female delivered a plastic ice bag and a cardboard Budweiser beer box to the nest on the same day in 1989.

C3.4 NEST PARASITES

Avian ectoparasites include flies, fleas, lice, bedbugs, ticks, and mites. These organisms can cause mortality (if present in sufficient numbers) by feeding on birds, weakening them, and making them more susceptible to secondary infection. Ectoparasites may also transmit endoparasitic worms, protozoans, bacteria, and viruses (Phillips 1990). Nest parasites have only recently become apparent as a contributing factor to juvenile bald eagle mortality. Hildebrandt and Ohmart (1978) found no parasites in nests or on nestlings, and Hildebrandt (1981) reported finding only dermestid beetle larvae (*Dermestidae*) in nests. No parasites were mentioned in Arizona bald eagle research until Grubb (1984) documented the occurrence of Mexican chicken bugs (*Haematosiphon inodorus*) in bald eagle nests. The parasite has also been found in golden eagle nests in Idaho (M. Kochert pers. comm.) and Arizona (Grubb 1986b). Mexican chicken bugs appear more prevalent in cliff nesting raptors than those which nest in trees. Platt (1975) documented the parasite in nests of prairie falcons, red-tailed hawks, and golden eagles, and reported on its occurrence in nests of the California condor, turkey vulture, great horned owl, and barn owl. In addition, Lee (1955) noted the bug on domestic chickens and turkeys.

The Mexican chicken bug is a bloodsucking ectoparasite of the Cimicidae family, similar to a bed bug (Figure C3.4-1). The bugs live in or near nests or roosts, and emerge to feed on the young and/or adults at night (Usinger 1966, Phillips 1990). In one laboratory experiment (Lee 1955), adult bugs survived only a few weeks without eating, and nymphs for only 5–8 days. In contrast, Phillips (1990) reported that females lay hundreds of eggs, and that all stages can go for months without feeding. This parasite likely caused or contributed to the death of both eaglets at the Redmond nest in 1984, and, in 1985, the bug was found in the Pinal nest two weeks after fledging, and in two golden eagle nests one week following fledging (Grubb 1986b).

From 1987–1989, we found nest parasites in 12 (32%) of 37 examined nests which contained broods (Table C3.4-1). If tree and cliff nests are separated, parasites were found in 39 percent of cliff nests, but we did not find any in tree nests. We found Mexican chicken bugs at four bald eagle nests in 1987, three in 1988, and two in 1989. High densities of the parasite occurred at the Ladders and Cibecue

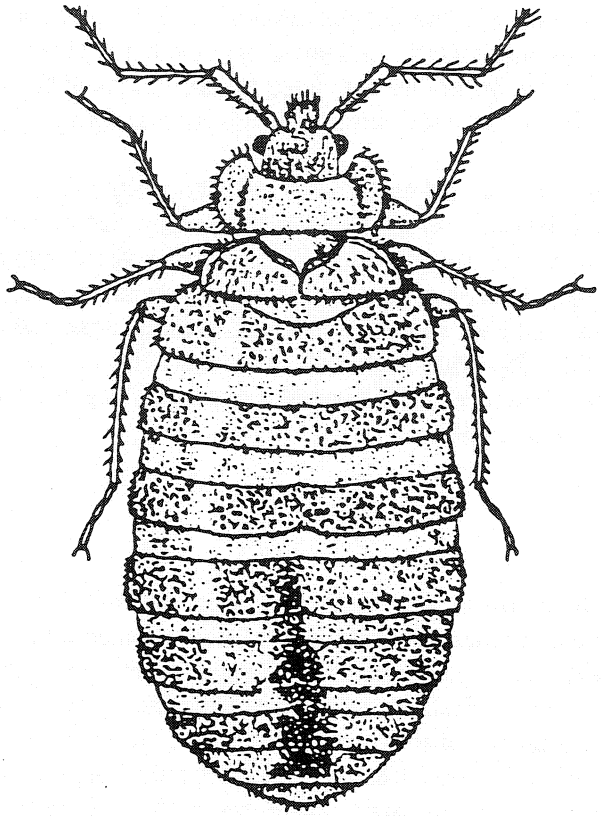


Figure C3.4-1. Enlarged dorsal view of mature bedbug, a close relative of the Mexican chicken bug, engorged with blood.

breeding areas in 1987, where two and one young died, respectively. Upon entering nests to retrieve deceased nestlings, biologists were covered by the bugs. No immediate irritation occurred, apparently due to a form of anesthetic present in the bugs' saliva (M. Kochert pers. comm.), so the bites of the offending parasites initially passed unnoticed. Within 24 hours, however, a severe itching dermatitis appeared and remained for over six weeks. Mexican chicken bugs were found again at a high density at the Ladders breeding area in 1989 (same nest as 1987), two weeks after the two young successfully fledged. However, no bugs had been apparent when the young were banded at six weeks of age.

We observed chicken bugs in low density at the Redmond breeding area in 1987 where two young fledged. In 1988, the parasite occurred in high numbers in a new nest 1.5 km north of the pinnacle nest. When approached for banding, both eaglets were perched on a ledge away from the nest. We saw no eaglets in the nest from a helicopter on 19 May. A subsequent search of the area revealed one young dead in the nest and the other dead 50 m west of the nest. We entered the nest in July, two months later,

Table C3.4-1. Occurrence of nest parasites in Arizona bald eagle nests containing broods, which we examined during 1987-1989.[1]

Breeding Area	1987	1988	1989
Alamo	—	0	0
Bartlett	—	—	Tick[3]
Blue Point	0	0	0
Cibecue	H (1D)	—	—
Cliff	—	0	0
Coolidge	0	H (2F)	—
East Verde	0	0	0
Fort McDowell	0	—	0
Horse Mesa	0	0	—
Horseshoe	H (3F)*	M (1F)	0
Ive's Wash	0	0	Worms[4]
Ladders	H (2D)	0	H (2F)*
Lone Pine	—	0	—
Orme	0	2 Louseflies[2]	—
Pinal[5]	0	0	0
Redmond[6]	L (2F)	H (2D)	L (2D)
"76"	—	0	—

1 Mexican chicken bug (*Haematosiphon inodorus*) densities: H=high, M=moderate, L=low, and number of young fledged (No. F) or died (No. D).

2 First documented occurrence of this species (*Icosta nigra*) on bald eagles. One young fledged.

3 First documented occurrence of any tick on a bald eagle, and first state record of this species (*Argas cooleyi*) in Arizona. Two young fledged, one died in nest two days prior to fledging of siblings.

4 Unknown worms extracted from throats of young during surgery and necropsy. One young fledged, one died of injuries from nest fall.

5 Mexican chicken bugs reported in Pinal nest in 1985, after one young had fledged, by Teryl Grubb, USFS.

6 Mexican chicken bugs reported in Redmond nest in 1984, after two young died, by Teryl Grubb, USFS.

* Mexican chicken bugs found after young had fledged, but were not present when eaglets were banded.

— Not climbed or did not contain a brood.

0 No Parasites found.

and noticed only a few parasites. In 1989, a low density of chicken bugs was found in the Redmond pinnacle nest where two eaglets died at 1.5 weeks of age. See Section C3.5 for information on heat stress, the effects of which are likely aggravated by loss of fluids to chicken bugs.

We found no Mexican chicken bugs at the Horseshoe breeding area when we entered it for banding in 1987. Three eaglets fledged in late May, but when we entered the nest for measurement on 4 October it contained a heavy infestation of the parasite. That day, the adults were perched on a new nest built between July and September, 400 m west of the 1987 nest. This nest contained a moderate chicken bug infestation in April 1988 when we banded the eaglet, which later fledged successfully. Upon entering the nest for measurement in July 1988, we found only a few bugs.

A high density of Mexican chicken bugs existed at the Coolidge cliff nest during banding in April 1988. Due to the small nest ledge at this site, the BioSystems climber hung next to the nest to remove young for processing. When he stood in the nest to ascend the cliff, he received numerous bites. Both eaglets fledged, and we found no chicken bugs when measuring the nest in June.

To learn more about the invertebrate community within bald eagle nests in Arizona, we collected nest lining samples when performing banding and post-fledging climbs. James R. Phillips, a noted raptor parasitologist at Babson College, Massachusetts, analyzed two of these samples. Phillips indicated that our (Arizona's) nest lining was overly dry, making it difficult to detect invertebrates using a Berlese funnel, a common detection method involving placing the nest lining in a funnel under a heat lamp, with a jar of alcohol below. The nest lining slowly desiccates, causing the invertebrates to retreat into the alcohol. Instead, he floated the samples in a water bath and removed the invertebrates (J. Phillips pers. comm.).

Phillips analyzed a sample from a nest with heavy chicken bug infestation (Horseshoe 1987) and a sample from a presumably non-infested nest (Pinal 1987). In addition to the nest lining samples, we collected 19 bugs from the Horseshoe nest. Phillips identified these as 13 male and 6 female Mexican chicken bugs.

The Horseshoe sample (240 g dry weight) yielded 13 arthropods: 3 nonparasitic mites, 2 collembolans (fungivorous springtail insects), 4 dermestid beetle larvae (subfamily Attageninae), 2 clothes moth larvae (Tineidae), 1 adult fly, 1 fly larva, and 1 Mexican chicken bug.

The Pinal sample (256 g dry weight) yielded 69 arthropods (and also contained nematodes): 58 nonparasitic mites, 2 Psocoptera (booklice), 3 fly larvae of 2 genera, and 6 dermestid larvae.

These inventories show that nest-lining samples can be misleading when comparing the relative densities of chicken bugs in Arizona bald eagle nests. Although high numbers of Mexican chicken bugs occurred in the Horseshoe nest in 1987, only one of this species was extracted from the nest lining sample. Visual density estimates may also present problems because the parasite moves quickly over the top of the nest, across, and under the sticks. As a result, we categorized infestations visually as high, moderate, or low. We must also remember that infestations may be latent (i.e., parasites inactive at the time of visit or in the egg or nymph stage).

In 1987, three nests contained high densities of Mexican chicken bugs, and one nest had a low level of infestation. All of these nests fledged young in prior seasons, so parasite eggs may have been present when nesting began. Three of these pairs (Horseshoe, Ladders, and Redmond) moved to newly built nests in 1988, while Cibecue apparently failed to lay eggs, possibly as a result of mate loss the previous year. We noted heavy infestations of chicken bugs in two nests in 1988 (Redmond and Coolidge) and moderate densities in Horseshoe. Although the Coolidge nest had been used previously (old eggshell fragments were present), Redmond and Horseshoe were new nests. In 1989, the Redmond and Ladders nests (same nests as 1987) once again contained low and high densities of Mexican chicken bugs, respectively. However, the parasite was not found until after the two Ladders young had fledged in 1989. Both 1989 Redmond eaglets died at 1.5 weeks of age.

It appears that certain nests show a history of Mexican chicken bug infestation. The bugs were present at the Horseshoe breeding area in 1987 and 1988. The Redmond pinnacle nest contained bugs in 1984

(Grubb 1984) and, although the nest was not climbed in 1985 or 1986, the eaglets behaved normally and fledged successfully. The pinnacle nest harbored the parasite in 1987 and 1989, as did a newly built cliff nest in 1988. The Ladders nest at Chasm Creek also contained the bugs in 1987 and 1989.

Phillips (1990) reported that, "Sometimes these parasites do cause death or can pave the way for lethal secondary infections. Sick or injured birds are more vulnerable to parasites, and arthropod populations on these individuals are more likely to reach levels where they do serious damage." Mexican chicken bugs have apparently caused or contributed to the deaths of at least seven nestling bald eagles in Arizona during 1987–1989, 10 percent of those hatched (n = 72). We might therefore consider methods of controlling these parasites. Phillips explained that if nest parasites like cimicid bedbugs become established, chemical control agents may be necessary. Usinger (1966) reported that Mexican chicken bugs can be removed from poultry houses by a thorough application of hydrated DDT or BHC, although, needless to say, such a measure would be highly inappropriate as a modern management technique. A safe alternative might lie in the treatment of nests with pyrethrins, naturally-occurring plant-derived insecticides which are non-toxic to vertebrates. Phillips reported that:

> "Dose and toxicity information related to wild birds and 16 commonly used ectoparasite control chemicals are provided by Jackson [1985]. According to Axtell and Arends [1990], permethrin, a synthetic pyrethroid, is the most widely used chemical to control mites, lice, and bedbugs, because of its long-term effectiveness and the lack, so far, of resistance to it."

We should point out, however, that such applications might disrupt the natural invertebrate communities in bald eagle nests. In our opinion, the matter should be researched if continued infestations suggest management action.

In 1988, we found another parasite, previously unrecorded on bald eagles. Two louseflies (*Icosta nigra*) were collected from the Orme juvenile during banding. This parasite, family Hippoboscidae, is known from several other raptor species in Arizona (J. Phillips pers. comm.). It is a blood-sucking ectoparasite that lives in bird plumage. The larvae develop in the female fly and form cocoons after being laid in bird nests. The larvae metamorphose into adults, and the adults feed on the birds' blood, and also transmit blood protozoan parasites as well as skin mites and lice (Phillips 1990).

When the two 1989 Bartlett juveniles fledged to the ground, we picked them up for banding and radio-tagging. One eaglet fledged into a teddybear cholla cactus, so we spent 10 minutes pulling cholla spines out of the bird's face, feet, and body. In the process, we discovered a tick on the underside of the juvenile's right wing. The tick was removed and sent to a parasitologist. This represents the first documented occurrence of any tick on a bald eagle, and the first record of this species (*Argas cooleyi*) in Arizona (J. Phillips pers. comm.). Argasid ticks are usually rapid feeders, although larvae may remain attached to the host for several days. They inhabit nests, caves, burrows, and roosts, feeding mostly at night. They lay their eggs in rock crevices or under treebark where they also seek shelter (Phillips 1990).

Dr. Kathy Ingram, Liberty Wildlife Foundation, also extracted an unknown worm species from the throat of each of the Ive's Wash eaglets in 1989, one while in surgery, the other during necropsy. In addition, we found two snout beetles in the 1988 Ladders nest and collected trox beetles from several golden eagle nests in Arizona.

C3.5 SHADE AND HEAT STRESS

Heat stress has been debated as a possible mortality factor at Arizona bald eagle breeding areas (especially at the Redmond nest) since intensive research began in 1977 (Hildebrandt 1981, Ohmart and Sell 1980, Haywood and Ohmart 1982, Haywood and Ohmart 1983, Grubb *et al.* 1983, Grubb 1984, Grubb 1986a). While in the nest, adults provide shade for the eaglets until they are old enough to seek shade on their own. The young often huddle under the adults or their siblings for shade, and place their heads in small shade patches on the nest when available. Both the adults and nestlings pant during hot portions of the day; however, the adults and eaglets also perch in the sun when shade is available. The adults often drink from the river after shading the young, and after feeding, as do the eaglets once they fledge (Driscoll 1985, Driscoll and Buckley 1986, Driscoll unpublished field notes, Hildebrandt and Ohmart 1978, Hildebrandt 1981).

A time-lapse camera at the Bartlett nest in 1978 revealed the eaglets used shade 87 percent of the time it was available, although they also perched in the sun when shade was present on the nest (Hildebrandt 1981). The death of one Bartlett nestling and two Redmond eaglets in 1978 was attributed to the young falling from the nest while seeking shade (Hildebrandt 1981). Haywood and Ohmart (1983) monitored adult use of shaded verse unshaded perches, and stated, "Adult bald eagles in Arizona actively seek shaded perches as temperatures rise sufficiently to cause thermal stress." The data presented in Haywood and Ohmart (1983) were inconsistent in relating shade seeking to temperature. They found that adult use of shaded perches: (1) fluctuated without respect to temperature at Redmond; (2) increased with temperature at Bartlett and Pinal; and, (3) decreased as temperatures increased at Ladders, East Verde, and Horseshoe. Perhaps, because adults have access to drinking water and free flight, heat might be less stressful than to nest-bound eaglets.

Details on the solar exposure (full sun verses full or partial shade) of certain nests within Arizona bald eagle breeding areas were recorded in 1984 and 1985 by Grubb (1986a). At the 17 nests observed, Blue Point (nest 1) received the most sun, followed by Cliff (nest 2, artificial nest), Horse Mesa (nest 2), Redmond (nest 5), Cliff (nest 1), and East Verde (nest 6). Sites receiving no full sun were Pinal (nest 2), and Fort McDowell (nest 11). It is interesting that some cliff nests (Pinal 2, Cibecue 3, Ladders 4) received less sun than some tree nests ("76"). Grubb (1986a) explained that his analysis "... does not indicate exposure to full sun is a limiting factor for success or productivity ..."; however, "This finding does not rule out heat and/or temperature as potential factors influencing reproductive success and habitat selection. ..."

We compared ambient temperatures at Sky Harbor Airport in Phoenix to fledging ages and eaglet mortality in 1988 and 1989. In mid-May 1988, Arizona experienced a period of unusually high seasonal temperatures (Figure C3.5-1). During this period, young left their nests at five breeding areas. Their fate varied and apparently depended on their ages at the time of the heat wave. Two 12-week-old juveniles at Ladders fledged successfully. At Bartlett, the 11-week-old juveniles spent two days on the ground after fledging, but survived. However, it is likely that heat stress contributed to the deaths of five young at the Blue Point and Redmond breeding areas.

The three Blue Point juveniles left the nest on 14 and 16 May 1988 at 11 weeks of age, and by 23 May all three young were dead (Section D4.4). The eaglets were almost surely forced to leave the nest as a result of heat stress. The nest was positioned on top of a pinnacle in a canyon where heat is reflected from the canyon walls. Figure C3.5-2 indicates that temperatures for May, when the eaglets vacated the

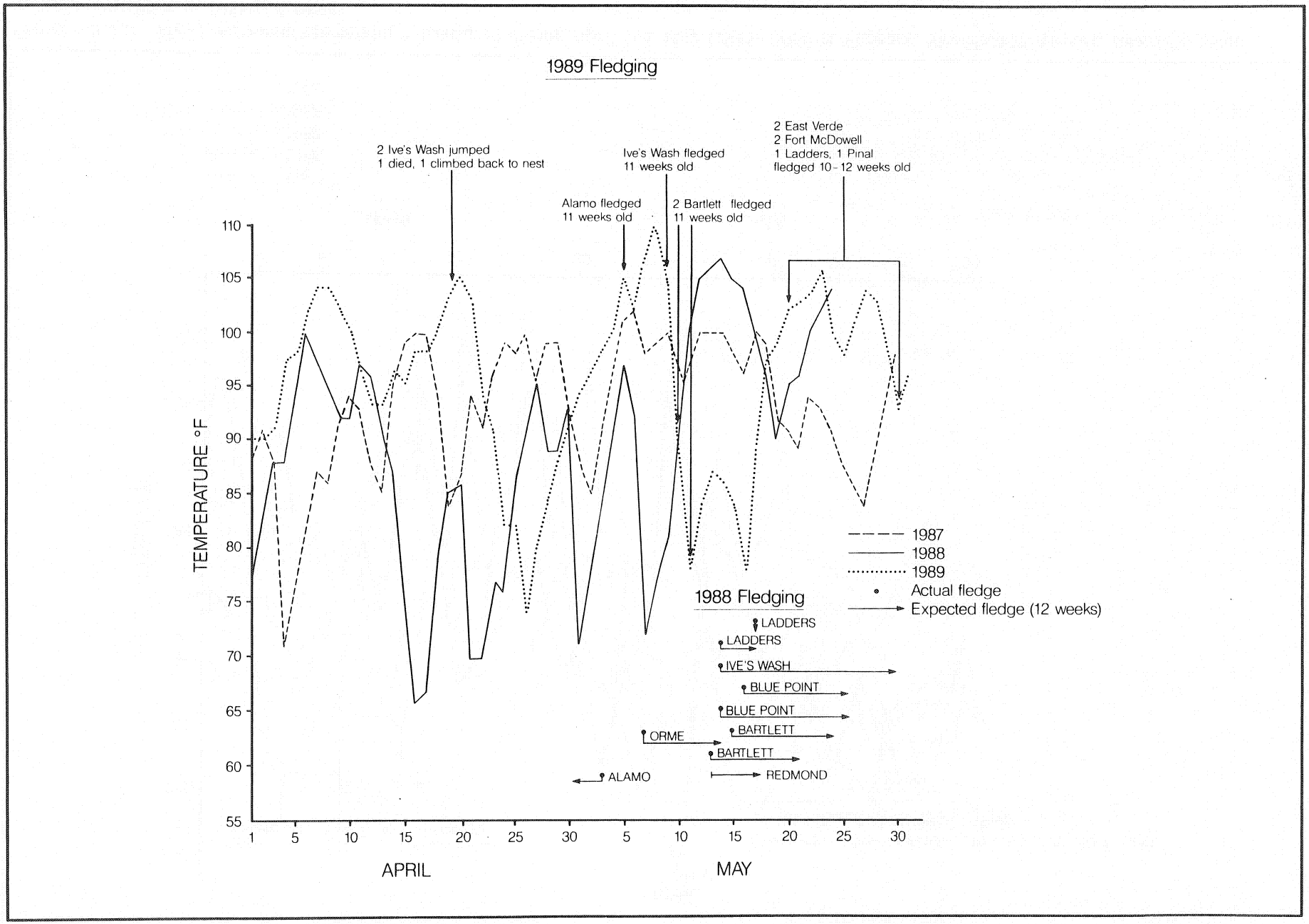


Figure C3.5-1. Daily maximum temperatures measured during April and May (1987-1989) at Phoenix, Sky Harbor Airport, related to some juvenile bald eagle fledging dates in 1988 and 1989.

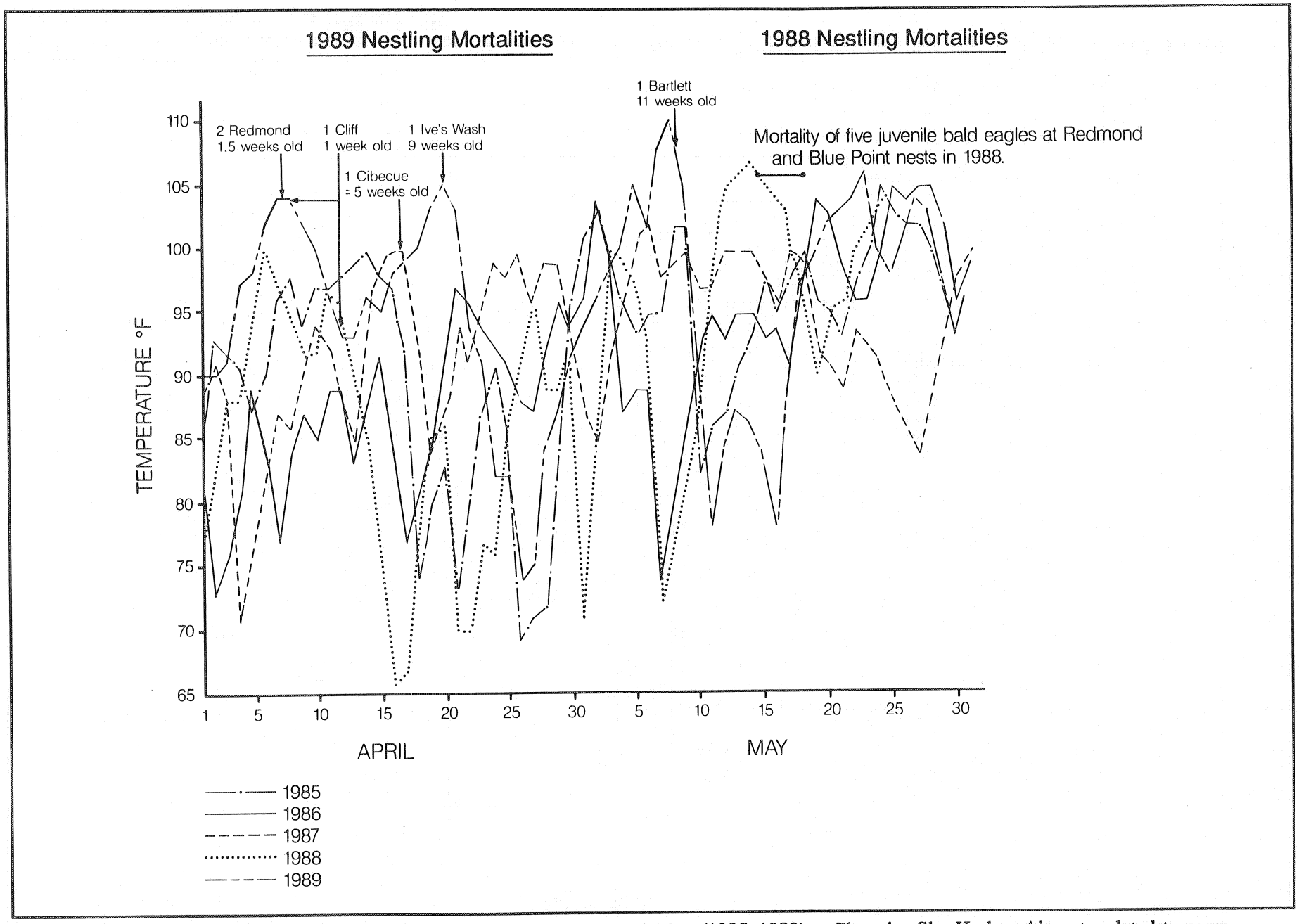


Figure C3.5-2. Daily maximum temperatures measured during April and May (1985–1989) at Phoenix, Sky Harbor Airport, related to some nestling mortalities in 1988 and 1989.

nest, were unprecedented during the previous four years at Phoenix. Our observations indicated that both juveniles and the adult female in the nest were heat stressed. One of the young birds appeared distressed as it walked frantically around the edge of the nest on bare rock, seeking but not finding shade.

The two Redmond juveniles died between 12–19 May (Section D4.25). The 1988 nest was on a west-facing cliff in a position directly exposed to intense solar heat. During banding, the climber noted the nest cliff was unusually hot. It may not be coincidental that the eaglets at Redmond died (one had exited the nest) at roughly the same time as those at Blue Point. However, the Redmond eagles were also exposed to Mexican chicken bugs (Section C3.4) which would have exacerbated the condition of heat stress or could have been the sole cause of death.

In 1989, four periods of unseasonably high temperatures were recorded at Phoenix, reaching maximums of 104°F on 7 April, 105°F on 20 April, 110°F on 8 May, and 106°F on 23 May (see Figure C3.5-1). Figure C3.5-2 indicates that these temperatures were unprecedented during the previous five years in April and May. Of the 10 known juvenile mortalities in 1989 (Section C3.2.3), six occurred during these temperature peaks.

Three juvenile bald eagles died during the first temperature peak, from 6–10 April 1989, two at the Redmond breeding area, and one at Cliff. The Redmond eaglets died on 6–7 April, at 1.5 weeks of age, when temperatures reached 104°F in Phoenix. It appears that the unseasonably intense heat contributed to the nestlings' demise, although a low density of Mexican chicken bugs was also found in the nest (Section C3.4). During the same period, one eaglet hatched (5 April) and died (prior to 12 April) at the Cliff nest site. Like Redmond, the heat may have affected the Cliff eaglet which was less than one week old.

During the second period of unseasonably high temperatures, peaking at 105°F on 20 April 1989, one nestling died at Cibecue and another at Ive's Wash. We do not know the details surrounding the death of the approximately five-week-old Cibecue eaglet, only that it died around 17 April (White Mountain–Fort Apache Wildlife Officer pers. comm.).

Moller *et al.* (1989) state that both Ive's Wash young jumped or fell from the nest on 19 April while attempting to find shade. The Alamo Reservoir region, on the fringe of the Mohave Desert, usually records higher temperatures than Phoenix, so it is likely the temperature at the nest area exceeded 105°F. The nestlings were only nine weeks old and could not fly. One eaglet climbed back to the nest; the other remained on a ledge overnight. On 20 April the juvenile jumped from the ledge into the canyon below the nest. The young eagle was found on 23 April with a broken left radius and ulna (wing) and severely dehydrated. The juvenile was transported to Liberty Wildlife Foundation, where it died of dehydration and shock on 25 April.

The third period of unseasonably high temperatures, from 4–9 May, peaked at 110°F on 8 May 1989. On 9 May, at 11 weeks of age, one eaglet died in the nest at the Bartlett breeding area. The remaining two young flew from the nest on 10 and 11 May and remained on the ground for several days before flying to safer perches. We did not retrieve the dead eaglet, because the nest climb would have required a helicopter, and the adults remained in or close to the nest to watch the two fledglings. In addition to the two Bartlett nestlings, the Alamo eaglet fledged on 5 May and the Ive's Wash eaglet on 9 May, all at 11 weeks of age (see Figure C3.5-1). These four juveniles make up 31 percent of the 13 young fledged in 1989.

The fourth temperature peak occurred from 20–28 May, with a high of 106°F on 23 May. Although no known mortalities were documented during this period, six nestlings ranging from 10–12 weeks of age fledged at East Verde, Fort McDowell, Ladders, and Pinal. This represents 46 percent of the 1989 fledglings; however, 12 weeks is the normal fledging age for bald eagles, so some of these fledgings may not have been temperature related (see Figure C3.5-1).

A number of factors contribute to potential high temperatures in Arizona bald eagle nests (see Figure A5.2-3). Depending on the degree of shading, nests can be exposed to direct and reflected solar radiation. The high conductivity of the rock substrate and surroundings of many nests may contribute to high temperatures either directly through conduction or indirectly through re-radiation of solar energy. From 1989–1990, we recorded four temperatures at cliff nests: (1) ambient; (2) on the nest surface; (3) in the nest interior (10–12 cm below nest surface); and, (4) on a nearby surface (out of the nest) exposed to direct sunlight, although low nest success limited sample size to seven. Temperatures (Celsius) on the nest surface averaged 8.4° (range 1–16.5) above ambient (n = 7), while those in the nest interior averaged 3.1° (range +2 to −10) below ambient (n = 5), and temperatures on exposed rock averaged 4.9° (range 1–9.5) above ambient (n = 7) (Table C3.5-1). In all samples, the nest surface area was the hottest, excluding Redmond, where the exposed cliff surface was 9° hotter than ambient, and 7° hotter than the nest surface.

Table C3.5-1. Temperatures (Celsius) recorded at Arizona bald eagle cliff nests from 1989–1990.

Breeding Area	Year	Nest No.	Ambient	On Nest Surface	10–12 cm Within Nest	On Exposed Rock
Horse Mesa	1989	2	26	33	28	32
Pinal	1989	1	19	20	20	20*
Orme	1989	1	25.5	42	— **	35
Ive's Wash	1989	1	27	31.5	— **	32
Redmond	1989	5	35	37	26	44
Bartlett	1990	2	33	48	23	34
Horse Mesa	1990	2	23	36	23.5	26

* Nest in shade.
** Nest too shallow for measurement.

Each year from 1985–1990, higher temperatures were recorded during April and May than the previous year. Even the best protected nests are subject to the high ambient temperatures noted in recent nesting seasons (e.g., 122°F at Phoenix in June 1990). It seems reasonable that without adults in attendance, the eggs or nestlings could rapidly be heated to well above ambient temperatures. Note that a number of proteins denature at approximately 106–108°F, and can become permanently inactive even if only slightly denatured (Dr. L.J. Calciano, University of California at Santa Cruz, pers. comm.).

At the Redmond breeding area, heat stress has been debated as a possible mortality factor since intensive research on Arizona bald eagles began in 1977 (Hildebrandt 1981, Ohmart and Sell 1980, Haywood and Ohmart 1982, Haywood and Ohmart 1983, Grubb *et al.* 1983, Grubb 1984, Grubb 1986a). Since 1978, heat stress may have contributed to the deaths of nine eaglets at Redmond.

Two eaglets died at Redmond in 1978: one in the nest, and one 1–2 days after fledging. Two eaglets hatched in 1979, but one fell from the nest. It was thought that the 1978 and 1979 young had fallen while seeking shade, due to heat stress (Hildebrandt 1981, Ohmart and Sell 1980, Haywood and Ohmart 1981). A shade structure was erected at the Redmond nest in the first week of May 1979. The remaining eaglet used the shade extensively, leaving it only to eat (Ohmart and Sell 1980). The shade was still in place in 1981, when two young fledged (Haywood and Ohmart 1982), but the structure fell after the 1981 season (Grubb 1986a). A new shade structure was erected on 23 April 1982. The two eaglets used the shade extensively, leaving it only to eat and exercise, until 6 May. After 6 May only one eaglet could fit under the shade at a time, and after 13 May both young were too big to use the shade (Firchow 1982). The two 1982 nestlings fledged successfully (Haywood and Ohmart 1983), and the shade fell after the 1982 season (Grubb pers. comm., Grubb 1986a).

Two young again fledged in 1983, without the benefit of artificial shade (Grubb 1986a). The two eaglets at Redmond died in 1984, but their mortalities were a month apart, and likely due to nest parasites or other factors, although heat stress may have compounded these problems (see Mexican Chicken Bug section above). An artificial shade was constructed of sticks prior to the 1985 breeding season, although the adults dismantled the shade while refurbishing the nest (Grubb 1986a). The two 1985 eaglets fledged without the benefit of artificial shade (Driscoll 1985). Three young also fledged from 1986–1987 without artificial shade.

In 1988, the two Redmond juveniles died from 12–19 May, when temperatures reached 109°F in Phoenix. The 1988 nest was on a west-facing cliff in a position directly exposed to intense solar heat. During banding, the climber noted the nest cliff was unusually hot. However, the Redmond eagles were also exposed to Mexican chicken bugs, which would have exacerbated the condition of heat stress or could have been the sole cause of death. In 1989, the two eaglets died on 6–7 April, at 1.5 weeks of age, when temperatures reached 104 in Phoenix. It appears that the unseasonably intense heat contributed to the nestlings demise, although a low density of Mexican chicken bugs was also found in the nest.

Grubb (1986a) found that Redmond (nest 5) received equal amounts of sun (full) and shade (full and partial) through the nesting season, with other breeding areas Horse Mesa (nest 2) and Blue Point (nest 1) enduring more full sun, yet successfully fledging young. Driscoll (1985) provided detailed information on solar exposure at Redmond in 1985, when two young fledged successfully. On days when the nest was continually watched from dawn to dusk (4 of every 10 days) in 1985, full sun occurred on the nest 45.4 percent of the time, while partial shade comprised 7.4 percent, and full shade 47.2 percent. Nest 5 entered full sun at 0945 hours from 9–13 February, then gradually earlier throughout the season, until the nest entered full sun at 0723 hours from 1–5 June, just prior to fledging. Full shade fell on the nest at approximately 1600 hours consistently through the season (Driscoll 1985). It is important to note that although the nest was in full sun only half of the time over the season, this period covered the hottest portion of the day, from 0723–1600 hours in June.

The Redmond adults provided shade to the eaglets during periods of full sun, until the young could seek shade on their own (Driscoll 1985). The angle of the sun on the pinnacle above (and west of) the nest,

as well as the outcrops on the south rim, created shade around the south and west portions of the nest during part of the day. When only a small patch of shade was available, the eaglets would stick their heads in the shade, leaving the rest of their bodies in the sun. The nestlings would also place their heads under the shadow of the adults or their sibling. In late May and June, an outcrop below the nest, on the south face of the pinnacle, provided shade early in the afternoon. The eaglets would climb down to this area and perch, returning to the nest when the adults delivered prey. The eaglets utilized the available natural shade, but also chose to perch in the sun when partial or full shade occurred on the nest (Driscoll 1985). Hildebrandt (1981) also noted the Redmond eaglets perched in full sun when shade was available on part of the nest.

After the adult shading the eaglets was relieved by its mate, the eagle would often fly down to a sandbar west of the nest to drink and bathe. On two occasions the male dunked his entire body, including head, under the water, then ruffled his feathers and repeated the process for up to 10 minutes. The eaglets also drank from the river after fledging (Driscoll 1985).

C3.6 SUBADULT AND NEAR-ADULT BALD EAGLE MORTALITY

Due to the vast areas covered by nonbreeding bald eagles, it is difficult to obtain data on mortality of subadults (1–3 years old) and near-adults (4 years old). Except for telemetry data, there is very little information on deaths among bald eagles of this age class in Arizona. Of the five known subadult and near-adult mortalities, four of the eagles were banded and three were radio-tagged as well (Table C3.6-1).

The first documented mortality of an Arizona subadult bald eagle occurred in 1980. The three-year-old eagle (T04), banded and telemetered as a nestling in 1977 at the Bartlett breeding area, was shot by a rancher 60 mi east of Calgary, Alberta, Canada (Ohmart 1985). See Section C5.1 for more details on T04.

The second record involved a 1–2-year-old bald eagle poisoned near Picacho Reservoir, Arizona in 1984, after feeding on an animal carcass which a rancher had laced with strychnine to kill predators (R. Mesta pers. comm.).

C3.6.1 San Carlos Subadult Female (SF01)

A rafting group on the Salt River observed an injured eagle on 21 June 1987 at the Canyon Creek confluence. Upon reaching a phone on 22 June they reported the incident. We flew to the area and found the bird perched on a boulder next to the river. Fluids were administered upon capture and during transport to the Phoenix Zoo. X-rays revealed a broken radius in the right wing that had partially calcified, indicating the break occurred 10–14 days earlier (Dr. Hood pers. comm.).

This subadult female bald eagle (SF01), most likely 3.5 years old (McCollough and Krohn 1986), displayed white flecking on a predominantly brown head, a white breast mottled with brown, and an inverted white triangle on her back. Rehabilitated, banded, and telemetered at the Phoenix Zoo, SF01 was released at San Carlos Reservoir on 9 October 1987, after a ceremony by the San Carlos Apaches.

SF01 remained at San Carlos reservoir through the end of November. We found her on 7 December on Pinto Creek near Roosevelt Reservoir, and on 2 and 20 January 1988 she was still in the reservoir area. We found her west of Schoolhouse Point on Roosevelt Reservoir on 27 January, roosting that night near

Plate C12. Subadult bald eagle, showing plumage typical at three years old. The head and body are brown-and-white mottled, the eyes are creamy brown, and the beak is black (photo by D. Driscoll).

Plate C13. Near-adult bald eagle, showing plumage typical at four years old. The head is white with brown mottling, the eyes are almost yellow, and the beak is mostly yellow (photo by D. Driscoll).

Table C3.6-1. Known Arizona subadult and near-adult bald eagle mortalities.

Date	Breeding Area	Hatch Year	No.	Sex*	Age	Comments
1980	Bartlett	1977	T04	—	3	Shot 60 miles east of Calgary, Alberta, Canada.
1984	—	—	—	—	1–2	Poisoned near Picacho Reservoir, Arizona, from feeding on an animal carcass which a rancher had laced with strychnine to kill predators.
April 1988	—	—	SF01	F	4	Apparently drowned in stock tank near Globe, Arizona. Both legs missing when eagle was recovered.
May 1988	East Verde	1984	NF01	F	4	Transmitter recovered near Gleason Flat on Salt River, Arizona. Transmitter cut off with knife. No sign of eagle. Foul play suspected.
April 1990	Horseshoe	1987	JO14	M	3	Found dead on Salt River, near Verde River confluence, Arizona. Both wings, tail, and left leg missing when eagle was recovered. Foul play suspected.

* Sexual differentiation based on body measurements.

the cliff dwellings at Tonto National Monument. On the night of 13 February she roosted on Breadman Mountain in the Salome Wilderness. During 4–17 March she continued to frequent the Salt arm of Roosevelt Reservoir and Meddler Point and soared on the slopes of the Sierra Anchas. Also during this period we found her soaring over the Salt River upstream of Cherry Creek, and on the upper Salt River 13 km southwest of Seneca. On 25 March she perched at Canyon Creek about 10 km upstream of its mouth.

On 19 April 1988, we received SF01's transmitter signal from a ranch building near Globe, Arizona. Officer E. Escobedo, Arizona Game and Fish Department, recovered the transmitter the next day and questioned the rancher concerning the fate of the eagle. SF01 had apparently drowned in a cylindrical stock tank around 1 April and was removed by the rancher's grandson. The carcass was recovered that day, but the feet had been cut off. This style of stock tank has a wire grid on top (Figure C3.6-1). The wires are intended to secure a plastic lid during winter months; however, these lids are no longer used and the wires serve no functional purpose.

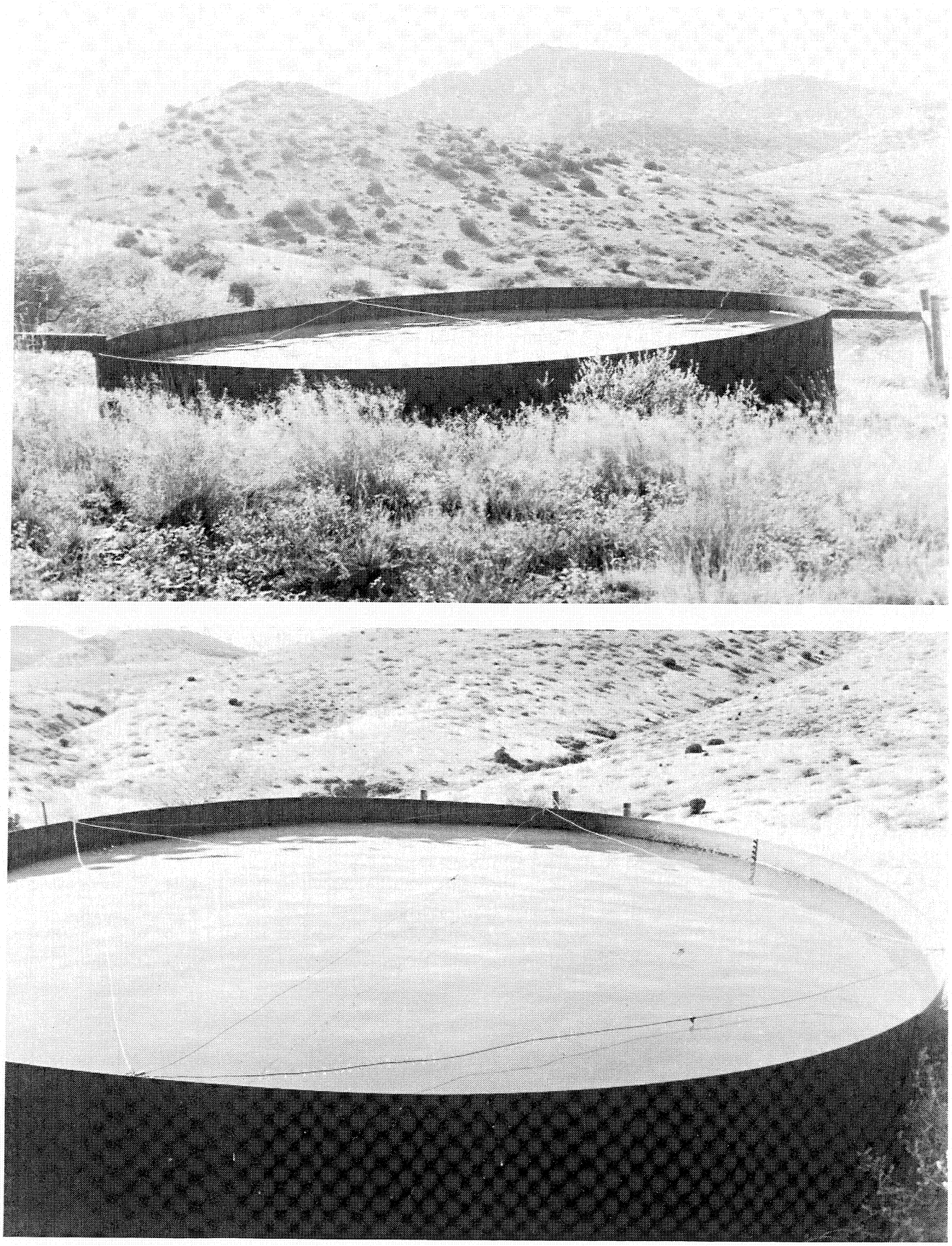


Figure C3.6-1. Stock tank near Globe where SF01 apparently drowned. Note the wires that may have compounded SF01's difficulties in escaping.

Stock tanks of this design have claimed the lives of many golden eagles in Colorado and Wyoming according to M. Lockhart (USFWS) and A. Harmata (Greater Yellowstone Ecosystem Bald Eagle Research Group) (pers. comm.). The eagles apparently land on the tank edge, lean forward to drink, then slip into the water. Once inside, the wire grid traps them due to the bird's large wing span. Management efforts in Wyoming and Colorado include placing a log inside the tank to give smaller birds and mammals a structure to climb up on. However, it is not known whether an eagle would be able to use this means of escape (A. Harmata pers. comm.).

This type of tank could be made more safe for eagles simply by cutting the wires to remove the grid, since they are no longer functional. These tanks might be rendered far more harmless to wildlife by placing a "ladder" at a shallow angle inside the tank and connecting it to the side and bottom. Such a ladder could be made from two parallel lengths of reinforcement bar with wire mesh between.

C3.6.2 Salome Bay Near-Adult Female (NF01)

We captured a near-adult female (NF01) bald eagle in Salome Bay of Roosevelt Reservoir on 4 March 1988, using a radio-controlled powersnare. The four-year-old NF01 had been banded as a nestling in 1984 at the East Verde breeding area by T. Grubb (Grubb 1986a). The eagle displayed brown flecking in the head, a brown eye-stripe, and a brown band on the distal margin of the tail, typical of four-year-old bald eagles (McCollough and Krohn 1986). The brown eye-stripes converged into a vertical stripe down the nape.

On 11 March, we found NF01 at the confluence of Carrizo Creek and the upper Salt River where at least a dozen bald eagles were sighted a few days later (T. Gatz pers. comm.). Obviously some event involving prey was taking place, although we were unable to conduct an investigation at the time. NF01 flew along the southern slope of the Sierra Anchas on 14 March and just east of Weaver's Needle in the Superstition Mountains on 17 March. She returned to the Salt River at Highway 60 on 25 March and we found her on the East Verde River on 2 April.

On 19 April we recorded a flying-type signal approximately 8 km upstream of the Cherry Creek confluence on the Salt River. We received the same signal from the same location about 2 km downstream of Gleason Flat on the Salt River on 3 and 7 May. We noted that the pulse was steady on these occasions, indicating the possibility of a dead bird. We entered the area on 9 May and found NF01's transmitter laying beneath a bush on the slope of a side canyon approximately 300 m south of Km 157.5 about 1.5 km downstream of Black Rock Rapid. The teflon ribbon used for transmitter attachment had been cut in two places with a sharp knife, but we found no blood or any other traces of NF01. We surmise that the bird died between 2 and 19 April, likely the victim of a shooting (see Section C3.8).

C3.6.3 Horseshoe Subadult Male (JO14)

We banded JO14 as a nestling at the Horseshoe breeding area in 1987 and read his VID band (blue H) on 24 November 1987 at the Tonto Creek estuary on Roosevelt Reservoir. We had no other sightings of JO14 until 17 April 1990 when a wildlife officer for the Salt River Indian Reservation found the three-year-old eagle dead along the Salt River, near the Verde River confluence. The eagle had been dismembered, with both wings, tail, and left leg removed. There is little doubt this subadult bald eagle was shot, possibly for the black-market feather trade (see Section C3.8). The officer who discovered the eagle said he had also found several shot Harris' hawks in the area.

C3.6.4 Summary of Subadult and Near-Adult Mortality

Only five subadult and near-adult bald eagle mortalities have been recorded for Arizona eagles, four of which were documented because the eagle was telemetered or banded. It is important to note that this number represents a very minimum mortality figure. Arizona's non-breeding bald eagles range over a vast area, from Mexico to Canada, so actually witnessing the mortality of a subadult or near-adult eagle, or finding a carcass (before scavengers) in this vast expanse would be extremely rare, unless the eagle was radio-tagged.

C3.7 ADULT MORTALITY

Mortality in adult bald eagles is difficult to assess. Replacement within a pair may occur unnoticed, even in a monitored population, unless the new adult is banded or has plumage characteristics significantly different from its predecessor. The chance of observing a mortality or of recovering postmortem evidence is slight at best without the aid of telemetry.

Plate C14. Adult bald eagle, showing plumage typical of adult birds five years and older. The head is white and the eyes and beak are yellow (photo by D. Driscoll).

There have been 39 known adult bald eagle mortalities in Arizona, based on knowledge obtained both *directly* from known deaths and *indirectly* from evidence of replacement or disappearance (Table C3.7-1). In the latter case, we are assuming that no mate exchanges occurred between territories from year to year. This supposition may be erroneous but is supported by the evidence available. In any case, it is essential

Table C3.7-1. Known changes in adult tenure at Arizona bald eagle breeding areas.

Date	Case	Breeding Area	Sex	Age*	Incident	Comments
1951-52	1,2	Rock Creek	Both	—	Death	One or both adults shot.
1954	—	Rock Creek	Both	—	Replacement	Two adults at nest.
1959	—	Rock Creek	Both	—	Disappeared burned.	Both adults absent following fire. Nest tree
1964	3	Bartlett	?	—	Death	Adult shot.
1965	—	Bartlett	?	—	Replacement	New adult.
1971	4,5	Blue Point	Both	4	Replacement	Replaced prior to 13 November.
1972	6	Blue Point	?	—	Death	Carcass found near nest tree on 22 May.
1977	7	Ft. McDowell	M	4	Replacement	
	8	Redmond	M	3	Replacement	Did not breed.
	9	Redmond	F	4	Replacement	Did not breed.
1978	—	Redmond	M	4		Possibly same male as 1977.
	10	Redmond	F	4	Replacement	
	—	Redmond	?	—	Death	Skull found below nest pinnacle. Possibly 1976 or 1977 adult.
	11	Bartlett	M	4	Replacement	
1980	12	Blue Point	?	4	Replacement	Did not breed.
1982	13	"76"	F	—	Disappeared	Disappearance followed aggressive interaction with golden eagle.
1983	—	"76"	F	—	Replacement	New female.
	14	Blue Point	M	—	Disappeared	Disappeared 13 February. Female incubating.
	—	Blue Point	M	4.0	Replacement	AM01 (1979 Fort McDowell nestling) took over on 14 February.
1984	—	Pleasant	M	4	Near-adult	
1985	—	Pleasant	M	5	Near-adult	Possibly same male as 1984.
	15	Ft. McDowell	—	—	Death	Resident adults killed floater adult.
	16	Coolidge	F	4	Replacement	
1986	17	Bartlett	M	—	Death	Male shot - September 1986.
	18	Horse Mesa	F	5	Replacement	Near-adult.
1987	—	Bartlett	M	—	Replacement	New male.
	19	Horse Mesa	M	—	Death	Broken procoracoid and ruptured liver.
	20	Cibecue	F	—	Disappeared	Disappearance followed aggressive interaction with a floater near-adult male bald eagle.
	21	Orme	M	3.5	Replacement	Replacement between Sept. and Oct.
1988	—	Horse Mesa	M	—	Replacement	New male.
	—	Cibecue	F	—	Replacement	New female.
	22	Alamo	F	—	Replacement	Original female banded and telemetered as nestling in 1979 Bartlett or Fort McDowell breeding area. New female not banded.
	23	Bartlett	M	4.0	Replacement	AM04 (1984 Blue Point nestling).
	24	Blue Point	F	4	Replacement	
	25	Ive's Wash	M	4-5	Replacement	

Table C3.7-1. (continued)

Date	Case	Breeding Area	Sex	Age*	Incident	Comments
1988	26	Redmond	M	4-5	Replacement	
	27	"76"	M	—	Replacement	New male—banded.
	28	Sheep	M	—	Disappeared	Disappeared 26 March.
	—	Sheep	M	4		Banded near-adult male in area following disappearance of resident male.
1989	29	Cibecue	M	12.0	Death	AM07 (1977 Bartlett nestling) rescued 21 Nov. 1988 with broken ulna. Released 16 Jan. 1989. Captured 22 Feb. in excellent health. Located at Gleason Flat on 27 Feb. Found dead 11 Apr. 1989 near Hess Canyon.
	—	Cibecue	M	—	Replacement	Injured male replaced from November 1988–January 1989.
	30	Orme	F	4	Replacement	
	31	Ladders	M	—	Death	Hit in back of head by stooping peregrine falcon on 3 April 1989. Flight and balance immediately hampered. First forage 14 April. Died 6–10 May 1989.
	—	Ladders	M	—	Replacement	Replacement prior to 29 December 1989. New male—banded.
	32	Alamo	F	—	Replacement	New female—banded.
	33	Fort McDowell	F	—	Replacement	New female—banded.
	—	Perkinsville	?	4		Near-adult in pair.
1990	—	Perkinsville	M	5		Near-adult—possibly same as 1989.
	—	Perkinsville	F	5		Near-adult—possibly same as 1989. Female banded.
	34	Pleasant	M	4	Replacement	
	35	Pleasant	F	—	Replacement	New female—banded.
	36	Alamo	M	—	Replacement	New male—banded.
	37	Blue Point	F	3	Replacement	Subadult female performing courtship flights with adult male.
	—	Orme	F	5		Near-adult—possibly same as 1989.
	38	Cibecue	F	4–5	Replacement	
	39	Ladders	M	6.5	Death	Male (1984 Horseshoe nestling) found dead in Verde River, near confluence of West Clear Creek, 21 December 1990.

SUMMARY

Known deaths	11	
Disappearances	4	
Known replacements	35	(11 replacements following known mortality or disappearance)
Total probable mortalities	39	

* Age estimations on the basis of plumage characteristics (McCollough and Krohn 1986).

Note — Adult bald eagle found dead near Payson in March 1989.

to consider any and all aspects of adult mortality because the well-being of the adult segment of the population probably bears more upon the continuance of Arizona bald eagles than any other factor. Demographically, each breeding adult is a survivor of at least five years of numerous mortal dangers. Breeding adults have great value, and if our increased knowledge only slightly augments their survivorship, the effort to obtain the knowledge may be worthwhile. In most cases, the cause of death is unknown, but because of the importance of adult survivorship to the population, it is valuable to assemble any and all circumstantial evidence and for biologists to express opinions on the basis of such evidence.

C3.7.1 Direct Data of Adult Mortality

Of the 39 known Arizona adult bald eagle mortalities, there are 11 documented cases involving witnessed deaths and/or recovered dead eagles. The first occurred at the Rock Creek breeding area during 1951–1952 (Case 1, 2). One or both adults at this nest site, off the Tonto Arm of Roosevelt Reservoir, were shot by a University of Arizona graduate student for the University's Museum collection (McCullough unpub. field notes). In 1964, one adult was shot at the Bartlett territory (Rubink and Podborny 1976) (Case 3). In 1972, the decomposed carcass of an adult bald eagle was found near the Blue Point nest tree (Simpson unpublished field notes) (Case 6), and the skull of an adult was found below the Redmond pinnacle nest in 1978 (Hildebrandt 1981) (see Cases 8, 9, and 10). The Fort McDowell pair apparently killed an adult bald eagle in their nest area in 1985 (Morgan and Sudar 1985) (Case 15). The Bartlett male was shot in September 1986 (Case 17). The adult was transported to Southside Animal Hospital, but died a few days later of injuries resulting from the bullet wound. Details on adult mortalities at individual breeding areas are provided in Section D4.

Horse Mesa Adult Male—1987. The adult male at the Horse Mesa breeding area died the night of 11 April 1987 (Case 19). SRP personnel found the eagle below the nest cliff on the morning of 12 April. Necropsy revealed a broken procoracoid (shoulder) and a ruptured liver, apparently received during impact with a cliff or powerline. No other abrasions or wounds were in evidence, except for scrapes on top of the eagle's feet. One of many possibilities is the eagle was pursued by a peregrine and inadvertently struck the cliff or a powerline. Peregrines were observed chasing and stooping on the adult eagles in 1986, occasionally striking the eagles and even knocking them off perches (Driscoll and Buckley 1986). Peregrines were sighted regularly in the Horse Mesa breeding area in 1986, and it is likely that a falcon eyrie exists nearby.

James Enderson (Colorado College) told us that peregrines relentlessly harass golden eagles who enter the vicinities of peregrine eyries in Colorado, and he believes this to be the reason why the two species rarely nest close together. He said that prairie falcons also attack eagles, but seem to do so with less determination than nesting peregrines. Enderson added that both bald and golden eagles are very dangerous to peregrines, especially when the latter are on the ground, and, even in flight, peregrines are very reluctant to let the eagle get above them. Golden eagles may kill recently fledged juvenile peregrines, particularly at artificial hack sites where adult peregrines are not present to protect them (Janet Linthicum pers. comm.).

Cibecue Adult Male (AM07). We rescued the Cibecue male (AM07) on 21 November 1988 from the river below the nest and transported him to Liberty Wildlife Foundation. X-rays revealed one of the eagles wings was broken in two places, with a section broken out of the ulna as if it had been struck from above. The adult was banded as a nestling in 1977 at the Bartlett breeding area by Robert Ohmart, ASU. We placed a VID band on his left tarsus, and radio-tagged AM07 so we could monitor his

movements following rehabilitation. On 16 January 1989, we released AM07 at the Tonto Creek estuary on Roosevelt Reservoir, where he remained for most of January and February. The eagle appeared to be in excellent health, with well developed breast muscle (a measure of body condition) when captured in the Pinal nesting territory on 22 February. AM07 was found dead on 11 April 1989 near Hess Canyon, north of Globe, Arizona (Case 29). The eagle's state of decomposition precluded determining the cause of death.

Ladders Adult Male (AM08). We captured and telemetered the Ladders male (AM08) on 2 April 1989. While tracking the eagle on the afternoon of 3 April, we observed him flying upstream from the nest area, crossing the river at Km 167.4. At 1614, AM08 was struck from above by a peregrine falcon. Immediately following the strike, AM08 turned and headed back to the nest. His flight was erratic; with each wing beat his whole body would tilt laterally up to 180 degrees (P. Carroll, notes). The eagle's head was swaying from side to side and his course was zigzagged. At 1617, he entered the nest area and came dangerously close to flying into a cliff face (G. Beatty, notes). At 1630, he landed with difficulty at the nest and perched with his mouth open, "panting."

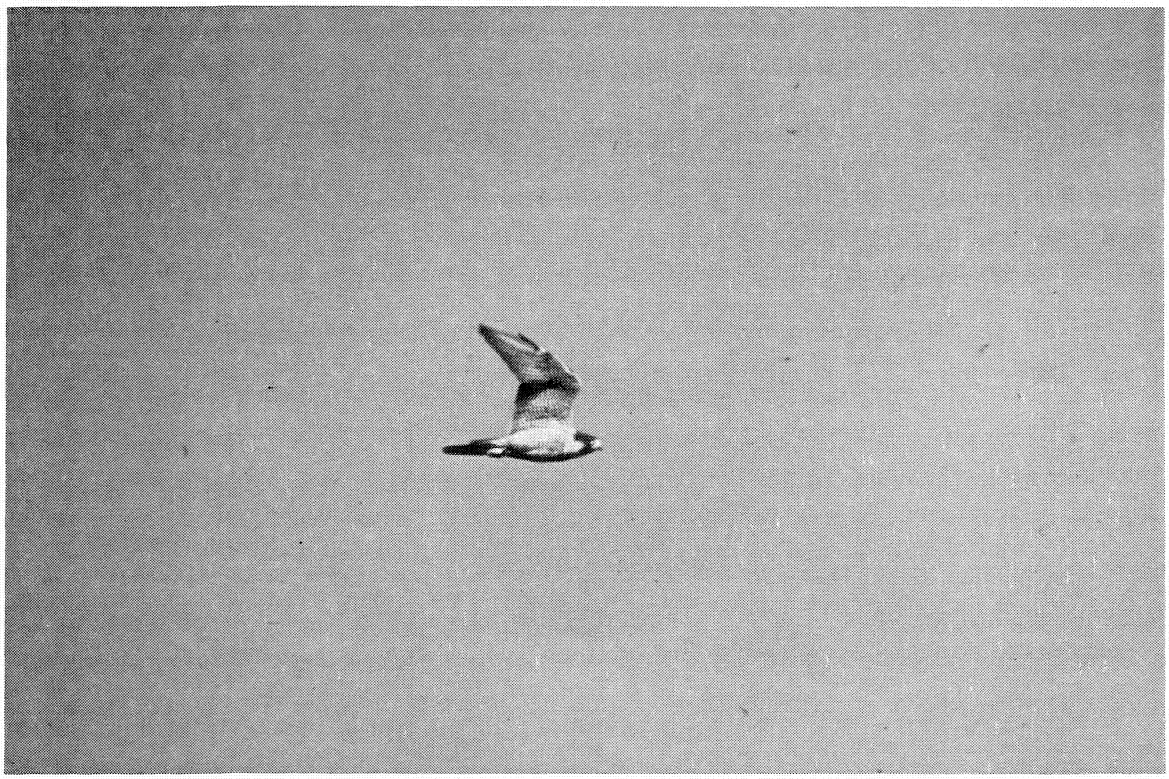


Plate C15. Peregrine falcons and bald eagles may be extremely aggressive toward each other near their eyries (Photo by Scott Francis).

AM08 remained sluggish and did not leave the nest area for the next three days. He perched on or near the nest, shaded the eaglets, and ate fish delivered by the female. The male made a few brief and erratic

flights. At times he would fly from the nest several meters and his whole body would jerk back, as if there were a string tied to his wings and it was being pulled sharply. Our observations terminated on 6 April, and resumed on 12 April.

By 12–13 April, AM08 appeared to be recovering and made two prey deliveries to the nest. He made fewer erratic flights, but still remained in the nest area. On 14 April he began leaving the nest area and resumed his regular activities, soaring and foraging with only occasional erratic flights. From then on, his condition appeared to be steadily improving.

During 16 full days of observation between 12 April and 3 May 1989, AM08 did not leave the nest vicinity on seven days. However, on three of those days he foraged successfully in the nest area. On the nine days the male left the nest area, he perched on Beasley Cliffs (Km 168.1) or on a sycamore snag at Km 177.9. He perched once on the cliffs near Rodeo Flats at Km 160.6. Throughout this period, AM08 foraged successfully a total of seven times and perched from Km 160.6–177.9, a 17.3 km range. There were no observations from 6–9 May; however, on 10 May 1989 we found AM08 dead at Km 162.6, across the river from the nest. The eagle's state of decomposition suggested he died 3–4 days previously.

AM08's death may have resulted from brain damage caused by the peregrine attack (Case 31). The behavior displayed by AM08 after the peregrine blow was typical of that by other bald and golden eagles which have been struck in the head by falcons (M. Lockhart pers. comm.). The birds act very disoriented at first (likely from a bruise on the brain), then appear as if they are getting well, only to die three to four weeks later. It is thought that the bruise on the brain causes a blood clot, and the brain begins deteriorating before the eagle actually dies.

On the basis of our report, Dr. James Rousch, DVM, suggests that the eagle may have sustained an intracranial hemorrhage, because the symptoms seemed to be progressive in the hours after the peregrine impact. Dr. Rousch says that scar tissue may have subsequently developed and caused epileptiform symptoms. The eagle may have recovered from the hemorrhage, then had an epileptic seizure weeks later.

The fact that AM08 was telemetered the day before the peregrine encounter is probably more than merely coincidental. Dr. Rousch suspects that the eagle was exhibiting a stress response from being captured and handled the previous day, and as a result appeared more vulnerable to the peregrine. However, peregrine falcons have struck apparently perfectly healthy eagles (see Horse Mesa above, A. Harmata pers. comm., M. Lockhart pers. comm.). The peregrine's attack was probably territorial. We observed adult peregrines in the vicinity of Beasley Flat, so there is likely a breeding pair in the area.

Hays (1987) reported an incident in which a pair of nesting peregrines killed an adult golden eagle. The eagle was first attacked by the female peregrine as it passed below the eyrie. The male soon joined the female and together they made a series of stoops that drove the eagle into the cliff face several times, after which it appeared to lose its balance. The killing blow apparently came when the female falcon hit the eagle "in the head or neck" and it fell lifeless to the trees below. The eagle was not recovered, but it was presumed dead as it was not seen again.

Ladders Adult Male—1990. The 1989 Ladders male (AM08, see above) was replaced by an adult male, with a USFWS band on his right tarsus, by December 1989. This new male bald eagle was found dead

in the Verde River, near the confluence of West Clear Creek, on 21 December 1990 (Case 39). The carcass was very decomposed, and it was not collected by the person who found the eagle, so the cause of death remains unknown. However, the USFWS band was removed and turned in to AGF. The 6.5-year-old male was a 1984 nestling (629-14562) from the Horseshoe breeding area.

C3.7.2 Indirect Data of Adult Mortality

Table C3.7-1 also lists 28 inferred instances of mortality in Arizona bald eagles. Replacement, documented by the presence of a near-adult (plumage characteristic of 3–4-year-old eagle) in a breeding pair, accounted for 18 cases. One replacement entailed the substitution of an unbanded female for a banded one, and five involved a banded adult appearing in a previously unbanded pair. On four known occasions, adults disappeared from nest sites. Details on adult mortalities at individual breeding areas are provided in Section D4.

Disappearance of Adults. The first known case of an adult disappearing from a breeding area occurred in 1982 when the adult female at the "76" breeding area disappeared following an aggressive interaction with a golden eagle (Haywood and Ohmart 1983) (Case 13). The 1987 Cibecue female vanished following an aggressive interaction with a near-adult male bald eagle (Carroll and Housser, notes) (Case 20) (see Section D4.8), and the Sheep male disappeared on 26 March 1988 (Case 28). The Blue Point male was last seen on 13 February 1983 (Case 14) and was replaced by a near-adult banded male on 14 February (Grubb *et al.* 1983). We captured the "new" Blue Point male in 1987 and found him to have been banded by Robert Ohmart, ASU, as a nestling in 1979, making him four years old at the time of replacement (see Section D4.4).

Near-Adults in Breeding Pairs. The first documented mate replacement by a near-adult bald eagle in Arizona occurred at the Blue Point breeding area on 13 November 1971 when Simpson (unpublished field notes) observed near-adult plumage (brown mottling on an overall white head and tail) on both adults (Case 4, 5). In 1977, the Fort McDowell male (Case 7) and the Redmond male and female (Case 8, 9) displayed near-adult plumage. The Redmond male, described as a "late plumaged immature", was assumed to be a three-year-old. The Redmond male and female (Case 10) in 1978 also showed near-adult plumage, as did the Bartlett male (Case 11) (Hildebrandt 1981). The Blue Point pair contained a near-adult in 1980 (Haywood and Ohmart 1981) (Case 12), and the adult male was replaced by a near-adult in 1983 (see Section D4.4 and Case 14).

When the Coolidge nest was found in 1985, the female displayed near-adult plumage (Forbis 1985) (Case 16). The Horse Mesa female (likely five years old) had a brown stripe down her nape (Driscoll and Buckley 1986) (Case 18), which extends from the brown eye-stripes on typical four-year-old eagles (McCollough and Krohn 1986). Near-adults successfully raised young at five breeding areas in 1988: the Orme male (Case 21), Bartlett male (Case 23), Blue Point female (Case 24), Ive's Wash male (Case 25), and Redmond male (Case 26). A near-adult banded male showed up in the Sheep breeding area in 1988, following the disappearance of the resident male on 26 March (see Case 28). The Orme female was replaced by a near-adult in 1989 (Case 30), as was the 1990 Pleasant male (Case 34), and the 1990 Cibecue female (Case 38). The 1990 Blue Point female was a subadult, displaying typical plumage of a three-year-old bald eagle (McCollough and Krohn 1986) (Case 37).

Near-adult bald eagles have been documented breeding at other nest sites in Arizona (see Table C3.7-1), although the death of their predecessor was recorded. When the Pleasant breeding area was first found occupied in 1984, the male was a near-adult (U.S. Bureau of Reclamation 1984b). In 1985, the male

again displayed near-adult plumage (brown spots on his head and tail), but may have been the same male as 1984 (Berger and Droege 1985). At least one near-adult existed in the new Perkinsville pair in 1989, due to the presence of near-adult feathers in and below the nest. Both eagles were documented as near-adults in 1990, and a band sighted on the female. The Perkinsville breeding area was last known occupied in the late 1960s or early 1970s.

Banded Adults in Breeding Pairs. Nestling bald eagles have been banded in Arizona since 1977 (see Section C6), although no effort was made to band all nestlings until BioSystems' study. By banding all known Arizona nestlings with USFWS and VID bands, it will be possible to document the survivorship of individuals well into the future, especially when the eagles reach breeding age (4–5) and their VID bands can be read at nest sites with spotting scopes.

Five replacements in breeding adults were documented by the presence of a banded individual in a previously unbanded pair. A USFWS band was sighted on the 1988 male at the "76" breeding area (Case 27), the 1989 Alamo (Case 32) and Fort McDowell females (Case 33), and the 1990 Pleasant female (Case 35) and Alamo male (Case 36). Other banded adults are known to exist in breeding pairs of Arizona bald eagles (see Section C6); however, replacement was not documented by the band sighting.

Chino/Alamo Adult Female—1985–1987. When the Chino breeding area was discovered in 1985, the adult female carried a backpack transmitter and was banded on the right leg with a USFWS band (Hall unpublished field notes, R. Hall pers. comm.). Robert Ohmart telemetered six juveniles; two each year from 1977–1979; both 1977 birds and one from 1978 have since died. The other 1978 bird, which disappeared post-fledging, was banded on the left leg (see Section C6). Assuming she was an Arizona nestling, the 1985 Chino female would have been six years old and from the 1979 Bartlett or Fort McDowell nest (see Section C5.1 and Table C5.1-1). The Chino pair fledged two young in 1985 and failed in 1986, but raised two foster young from the inundated Horseshoe nest site.

In December 1986, the Chino female (identified by her transmitter and band) and a mate constructed a nest at the upper end (northern shore) of Alamo Reservoir, 7.5 km downstream of her existing nest (R. Hall pers. com.). The telemetry unit fell off prior to January 1987, but the female retained a dorsal white patch in its location.

In the interim, a pair of eagles moved into the Chino breeding area and built a new nest (nest 2) in a cottonwood snag just upstream of the existing nest (nest 1). Thus, with Chino active, the new nest at Alamo Reservoir was named the Alamo breeding area (see Section D4.1). Since the adult males at both territories were not banded, several hypotheses are possible.

1. The Chino pair moved to Alamo in 1987 and a new pair moved into Chino.

2. The radio-tagged Chino female moved to Alamo and acquired a new male, while the Chino male remained and found a new female.

3. The 1985 and 1986 Chino male died and the female recruited a new male at Alamo Reservoir in 1987, while a new pair moved into Chino.

All three events are possible; however, No. 1 or No. 3 is more likely, given our current knowledge of bald eagle biology and behavior. Although male bald eagles have been known to breed with two females

in the same season (Section D4.23), switching mates (No. 2) would be unlikely and has not been recorded in bald eagles (see Section D4.18). In 1986, the Chino pair "... utilized the reservoir on all occasions that observations were made there" (Sudar and Morgan 1986), which lends some support to the first theory. Also, in the period from 1985–1987, the reservoir (Alamo Reservoir) receded from a northern boundary upstream of the Big Sandy and Santa Maria River confluence (Hall unpublished field notes) to a point below Brown's Crossing. The Chino eagles may have moved to Alamo in order to be closer to their foraging areas. The current Alamo nests are within the minimum home range described for the Chino pair in 1986 (Sudar and Morgan 1986).

The Alamo female was replaced by an unbanded adult in 1988 (Case 22), and the Chino breeding area was unoccupied at known nest sites.

C3.7.3 Discussion of Adult Mortality

When we discuss mortality in breeding adults, it is important to note that many more adults are likely replaced than we know about. The most studied breeding areas are those located close to Phoenix. The more remote sites are difficult to access and are not regularly monitored. Of the 39 known adult bald eagle mortalities in Arizona, 21 (54%) were recorded from 1987–1990 (see Table C3.7-1). The preponderance of documented mortalities in the past four years is partially due to the fact that we have been keeping a close watch on individuals within each pair at most nest sites. For instance, we have no records of adult mortalities at Cedar Basin or Lone Pine, two breeding areas located in a remote section of the upper Salt River. This does not mean that no mortalities have occurred, simply that no one was present to document the event. Therefore, the data presented in this section represent a minimum number of mortalities for adult bald eagles in Arizona. A minimum of 21 deaths from 1987–1990, averages to 5.25 adult mortalities each year, and represents 16 percent of the adult-years at monitored nest sites. At the four breeding areas closest to the Phoenix metropolitan area, there was a 22 percent (n = 7) minimum yearly adult mortality rate.

The 39 documented mortalities were recorded at only 15 of Arizona's 28 breeding areas (Table C3.7-2). The Blue Point breeding area has experienced the most known adult mortalities in Arizona, seven in 15 years of known occupancy. The site has lost two males, three females, and two adults of unknown sex. Though the current male (AM01) has been a part of the pair since 1983 (see Section D4.4), the adult female was replaced by a near-adult in 1988, and she by a subadult in 1990.

The Redmond breeding area ranked second in adult mortality, with two males and two females replaced in 16 years of occupancy. Both adults were replaced in 1977 and the female in 1978. The skull of an adult was found below the pinnacle nest in 1978, thought to be from one of the 1976 or 1977 adults (Hildebrandt 1981). The male was replaced by a near-adult in 1988.

The Bartlett territory has also experienced a high rate of adult mortality. Three males and an adult of unknown sex have been replaced at Bartlett. An adult was shot in 1964 and replaced in 1965 (Rubink and Podborny 1976), the male was replaced in 1978 (Hildebrandt 1981), the male was shot in 1986, replaced in 1987, and replaced again in 1988 by a near-adult. Two adults at Bartlett are known to have been shot, and people have been witnessed shooting at recently fledged juveniles (see Section D4.3).

The Alamo breeding area has a serious problem with adult mortality. In the four years of its existence, two females and one male have been replaced. When the territory was founded in 1987, the adult female carried a USFWS band on her right tarsus. She was replaced by an unbanded female in 1988, which was

Table C3.7-2. Arizona bald eagle breeding areas ranked by adult mortality.

Rank	Breeding Area	Total Occupied Years	Adult Mortalities
1	Blue Point	15	7
2	Redmond	16	4
3	Bartlett	24	4
4	Alamo	4	3
5	Cibecue	15	3
6	Rock Creek	4	2
7	Orme	5	2
8	Pleasant	5	2
9	Horse Mesa	8	2
10	"76"	10	2
11	Ladders	16	2
10	Fort McDowell	21	2
13	Ive's Wash	4	1
14	Coolidge	6	1
15	Sheep	9	1
16	Unknown	—	1 *
Total			39

* Adult killed by Fort McDowell eagles on 30 April 1985.

again replaced by a female banded on her right tarsus in 1989. No apparent changes in the Alamo male occurred until 1990 when he was replaced by a male banded on the right tarsus. The Alamo pair has been known to steal ducks from hunters, plucking them out of the reservoir prior to the dog's retrieval. This may be a matter of serious concern, since steel shot was not mandatory until the 1990–1991 season.

Cibecue has had three known adult deaths in 15 years of occupancy. Cibecue also ranked first in juvenile mortalities, with 13 young dying or disappearing from the nest.

The Orme breeding area shows signs of mortality problems. The nest site was discovered in 1987 and has already had two known replacements. The male was replaced by a subadult in the fall of 1987 and the female by a near-adult in 1989. A person was observed shooting at an Orme adult in December 1990 (T. Tibbitts pers. comm.). Although witnesses reported the adult fell from its perch, no carcass was found. A subadult bald eagle (3-year-old JO14) was also found in this area on 17 April 1990, with his wings, tail, and left leg missing, and was also likely shot.

Aggressive Interactions. Aggressive interactions with bald or golden eagles appear to have accounted for one known adult mortality (Fort McDowell 1985) and two disappearances of adult females (76 nest in 1982 and Cibecue in 1987). Altercations between breeders and non-breeders over nesting territories have been observed in Arizona bald eagles (see Section D4.8) and Rhodesia's black eagles (*Aquila verreauxii*) (Gargett 1975, Gargett 1990), occasionally resulting in the death of an adult (Roberts 1985, Morgan and Sudar 1985, see Section D4.13). While banding nestling bald eagles on the Rio Yaqui, Sonora, Mexico, we found a dead adult male below the Hecho nest. The adult male had brown body feathers lodged in its beak, likely indicating an altercation with another adult, and had already been replaced by a new male (Brown and Olivera 1988). Ron Jackman (BioSystems) documented the replacement of a radio-tagged adult female on the Pit River, California, in 1990. The female was found freshly killed, with talon wounds in her breast, and a new female was courting the adult male (R. Jackman pers. comm.).

The Horse Mesa adult pair engaged in aggressive interactions with peregrine falcons on several occasions in 1986. In one instance the adult female was knocked off a pinnacle above the nest and lost a few feathers when she was struck in the back by a stooping peregrine (Driscoll and Buckley 1986). Such an attack may have been involved in the death of the Horse Mesa adult male in 1987, and a peregrine was likely responsible for the death of the Ladders male in 1989 (see Section C3.7). Aggressive interactions may also have been involved in the injury of a subadult (SF01) in 1987 and an adult at Cibecue (AM07) in 1988.

Shooting. There have been several documented cases of adult bald eagles being shot in Arizona: one or both adults at Rock Creek in 1951–1952, and two adults at Bartlett in 1964 and 1986. Hildebrandt (1981) witnessed people shooting at recently fledged juveniles at Bartlett in 1977, and a person was observed shooting at one of the Orme adults in December 1990 (T. Tibbitts pers. comm.). We also observed a person shooting at the Ladders male in 1989. Discharges from handguns, shotguns, rifles, and automatic weapons are a common occurrence in some breeding areas accessible to the public, especially Cliff, Bartlett, Pinal, Blue Point, Orme, Fort McDowell, Horseshoe, and Alamo. We have found shotgun shells, rifle cartridges, and beer cans near, below, and in Arizona bald eagle nests.

Poisoning. A 1–2-year-old bald eagle was poisoned near Picacho Reservoir, Arizona, in 1984 after feeding on an animal carcass laced with strychnine to kill predators (R. Mesta pers. comm.). Although we are not certain any Arizona bald eagles died from poisoning during our study, it may have been a factor in two known mortalities—Cibecue (AM07) and Blue Point (JD10). The use of poisoned carcasses to kill coyotes indiscriminately kills raptors, and could easily kill a bald eagle, which also feeds on carrion. This method for killing coyotes is widely used by ranchers, and in 1987 near Casa Grande, Arizona, three golden eagles, and a variety of other birds of prey were found dead near a carcass laced with strychnine to kill coyotes.

C3.8 SUMMARY OF MORTALITY

From egg to adulthood, a bald eagle cohort is reduced by a multitude of mortality agents, so that those individuals that reach breeding maturity at 4–5 years are some fraction of the original number of eggs produced in the base year. At minimum, Arizona bald eagles suffer a 27.6 percent mortality rate in the egg stage (see Section C3.1). Of those eggs that do hatch, 15.9 percent of the eaglets die before fledging, and an additional 4.8 percent die prior to departing the nest area, resulting in a 20.7 percent minimum mortality rate prior to migration (see Section C3.2). Of the 381 known eggs laid, 219 (57.5%)

at most survived to migrate as juveniles, and likely more eggs and post-fledging young died than are known about (see discussion in Section C3.2). As mentioned in Section C3.6, it is very difficult to document and almost impossible to measure mortality in the 1–4-year-age class (subadults and near-adults). It is also difficult to document mortality in breeding adults; however, by monitoring known banded adults at nest sites (and replacements by near-adult eagles), we can at least arrive at a minimum mortality figure (see Section C3.7).

Mortality rates vary for different populations of bald eagles throughout North America, and for each age class within a population. In one study, nearly 100 percent of the nestlings died before fledging, although, on average, 85 percent of the eaglets which hatch survive to fledge (Stalmaster 1987). After fledging, mortality likely takes its greatest toll in the eagle's first year of life when the juveniles are learning to hunt and fend for themselves. Some studies suggested that only 28.5 percent of fledged young were alive one year after fledging, 14.5 percent two years after, and 9.1 percent three years after (Stalmaster 1987). Another study maintained that 78.5 percent died in their first year, and nearly 100 percent died prior to reaching adulthood (Brown and Amadon 1968). Stalmaster (1987) notes that overall, less than 10 percent of newly hatched eaglets will reach adulthood.

Broley (1947) reported that of 48 band recoveries for Florida bald eagle nestlings, 24 (50%) were shot. Throughout the bald eagle's range, the United States, Canada, and Mexico, shooting is still the number one cause of bald eagle mortality (43.0%), followed by impact injuries (14.4%) (with cars, towers, planes, power lines, *etc.*), poisoning (12.6%), electrocution (7.8%), trapping (3.2%), and drowning (3.2%). These six factors accounted for the deaths of 84.2 percent of bald eagles autopsied from 1960–1977 (Stalmaster 1987). The remaining 15.8 percent were from natural factors such as infections and diseases. Similar mortality agents were described by Henny and Anthony (1989).

Stalmaster (1987) provides a discussion on the causes of bald eagle mortality throughout North America, and an excerpt is presented here for the benefit of readers who do not have access to this book, and to point out the considerable impact humans may have on bald eagle deaths.

> It is difficult to discuss mortality of bald eagles without implicating human activities. Without question the leading cause of death continues to be indiscriminate shooting, by irresponsible persons. As many as five hundred eagles die because of humans each year. In some areas, over 50 percent of the fledgling birds are shot every year. During 1982, three hundred birds were killed by a group of professional eagle killers. Most eagles are killed by stockmen, especially sheep ranchers who believe that eagles kill lambs, by Native Americans for the profit of selling feathers and parts to other Indians, and by irresponsible hunters who either misidentify eagles or kill them for sport. Of ninety-two bald eagles in captivity in 1975, forty-one (44%) were injured because of humans, and at least thirty-one (36%) were shot. Of two hundred eagles admitted to a rehabilitation center, 76 percent had traumatic injuries due to shooting, trapping, collisions, and other human-related accidents. At least 128,273 bald eagles were shot or killed between 1917 and 1952 in Alaska because a bounty was paid for them.
>
> Injuries or deaths caused by impacts and collisions with such obstacles as cars, airplanes, towers, and power lines, account for a large number of eagle fatalities each year. Poisoning also is an important cause of death. Most poisoning deaths are due to indiscriminate use of contaminated carrion for controlling coyotes, the use of pesticides to control insects, and industrial pollution. Electrocution still causes many deaths. When precautions are not taken while constructing power

lines and poles, eagles that perch on or near them may be electrocuted. Accidental trapping with leg traps is a problem, and birds can be drowned while being held underwater in one. Surprisingly, emaciation, which results from starvation, accounts for few deaths, but many birds that are weakened by a lack of food probably fall victim to disease or illness. Fights with other eagles can be injurious or fatal. The list of incidental diseases, infections, and other causes of death reads like a file from the New England Journal of Medicine. It is a sobering thought that approximately 80 percent of all known bald eagle deaths are related to humans.

There have been 101 known bald eagle mortalities in Arizona, 57 juveniles (nestlings and fledglings prior to migration), 5 subadults and near-adults (1–4 years old), and 39 adults. The large percentage of known juvenile mortalities is linked to their presence in the nest, where deaths are relatively easy to document through nest visits, ORA flights, and the ABENWP. Similarly, the high number of known adult mortalities is a product of their presence near the nest during the breeding season, where changes in tenure are apparent from the presence or absence of bands, and near-adult replacements. Mortality in the 1–4-year-age class is difficult to document without telemetry, due to the high mobility and vast ranges of these eagles. Four of the five known subadult and near-adult deaths were documented because the eagles were banded or radio-tagged. There is no doubt that many more bald eagle mortalities have occurred than were documented. Even if the eagles are banded, the chances of finding a carcass in the vast expanse of the Arizona desert (or North American wilderness in the case of migrant juveniles and 1–4-year-old birds), before predators or scavengers, is remote at best.

Of the 101 known Arizona bald eagle deaths, 43 percent (n = 43) died of unknown causes, 41 percent (n = 41) were apparently natural mortalities, and 17 percent (n = 17) were human-induced. The cause of death was unknown in 14 percent (n = 8) of the 57 known juvenile deaths, while 65 percent (n = 37) were apparently natural, and 21 percent (n = 12) were human-induced (see Section C3.2). Only five mortalities were documented in the 1–4-year-age class; however, all five (100%) were human-induced (see Section C3.6). Of the 39 known adult deaths, 80 percent (n = 31) were of unknown causes, while 10 percent (n = 4) were apparently natural, and 10 percent (n = 4) were human-induced (see Section C3.7). It is likely that humans caused or contributed to a larger portion of the known Arizona bald eagle mortalities. Even if we are lucky enough to locate a dead eagle, the rapid decomposition of carcasses (and numerous scavengers) in the desert environment precludes determination of mortality factors in many cases.

C3.8.1 The Black-Market Feather Trade

On the black market, a bald eagle carcass may be valued at hundreds of dollars (R. Mesta, USFWS, pers. comm.). The feathers, feet, beak, and talons are used for ornamentation, costumes, jewelry, and souvenirs. However, Native American tribes which use bald eagle feathers for religious ceremonies may legally obtain feathers through the USFWS feather bank in Ashland, Oregon, which houses feathers from eagles confiscated by agents or found dead by the public.

Several Arizona adult bald eagles have died from gunshot wounds (Rock Creek 1951–1952, Bartlett 1964, Bartlett 1986) (Section C3.7), as have subadults (Section C3.6), and possibly juveniles (Blue Point 1987) (Section C3.2). Although, if we know the birds were shot, someone turned in the carcass, which removes most suspicion of the black-market feather trade. However, in other cases where adults have disappeared without a trace, such an explanation is conceivable.

The Salome Bay near-adult female's (NF01) transmitter was found on the upper Salt River (Section C3.6). The transmitter had been cut off with a knife and placed under a bush, but no sign of the eagle (blood, feathers, or carcass) was found. A human handled the eagle to cut the transmitter off, and it appears they carried the near-adult away with them. In this area, from Globe north to the Salt River, we found two other dead, radio-tagged bald eagles during 1988–1989 (SF01 and AM07).

In a more obvious situation, the dismembered Horseshoe subadult male (JO14) was found on the lower Salt River (Section C3.6). The eagles feet, wings, and tail had been removed. A person also attempted to shoot one of the Orme adults in this area in 1990.

A source (who wishes to remain anonymous) found the carcass of an adult bald eagle in a wooden box under a blue tarp on a knoll near San Carlos Reservoir. The adult's wings, feet, and tail were missing, and the carcass had been completely plucked, although the head and beak were not taken. This source also told of the buying and selling of bald eagle feathers on the reservation.

The black-market feather trade is not limited to bald eagles; golden eagles in Arizona also appear to be victims. In June 1988, BioSystems and USFWS biologists were asked by AGF to climb several golden eagle nests to band the eaglets. AGF wanted to mark the young eagles because they thought (in previous years) someone had stolen the eaglets out of the nests. None of the breeding areas we visited contained young, although signs of young were present in at least one nest. Disputes over the stealing of nestling golden eagles on the Hopi and Navajo reservations in northern Arizona were widely publicized in the mid-1980s.

On 28 June 1988, BioSystems biologists were called to pick up an injured eagle near the town of Dugas. When we arrived on the scene, we found the eagle was a nestling golden eagle which had fledged early. Volunteers from the AGF Adobe Mountain Facility took the young eagle for tests. The following day, BioSystems biologists found the nest cliff and checked the possibility of returning the eaglet to the nest. Once near the nest cliff, we followed a well worn trail, with freshly broken sticks on it, to the nest. The nest was easily entered without climbing gear. It appeared that someone had tried to enter the nest and had scared the young eagle, which jumped and soared to the spot where we picked it up.

In April 1990, we were informed of a similar situation with two golden eagle nests found north of Roosevelt Reservoir. Both nests had trails, one marked with rock cairns, that led to a point directly above the cliff nests (M. Cross pers. comm.).

These observations of golden eagle nests are presented because juvenile golden eagles are valued on the black market for their feathers, especially the banded tail feathers, and brown-flecked wing feathers. The high rate of mortality in breeding adult bald eagles and apparent lack of a floating population of nonbreeding adults, lends support to the hypothesis (and the evidence presented here) that some of Arizona's adult bald eagles are possibly being shot for the black-market feather trade.

C4 HUMAN IMPACTS

A variety of human activities impact Arizona bald eagle breeding areas, including (but not restricted to) intrusion into the nest area for recreation or other purposes, land and water management practices, and low level aircraft. Human intrusion into breeding areas is clearly a significant problem in Arizona, and has resulted in management agencies placing closures around a number of nest sites (see Section C4.6). Even land management practices far away (upstream) can affect river conditions within a breeding area. Overgrazing has caused widespread erosion and arroyo-cutting, and seriously degraded riparian habitat in Arizona since the late 1800s (see Section D2), and continues to do so today. Arizona bald eagle nest sites may be prone to aircraft disturbances due to low level military jet training, test flights of military helicopters built in Mesa, and the use of helicopters to access remote areas of the state for a variety of purposes. Details on human impacts at each of the 28 Arizona bald eagle breeding areas is provided in Section D4. In addition, pesticides used for agriculture (especially cotton) in Arizona, other parts of the western United States and Mexico (where DDT is still widely used), and Canada can contaminate streams and fish (eagle prey), as well as migrating juveniles and subadults (see sections C5 and A4).

C4.1 RECREATION AND LOW LEVEL AIRCRAFT

There are many types of recreation activity that occur within Arizona bald eagle breeding areas. Eagle responses to these activities vary with the person's mode of transportation (foot, vehicle, horse, boat), as well as what the person is doing (shooting, fishing, hiking), the duration of the event (camping, picnicking, moving through area), and the distance of the activity from the nest. Responses also vary with individual eagles and between breeding areas. We assume that pairs nesting in high recreation use areas become somewhat acclimated to the normal activities within their territory, and build up a tolerance to certain types and levels of recreation, as long as the action does not directly impact the birds (shooting). For example, at the Blue Point breeding area, as many as 40,000 people (mostly tubers) use the lower Salt River in a weekend (see Section D4.4). The Blue Point eagles seem to tolerate tubers on the shoreline. However, at the remote Redmond breeding area, the eagles left the eggs during incubation when rafters and kayakers stopped on the beach across the river from the nest pinnacle (see Section D4.25).

Eagles can be indirectly affected by recreation activity such as fishermen occupying a portion of the river normally used for foraging by the eagles. Rivercraft may float through foraging areas at such great frequency (highest on weekends) that the eagles are excluded from foraging sites. In some cases, high levels of recreation appear to cause the eagles to nest in more secluded sites, farther away from water and people (see sections D4.4, D4.19, and D4.20).

The eagle's response to an activity also varies with temporal factors. The timing of a disturbance within the breeding cycle is likely the most crucial factor which determines any adverse impacts on nest success. A disturbance just prior to egg laying may cause the pair to move to an alternate nest away from the problem area, or possibly preclude laying in severe cases or situations of multiple disturbances. Disruptions near the nest during incubation may also cause nest failure or abandonment. Once the eaglets hatch, there is a stronger bond between the adults and the nest. The more time the adults invest in the young, the stronger this bond becomes.

The same disturbance which may cause nest failure during incubation may have a lesser impact as the young grow older (Stalmaster 1987). Nestling bald eagles are capable of thermoregulation at about three weeks of age, and after about four weeks the adults leave the nest unattended for increasing amounts of time (see Section C2.1). Such information on bald eagle behavior and nest success proves valuable when scheduling nest climbs to band young. Climbing the nest at six weeks of age presents little threat to the eaglets or the success of the nest. In most instances, the nest is climbed in the morning and the eagles are back to normal activities in the afternoon. Individual adults may take longer to return to the nest following a climb, and this is likely due to varying tolerance levels based on previous exposure to humans and disturbances near the nest.

Although Grubb (1986a) and Forbis (1986) maintained that climbing nests to band Arizona eaglets had an adverse effect on productivity the following year, our data show no such correlation (see Section C6), and even suggest a stronger nest site tenacity the following year (see Section C2.2.2). Our findings are in agreement with those in other bald eagle populations as expressed by Stalmaster (1987), "Visiting a nest while young are present rarely causes desertion and does not change nest activity in subsequent years." Although in isolated cases a nest climb may disrupt the adults' usual behavior pattern for the remainder of the day, the eagles return to their normal procedures the following day.

Human impacts on breeding bald eagles have been the subject of considerable study in Arizona, and throughout North America. There are numerous records of bald eagles nesting close to human populations; however, most of these accounts fail to explain whether the eagles nested in that location prior to human intrusion. Broley (1947) and Stumph and Creighton (1977) present some examples of bald eagles nesting near human activity. In Arizona, Hildebrandt and Ohmart (1978) noted that, "Intrusions into eagle use areas by humans always resulted in the rapid exit of the eagle from the area." They also explained that aircraft flying at greater than 200 ft above ground level (AGL) were merely watched by the nesting eagles; however, other eagles were very disturbed by low-level flights. Hildebrandt (1981) witnessed a more malicious activity, people shooting at recently fledged juveniles in the Bartlett breeding area. People were also observed shooting at the Ladders male in 1989, and an Orme adult in 1990 (see Section C3).

In attempts to quantify the types and levels of disturbance at Arizona bald eagle breeding areas, the frequency and duration of human activities have been monitored, as well as the nesting eagles' reactions to these activities. Rubink and Podborny (1976) described hiking and climbing near the nest as a high level of disturbance to the eagles. Shooting also caused a high level of disturbance, including adult mortality and nest abandonment (see sections D4.3 and D5.15). Aircraft elicited variable responses from the eagles, while river floating and horseback riding caused little or no disturbance (Rubink and Podborny 1976). Similarly, Ohmart and Sell (1980) explained that river floating, horseback riding, fishing, and nest observation (data collection by biologists) resulted in little or no disturbance to the eagles. Haywood and Ohmart (1982) noted that low flying aircraft and sonic booms resulted in high disturbance reactions from the eagles, while river floating and fishing caused little or no disturbance. Haywood and Ohmart (1982) stated "The most severe human disturbance occurred when two men reached the top of the nest cliff, fired a high-power rifle, and rolled boulders down the cliff face."

The analysis of human impacts at bald eagle breeding areas in Arizona was intensified in 1982. Haywood and Ohmart (1983) classified human activities into eight categories, and quantified the eagles reactions to each activity as (1) no apparent reaction, (2) eagle attempts to locate sound or casual observation, (3) behavior which indicated a state of excitement or perturbation, and (4) flights and/or vocalizations. They

found that jets were the most frequent human activity near nests, followed by rivercraft, helicopters, people on foot, airplanes, gunfire, vehicles, and sonic booms. Most activity elicited no reaction or casual observation (Responses 1 and 2) by the eagle; however, jets caused high levels of excitement (Response 3), while people on foot and rivercraft resulted in high levels of flights and/or vocalizations (Response 4). Of all activities causing flights and/or vocalizations (Response 4), people on foot and rivercraft contributed 76 percent, and 99 percent of all Response 4 reactions were due to activities within 500 m of the nest. In summary, Haywood and Ohmart (1983) explained, "Therefore, greatest disturbances of bald eagles occurred as a result of human interactions in the form of people on foot or in rivercraft, that were initiated at distances of less than 500 m from the nest."

Human impacts on breeding bald eagles in Arizona were studied intensively again from 1983–1985. Grubb (1986a) classified human activities into 13 categories, and quantified the eagles reactions to each activity as (1) none, (2) alert or restless, (3) short flight, and (4) long flight or leaves area. Light planes occurred with the highest frequency near nests, followed by helicopters, jets, gunshots, tubers, hikers, canoes, all-terrain cycles, vehicles, boats, fishermen, sonic booms, and hunters. The greatest disturbance to the eagles occurred from hikers, followed by fishermen, hunters, vehicles, gunshots, tubers, canoes, all-terrain cycles, helicopters, sonic booms, light planes, boats, and jets. The eagles showed no reaction to activities over 714 yards from the nest, were alert or restless at 465 yards, took short flights at 240 yards, and embarked on long flights or left the area when human activities approached within 212 yards (Grubb 1986a). Details on the frequency and response of nesting eagles to human activities at each breeding area studied from 1983–1985 are presented in Grubb (1986a). Grubb (1986a) concluded that, "... tree-nesting pairs of breeding eagles show a higher rate of response to disturbance than cliff nesters."

The data presented in Grubb (1986a) and Grubb and King (1991) are unlike those of Haywood and Ohmart (1983) in that no code was used to differentiate an eagle casually watching an activity from actual responses. Thus, if an eagle simply watched an activity, the response was coded as "alert or restless." Although Grubb maintained that tree-nesters respond more to disturbance than cliff nesters, the Cibecue breeding area (which contains only cliff nests) had the highest rate of response (92%). The three nests at Cibecue are in major use areas, one above a frequently used hiking trail along Cibecue Creek, one above a well-travelled road, and one across the river from a picnic area and beach. What this seems to indicate is that bald eagles nesting in trees or cliffs low to the ground (2 of the 3 nests at Cibecue) are subjected to more human disturbance than those nesting on high cliffs. Not surprisingly, Arizona bald eagles select cliff nests (73% of nest-years) over tree nests at breeding areas where both are available (see Section C2.2). In addition, increased recreation may be the reason the Cibecue pinnacle nest has not been used since 1980, and Mule Hoof has not been known active since 1979.

The 13 activity types monitored by Grubb (1986a) can be easily transformed into the eight categories used by Haywood and Ohmart (1983), simply by combining hiking, hunting, and fishing into "people on foot," tubers, boats, and canoes into "rivercraft," and all-terrain cycles and vehicles into "vehicles." In doing this, people on foot caused the greatest impact, followed by rivercraft, vehicles, and gunshots. Thus, for both studies, people on foot caused the greatest disturbance to nesting bald eagles in Arizona, followed by rivercraft. The data from these two studies also indicate that on average, nesting bald eagles in Arizona are disturbed by activities within 500 meters of the nest, and flush from the nest or perches when human activities approach within 250 m.

Rafters and kayakers may cause significant disturbances when they beach near bald eagle nests to picnic or camp. In the past, the river runners, knowing the nest locations, have stopped there specifically to

watch the eagles, without realizing they were disturbing the birds. River runners have been responsible for the most critical disturbances at some nest sites, and have caused adults to leave the eggs during incubation (see Section D4.25). In more serious cases, rafters and kayakers have attempted to climb nest pinnacles (see Section D4.25) and contributed to the failure of nests by climbing above nests to photograph the eagles and young (see Section D4.8). However, we regard these as isolated incidents, and for the most part the knowledgeable river runners have contributed to the well-being of the eagles by promptly reporting injured birds and educating their clients about the eagles.

McDonnell Douglas, in Mesa, builds military "Apache"™ helicopters and conducts test flights along the lower Salt and Verde rivers. These test flights on many occasions bring the helicopters up the river at tree level, flushing adults off the nest and perches (see Section D4.13). In addition TV news helicopters have caused serious disturbances at several breeding areas. In one case, heavy helicopter traffic may have contributed to the death of one eaglet, and the early fledging of another nestling (see Section D4.4). In another case, a Channel 12 news helicopter was documented chasing adult eagles and hovering over the nest containing two young eaglets, apparently while attempting to film the birds (see Section D4.14).

Most disturbances are probably not intentional and could be avoided with public information programs. A few disturbances have been malicious, such as shooting (see sections D4.3, D4.20, D5.15, and C3), and nests have failed due to photographers who should have known better than to approach nesting eagles at close range (see sections D4.8 and D4.26).

C4.2 GRAZING

The detrimental impacts overgrazing has had on the Arizona landscape since the late 1800s are well documented (see Section D2). Overgrazing of uplands caused in large scale erosion and arroyo-cutting throughout the state, and grazing in riparian areas has eradicated most regeneration of cottonwoods, sycamores, and willows which could be used as perching and nesting substrate by bald eagles. Overgrazing in riparian areas has also contributed to the spread of tamarisk (salt cedar), an introduced shrub which has little value for wildlife, prevents the establishment of natural tree species, and rapidly occupies new areas.

The Arizona bald eagle breeding area most impacted by overgrazing is Sheep (Tonto Creek), where large trees (including the nest tree) are rapidly falling apart, and there is very little regeneration to replace them (see Section D4.27). The Alamo and Chino breeding areas have also been impacted by overgrazing, yet recent cattle exclusion has improved regeneration of cottonwoods and willows (see sections D4.1 and D4.7). However, it will be decades before these new young seedlings are large enough to provide trees for nesting and perching habitat. The impacts of overgrazing near other Arizona bald eagle nest sites are described under each breeding area in Section D4.

Many habitat documents (see Section D2) and each Arizona bald eagle study have stressed the detrimental effects of overgrazing on riparian habitats in Arizona. The destruction of riparian habitats not only adversely affects bald eagles, but impacts many other species of wildlife as well, including birds, mammals, fish, and invertebrates (see Section D2). Rubink and Podborny (1976) believed that the destruction of riparian habitat has had extremely detrimental effects on the nesting and feeding areas of bald eagles. Hildebrandt and Ohmart (1978) addressed the grazing problem specifically, stating, "A distinct threat appears to be facing the maintenance of quality within Arizona's Lower Sonoran eagle

habitat. This is the nearly total lack of replacement of major riparian tree species as a result of grazing by domestic livestock." Many tree nests are located in overmature trees and snags, and replacement trees are lacking. Furthermore, they suggested, "Maintenance of eagle habitat in the Lower Sonoran Life Zone must include an effort to replace the dominant riparian trees which make up this important habitat factor. ..." and, "The most practical methods appear to be exclosure of domestic livestock from prospective seedbeds in riparian regions and tree planting. Both may be necessary."

Ohmart and Sell (1980) noted that cattle grazing has reduced bald eagle habitat by preventing nest, perch, and roost tree regeneration in riparian habitat. Hildebrandt (1981) again addressed the cattle grazing problem, explaining:

> "Grazing by domestic livestock has also had a serious impact upon dominant native vegetation in Southwestern riparian systems by suppressing the normal tree replacement process. Little or no replacement of cottonwoods, sycamores, and willows has recently occurred within the study area. Normal germination and seedling development occurs, but the palatable seedlings are immediately consumed by livestock."

Subsequently, Haywood and Ohmart (1982) also argued that, "Overgrazing of riparian communities has restricted regeneration of cottonwood ..." and Haywood and Ohmart (1981) noted, "Over the years there has been a decrease in numbers of large, dominant cottonwoods along the Salt and Verde rivers, which are often utilized by bald eagles for nesting."

We stress that large trees along the Salt and Verde rivers and Tonto Creek are old and in various stages of decay, and there are no young trees in many areas (see Section D2, D4, C2.2, and A6). Overgrazing of upland habitat has resulted in the loss of vegetative cover, and further compounded the degradation of riparian areas. Historically, torrential rains were not uncommon in the mountainous regions of the Southwest, and the water would flow off in thin even sheets everywhere, strongly retarded by friction against the vegetation (Davis 1982, Hastings and Turner 1965, Hayden 1965). Thus, the water would saturate the land, replenish the groundwater supply, and provide natural irrigation to vast expanses of grasslands on the plains and valley floors. However, after the severe overgrazing from 1870 to 1893 much of the former lush grassland in Arizona lay in ruin, the earth left bare and compacted, especially along cattle trails. This compaction reduced infiltration rates, which, compounded by the loss of vegetation, allowed water to flow over the land even faster.

The trails also created small trenches, where rain waters, now flowing off the slopes faster due to vegetation loss, concentrated. This path of least resistance allowed a larger volume of water to pour off the slopes in a concentrated area, and subsequently cut arroyos into the hillsides. These gullies grew larger and deeper with each heavy rain. This principle, explained in Section D2, results in large-scale erosion, arroyo-cutting, and flooding. The increased runoff also reduced the amount of water which could infiltrate the earth, leaving uplands dryer than in the days before arroyos. Thus, instead of saturating the land, replenishing the groundwater supply, and providing natural irrigation, the water swiftly made its way downstream, carrying most of its beneficial qualities with it, and leaving flotsam and jetsam in its wake.

The impact that the overgrazing of 1870–1900 had on the land is still with us today, and the condition of the land and habitat continues to be degraded. Formerly perennial rivers and creeks are now intermittent or ephemeral. When heavy rains fall, flash floods continue the cycle of erosion and cut

deeper into the earth. The growing ravines, along with groundwater pumping for irrigation and metropolitan areas, continue to lower the water table and create even drier soil conditions. Stream channels, once wide and shallow, are now narrow and deeply incised. The sloughs, backwaters, and marshes created by beaver dams are now gone, along with the cienegas. As the water table drops, the remnants of the riparian forests continue to disintegrate. Further impacted by continual grazing which prevents regeneration (Rubink and Podborny 1976, Stumph and Creighton 1977, Hildebrandt and Ohmart 1978, Ohmart and Sell 1980, Hildebrandt 1981, Haywood and Ohmart 1981, Haywood and Ohmart 1982, and this report), the riparian forests have completely disappeared in some areas, and have become mere shadows of their former grandeur in others. Many riparian corridors now support only a single line of trees, or single isolated trees.

C4.3 AGRICULTURE AND WOOD CUTTING

The Arizona breeding area most threatened by agriculture is Fort McDowell, where vast mesquite bosques have been bulldozed, and portions of the Verde River diverted into a canal to irrigate the fields. During the initial clearing in 1984, the bulldozers approached within 50 m of the nest tree (containing three eaglets) before ABENWP personnel stopped the operators and informed them of the nest tree's location. Thus, most of the human disturbance buffer created by the mesquite bosque has been lost and the remaining bosque has been heavily thinned by wood cutting for fuel.

Plate C16. Agricultural fields along the regulated Verde River in the Fort McDowell breeding area, February 1989 (Photo by Daniel Driscoll).

During 1986–1990, we have observed the mesquite bosques in the Fort McDowell area gradually disappear. Each year, more of the bosque below the nest tree was cut for fuel-wood. We also observed large truckloads of this wood leaving the reservation to be sold in the Phoenix Metropolitan Area. Besides stabilizing the riparian soil and providing habitat for many species of wildlife, the mesquite bosques provide protection to the nest trees, acting as a buffer between human activities along the river and the eagles. The mesquite bosque below the nest trees was heavily thinned by wood cutting in 1989 and 1990, and was reported as an adverse impact on the Fort McDowell pair as early as 1977 (Hildebrandt and Ohmart 1978). There are numerous access roads along the river, and others have been worn through the thinned mesquite bosques. These roads carry recreationists below or very near nest trees, causing adults to flush from the nest and perches (see Section D4.13). Wood cutting near the nest has also been a problem at the Pinto breeding area (see Section D4.23).

In 1984, the mesquite bosque surrounding the Fort McDowell nest was bulldozed to within 50 m of the nest tree for agricultural purposes, and subsequent land clearing has approached within 30 m. An irrigation canal was constructed to divert Verde River water onto the fields, and the first crops were planted in 1986. Corn and sorghum were grown in the fields behind the nest in 1987. We climbed the nest for prey remains collection after the eaglet had fledged and found the entire soft inner portion of the nest lined with sorghum stalks, heads, and leaves; the nest also contained corn cobs and kernels. In 1989, cotton was planted in the fields adjacent to the nest. Helicopters sprayed pesticides and herbicides on the fields while young were in the nest. The risks of poisoning the eggs, young, and adults from herbicides and pesticides are unknown to us, nor can we comment on the risks of possibly contaminated crop material brought to the nest. Drifting mist from spraying likely spread to the nest and river, possibly directly reaching the young, adults, and prey populations. It may not be coincidental that the same female (banded), which produced two young in 1989, laid an unusually small (and infertile) "runt" egg in 1990, the season following aerial application of chemicals to cotton within 50 m of the nest tree. See Section D4.13.2 for more details on the runt egg.

Fort McDowell has been the most productive breeding area in Arizona, and has been occupied in 21 years since its discovery in 1968. The nest site was apparently unoccupied in 1972, and was not checked in 1969, the only two years the eagles were not *known* to have laid eggs. The Fort McDowell eagles have produced at least 38 eggs, of which 33 hatched, and 33 young fledged, resulting in a mean of 1.8 eggs, and 1.6 young produced per occupied year.

To examine the possible impacts of agriculture (and its inherent use of pesticides and herbicides) on the Fort McDowell pair, we compared productivity prior to and after the planting of crops (1986). In 16 occupied years from 1968–1985, the eagles produced at least 30 eggs, of which 28 hatched, and 28 young fledged, resulting in a mean of 1.9 eggs, and 1.8 young produced per occupied year. After the planting of crops (1986–1990), in five occupied years the eagles produced at least eight eggs, of which five hatched, and five young fledged, resulting in a mean of 1.6 eggs, and 1.0 young produced per occupied year. These results suggest that agriculture has had a negative impact, reducing bald eagle productivity by almost one young per year. However, the post-agriculture sample size is small (n = 5 years), and no doubt other agents, such as human disturbance have increased in recent years.

Another highly agricultural area is the Verde Valley, between Camp Verde and the Ladders breeding area (see Section D4.17). The Ladders eagles nest downstream of the agricultural activity, and are not directly affected. However, pesticides and herbicides may enter the river or local ponds. Here, and in the case

of Fort McDowell, the possible impact of agricultural chemicals on the eagles would depend on the kinds of substances used by the farmers.

In addition to land clearing for agriculture or ranching, streams have also been bulldozed in a number of bald eagle breeding areas. Ranchers have bulldozed the streambed to create small dams or alter the water course on Tonto Creek (in the "76" breeding area), the Salt River (at Horseshoe Bend in the Redmond breeding area), and the Verde River (in the Orme, Fort McDowell, and Ladders territories, and near the town of Cottonwood). At Horseshoe Bend on the Salt River, the rancher bulldozed the riverbed during the low summer flows of 1987 to alter the channel as a way of preventing further erosion of the cutbank on the south side of the river. Similarly, the channel was altered in the Orme breeding area to prevent the river from eroding a cutbank near a paved road. Small dams have been created in the riverbed at the Fort McDowell and Ladders nest sites, and also further upstream on the Verde River, near Cottonwood. The effects of these alterations on bald eagles are unknown.

C4.4 DAM OPERATIONS

Dam operations may affect breeding bald eagles in negative and positive ways (see Section B4). Normal dam operations often involve the use of heavy equipment, and helicopters on occasion, which could affect eagles nesting nearby. Unusual dam operations may also affect bald eagles by contributing to nest failure and nestling mortality (see sections D4.4, D4.15, and C3). These situations have involved regulated rivers being "shut off" (0 cfs flow) and reservoirs flooding tree nests.

During our study (1986–1990), much of the regulated Salt River in the Blue Point breeding area remained dry part of the year, with isolated pools occurring from Stewart Mountain Dam to the Verde River confluence. During the 1989 breeding season, with the Blue Point pair attempting to raise eaglets in a nest along the Salt River, the river was completely shut-off (0 cfs) from 22 January to 5 March 1989. During this period even isolated pools began drying up. As discussed in Section D4.4, increased disturbance and possibly the lack of foraging opportunities in the dry river likely contributed to the mortality of the two Blue Point eaglets in 1989. The lower Salt River in the Blue Point nesting area also remained dry during most of the 1990 bald eagle breeding season when, to our knowledge, no nesting was attempted. See Section D4.4 for more details on periods of low (or no) flow on the regulated Salt River, below Stewart Mountain Dam.

These cessations of flow below Stewart Mountain Dam also result in large fish-kills. In November 1986, during a period when less than 9 cfs leaked into the lower Salt, we counted 3.67 dead suckers per meter of river (over one per foot) in transects from Stewart Mountain Dam to the Verde river confluence. In randomly generated sample points, we counted as many as 1423 dead suckers per 100 m section. With the complete shut-off (0 cfs) in 1989 and 1990, fish kills of similar proportion likely occurred (see Section B4.2) for details on fish populations at Blue Point). Whether these kills affect sucker populations over the long term is unknown to us.

The Coolidge eagles apparently did not lay eggs in 1990 when water was shut off at Coolidge Dam; however, the failure to nest that year may have been coincidental. Haywood and Ohmart (1982) reported 0 cfs in the Verde River from 9 January to 7 May 1981 when both nests on the regulated Verde (Bartlett and Fort McDowell) successfully fledged young. However, the characteristics of the Verde River and the foraging ecology of the eagles were not described during this period, so it is not known if the

Plate C17. Stewart Mountain Dam, which backs up Saguaro Reservoir and controls flow in the regulated Salt River below the dam, February 1989. This photo was taken during the 1989 bald eagle breeding season, when no flow (0 cfs) was released from the dam (photo by D. Driscoll).

riverbed was dry, or if leakage from the dam supplied water to pools. It is also unknown if flow cessation, which might allow successful breeding in one year because of carrion production and increased live fish vulnerability, would depress fish populations in succeeding years.

In contrast, too much water has often been a problem at the Horseshoe breeding area, where the eagles have been plagued by nest inundation. The Horseshoe nest was inundated in 1979 with at least one egg, and in 1980 with two eggs, while in 1982 and 1986 two young had to be removed each year and fostered into other breeding areas prior to nest inundation. The Horseshoe tree nests have been inundated in other years, but the eagles either did not lay eggs or nested on the cliff.

C4.5 DISCUSSION OF HUMAN IMPACTS AT NEST SITES

From the information presented in the above sections, as well as the documentation of human impacts at each of the 28 known bald eagle breeding areas in Arizona (see Section D4), it is evident that human disturbance at bald eagle nest sites may negatively affect productivity (see sections C2.5 and C3). Arizona bald eagle nest sites receiving high levels of human disturbance have been somewhat protected by the creation of breeding area closures (see Section C4.6). However, in some cases, the closures have

not been enforced, and people sometimes ignore the signs, cut fences, and ram closure gates to gain entry (see sections D4.8, D4.13, D4.19, D4.20, and D4.23). In addition, some sites which do not have legal closures, receive large amounts of human disturbance each year (see sections D3.1.8, D3.1.13, D3.1.19, D3.1.20, and D3.1.23).

Human activities which have apparently caused or contributed to nest failure include recreation, low level aircraft, wood cutting, agriculture practices, and land clearing. In addition, large scale habitat loss has occurred from the grazing of domestic livestock, principally cattle. It is a disturbing fact that, even though the bald eagle is an endangered species, and only 28 breeding areas are known in Arizona, human impacts still cause or contribute to egg, nestling, and adult mortality, even within legally-designated closures. Moreover, eagle habitat is still being negatively impacted by cattle grazing, land clearing, and development.

There is mostly circumstantial evidence for whether or not each type of disturbance has a negative effect on bald eagle occupancy, productivity, and mortality. Despite the fact that Nest Watchers and other personnel have been present in the breeding areas for long periods, most human-related events leading to nest failure or mortality are often only inferred on the basis of situational considerations. The reason is that specific deleterious agents do not necessarily operate in high enough frequencies or at enough territories for a clear understanding and assessment of their effects, and there are tolerance differences between pairs. However, the cumulative effects of the many human-related factors indeed appears to impact bald eagle demographics, and, for this reason, it is still necessary to view each factor with a potential effect on a case-by case-basis.

C4.6 BREEDING AREA CLOSURES

Bald eagle breeding area closures have been created at eight nest sites in Arizona. The legal closures prohibit entry into nest areas during the breeding season at territories where there is considerable recreation pressure. When first created, many closures had various dates and restrictions. As more was learned about nesting chronology and human impacts, the closures were standardized. Beginning in 1987, each closure prohibited all entry from 1 December to 30 June every breeding season; however, rivercraft were allowed to pass through, but not disembark on land. The Redmond closure is unique, in that the breeding area is remote, and the main disturbance is from river runners beaching near the nest to camp or picnic. Thus, at Redmond the closure simply prohibits rivercraft from stopping in the nest area. One closure (Bartlett) prohibits vehicle entry on a year-round basis. Details on each closure are provided under the appropriate breeding area in Section D4, and the boundaries of these closures are plotted on maps in the Arizona Bald Eagle Nest Map Atlas (Section F).

The first bald eagle breeding area closure in Arizona was created at the Bartlett breeding area on 9 July 1979, due to high levels of recreation pressure. Tonto National Forest Order 12-29, closed the area to vehicles year round, and prohibited all entry from 1 November to 30 June. The closure dates were revised in 1987, prohibiting all entry from 1 December to 30 June each year. See Section D4.3 for details on human impacts at the Bartlett breeding area.

The second Arizona closure was created at the Ladders breeding area, in response to abundant recreation and the close proximity (and visibility) of some of the nests to the upper mesas. Closures were enacted by the Prescott National Forest in 1981, and the Coconino National Forest in 1982. These closures were

Plate C18. Closure signs and cable at the Bartlett breeding area, September 1986 (Photo by Daniel Driscoll).

combined and modified, and a new closure was enacted on 23 October 1984. Coconino and Prescott National Forest Order 16-52 closed the area to all entry from 1 December to 15 June. The closure dates were revised in 1987, to prohibit all entry from 1 December to 30 June. See Section D4.17 for details on human impacts at the Ladders breeding area.

Due to high levels of recreation pressure (mainly tubers and hikers), a closure was enacted at the Blue Point breeding area on 16 January 1984. Tonto National Forest Order 12-40-3R, closed a portion of the Goldfield Mountains, below Stewart Mountain Dam and south of the Salt River, to all entry from 1 December to 30 June each year. In addition, the Lower Salt River Recreation Area Closure, Tonto National Forest Order 36 CFR 261, was enacted on 26 October 1985. This order closes the lower Salt River from Stewart Mountain Dam to Granite Reef Dam between sunset and sunrise (except for fishing), prohibits the discharge of firearms (except for hunting), and also prohibits use of glass containers in the area. See Section D4.4 for details on human impacts at the Blue Point breeding area.

In response to high levels of recreation pressure, shooting, and vehicle traffic, a closure was created at the Cliff breeding area on 7 February 1985. Tonto National Forest Order 12-58, closed the area to all entry from 15 November to 15 July. The closure dates were revised in 1987, prohibiting all entry from 1 December to 30 June each year. See Section D4.9 for details on human impacts at the Cliff breeding area.

At Pleasant Reservoir, recreation and vehicle traffic on the river below the nest cliff (especially fishermen during white bass spawns) prompted a closure to protect the nest area from disturbance. The Maricopa County Parks and Recreation Department Closure, enacted on 18 December 1985, prohibited all entry within one square mile of the nest from 15 December to 15 June. The closure was extended to two square miles on 25 January 1986, and in 1987 the dates were revised to prohibit all entry from 1 December to 30 June. In addition to currently prohibiting entry into the nest area by land, the closure will be improved to protect the nest cliff from boaters following the completion of New Waddell Dam (T. Gatz, pers. comm.). See Section D4.24 for details on human impacts at the Pleasant breeding area.

Due to disturbances caused by rafters and kayakers camping near the Redmond nests, a recommended "No Stop" zone was enacted by Tonto National Forest in 1986. The closure prevents rivercraft from beaching between Km 126.7 and 129.8 along the Salt River from 1 December to 30 June. There is no vehicle access into the Redmond breeding area; thus other forms of recreation have not posed a threat to this nesting pair. See Section D4.25 for details on human impacts at the Redmond breeding area.

The large amount of recreation centered around the nest trees at the "76" breeding area, including hunting and camping below the nest, vehicle traffic, and photographers inducing nest failure, prompted the enactment of a closure on 15 October 1987. The Tonto National Forest Order 12-65-R closed the area to all entry from 1 December to 30 June. See Section D4.26 for details on human impacts at the "76" breeding area.

The most recent Arizona bald eagle breeding area closure was created at the Ive's Wash breeding area on Alamo Reservoir in 1990. Due to recreation pressure on the upper reservoir, a closure was enacted on 6 March 1990 by the Arizona Game and Fish Department and the U.S. Army Corps of Engineers. This closure consisted of buoys placed 100 m around the nest (nest 2) and a sawhorse placed across the road leading to Woody's Cove. Recreationists consistently camp below the nest at Woody's Cove, and bass fishermen tie up to the nest tree (which is often in standing water), flushing the adults off the eggs. However, the closure was not created soon enough to save the nest from failure in 1990. See Section D4.16 for details on human impacts at the Ive's Wash breeding area.

Analysis of human impacts at other bald eagle breeding areas from 1977–1990, suggests that recreation pressure is increasing along waterways in Arizona (see human impacts under each breeding area in Section D4 and above). The Phoenix metropolitan area is one of the fastest growing communities in the United States, with over one million people counted in the 1990 census. Several cities connected to Phoenix have grown by up to 90 percent in the last decade. Since central Arizona is a desert ecosystem, the open habitat near water has become the "playground" for the Phoenix metropolitan area. All-terrain cycles, off-road vehicles, and shooters (mostly non-hunting related, such as handguns, semi-automatic, and automatic rifles) have caused severe disturbances by unknowingly approaching nest sites. In some cases, off-road vehicles have rammed closure gates and cut fences to enter breeding areas. As recreation pressure increases, expanded efforts to protect bald eagle breeding areas will no doubt be necessary.

From the information presented in sections D4, C3, and this section, bald eagle breeding areas needing closures include Fort McDowell, Alamo/Ive's Wash (upper end of reservoir), Pinto, Cibecue, and possibly Mule Hoof and Orme. In addition, the current closure at the Cliff breeding area is not sufficient and needs to be expanded, gated, fenced, posted, and enforced (see Section D4.9). Breeding areas suffering nest failures, or otherwise adversely impacted by human disturbance during the breeding season in 1987–1990, include "76" (1987), Fort McDowell (1987, 1988, 1989, 1990), Blue Point (1989),

Bartlett (1990), Cliff (1990), Ive's Wash (1990), and Orme (1990). See Section D4 for details on human disturbances at each of the above sites. Five of these sites already have legally designated closures; however, the closures need better enforcement. Failure to enforce closures in any one year sets an unfavorable precedent. When we informed recreationists the area was closed, they often said they did not see the signs, or they had read the signs and disregarded them because they had never been stopped from entering the area before.

Most entry into closures is not malicious, and simply explaining the situation to the people usually sparks a genuine interest in helping the eagles. Some of these people cheerfully leave the area having received information about the eagles and their needs. It is these same people who will help to protect nesting eagles by passing on closure information and rationale to others. This type of positive reaction can be spread over a much larger portion of the population through information programs, such as those conducted by Liberty Wildlife Foundation, and public viewing stations at nest sites with high recreation pressure. An interested and enlightened public will be supportive of bald eagle preservation and will help to ensure the continuance of funding for information programs and protection of nesting areas.

C4.7 EFFECTS OF PUBLIC USE AT FORAGING AREAS

Due to the ABENWP, there is a large amount of data on human disturbance near Arizona bald eagle nests; however, there is less information on human impacts at bald eagle foraging areas. From 1987-1989, we collected data on public use and associated eagle responses incidental to our other research. We observed 284 public user incidents occurring within 100m of an eagle at breeding areas we studied with telemetry (Bartlett, Blue Point, Cliff, East Verde, Ladders, Horseshoe, and Pinal/Pinto) from 1987-1989 (Table C4.7-1). Most major use categories were divided into motorized and non-motorized use. Eagles were closely approached most often by motorized boaters, including recreational boaters and anglers, resulting in a high number of flushes, especially by motorized anglers (56%). Anglers often troll along the shoreline, which brings them close to low hunting or eating perches such as inundated cottonwoods or mesquites. Anglers often make sudden movements, such as casting, as part of their fishing activity. In contrast, recreational boaters usually pass quickly through an area, so their disturbance is limited to that produced by the boat's movement and noise.

Non-motorized boating includes rafts, kayaks, and canoes. Boats using motors caused a higher percentage (27%) of flushes by eagles than did non-motorized boats and boats with the motor not running (16%), although the difference was not significant by Chi Square. Similarly, non-motorized fishing boats caused a lower percentage of flushes (31%) than those using motor boats (56%), but again, the difference was not significant by Chi Square.

Tubing appeared to cause a low percentage of flushes; however, the number of tubing observations is low, and restricted to the Blue Point territory. Blue Point annually has extremely high public use on the river, with up to 40,000 people on weekends (USFS Mesa Ranger District). However, during our study the eagles were nesting in a remote side canyon off Saguaro Reservoir. The Blue Point pair's use of the lower Salt River was mainly confined to Bulldog Cliffs, where they perched high above the water, in an area closed to public use. Thus, eagles were somewhat removed from the activity, and may have become accustomed to it.

Table C4.7-1. Summary of public use incidents (within 100 meters of an eagle) and eagle responses at the seven breeding areas studied with telemetry from 1987–1990.

Type Public Use	Number of Public Use Incidents	Percent of Total Incidents	Duration (minutes)	Percent Duration	Eagle Response to Public User					
					N	W	I	S	C	F
Fishing										
on foot	8	2.8	258	5.1	—	2	—	—	4	2
non-motorized or not using	16	5.6	413	8.1	6	4	—	—	1	5
using motor	61	21.3	405	8.0	12	15	—	—	—	34
Camping	1	0.4	29	0.6	1	—	—	—	—	—
Hiking	4	1.4	26	0.5	—	1	—	—	—	3
Picnicking	5	1.8	117	2.3	2	1	—	1	—	1
Swimming	2	0.7	79	1.6	—	2	—	—	—	—
Boating										
non-motorized	48	16.7	1280	25.1	12	27	1	—	—	8
not using motor	8	2.8	419	8.3	7	—	—	—	—	1
using motor	60	20.9	1154	22.7	28	16	—	—	—	16
Agency worker, wading	1	0.4	135	2.7	—	1	—	—	—	—
Shooting	6	2.1	82	1.6	2	—	—	—	—	4
Airplane	3	1.1	3	0.1	—	1	—	—	—	2
Helicopter	20	7.0	45	0.9	6	4	—	—	—	10
Low-level flight	15	5.3	15	0.3	13	1	—	—	—	1
Tubing	6	2.1	51	1.0	4	1	—	—	—	1
Motorcycle, off road	1	0.4	90	1.8	—	1	—	—	—	—
Four-wheel drive, off road	7	2.5	126	2.5	2	1	—	—	—	4
All-terrain cycle, off road	5	1.8	267	5.3	—	3	—	—	—	2
Jetski	3	1.1	61	1.2	1	1	—	—	—	1
Horseback riding	4	1.4	18	0.4	—	2	—	—	—	2
Total	284		5075		96	84	1	1	5	97

N=No response; W=Watching; I=Interruption of activity; S=Probable avoidance of area; C=Certain avoidance of area; F=Flush

Other activities which provoked a high percentage of flushes included shooting (67%) and off-road vehicles (57%), although sample size was low for both. Airplanes and helicopters both produced a large number of flushes, as did hikers, jetskiers, and horseback riders.

Similar to data on human disturbance near bald eagle nests (see above sections), the distance of public users to the eagle appeared to have an influence on the number of flushes. Eagles flushed in 43 percent of the instances where public users approached within 0–25 m, 35 percent at 25–50 m, and 29 percent at 51–100 meters.

Although human disturbance near nests has had negative impacts on Arizona bald eagle productivity (see above), we do not know the extent to which public use at foraging areas affects breeding success. If a territory contains numerous optimum foraging locations, the adult may leave the disturbed site to look for food in other areas. However, some food sources may be temporally and spatially isolated, and human presence at these sites may prevent eagles from exploiting the resource.

C5 FIELD STUDIES OF THE ECOLOGY OF NON-BREEDERS

In Section A4, we provided an overview of the post-fledging behavior, departure, migration, and return to Arizona of a sample of radio-tagged juvenile bald eagles. We also examined the movements of these birds and those of eight subadults and near-adults within the central Arizona region, with the idea of assessing their use of habitats during fall, winter, and spring. In the current section, we offer a more detailed report of field observations, both visual and telemetric, of this little known segment of the population. For the most part, we have endeavored here simply to chronicle the activities and movements of the birds rather than to select material to illustrate points of discussion.

C5.1 PREVIOUS STUDIES IN ARIZONA

Six Arizona nestling bald eagles were radio-tagged prior to 1986, two each year from 1977–1979 (Hildebrandt 1981, Sell 1982). These researchers applied Telonics 185-gram backpack transmitters with a 14-month battery life in 1977, 168-gram transmitters with a 14-month battery in 1978, and 185-gram transmitters with a 15-month battery life in 1979. Two of the eaglets died and one disappeared shortly after leaving the nest (Table C5.1-1). In 1977, the telemetered juvenile dispersed on 1 July, 37 days after fledging (Hildebrandt 1981). The two 1979 young left to migrate on 23 June and 4 July, at 44 and 51 days post-fledging, respectively (Sell 1982). No data on the migratory movements of either of the 1979 young were obtained, and the 1979 Fort McDowell eaglet was not sighted after dispersal (Sell 1982).

The 1979 Bartlett young returned to Roosevelt Reservoir where its signal was picked up by AGF personnel on 4 April 1980. The juvenile was sighted on Apache Reservoir in April, but apparently spent most of its time on Roosevelt Reservoir, using habitats near School House Point, Salome Creek, and the Tonto Creek estuary. This juvenile was once observed soaring with another subadult eagle carrying a USFWS band. The Bartlett eagle's transmitter batteries apparently failed on 6 July 1980, and the eagle was not sighted after that time (Sell 1982, Haywood and Ohmart 1981). Curiously, in our own studies of the movements of telemetered juveniles and subadults in Arizona during 1987–1990, we obtained no signals in Arizona during summer months despite considerable searching by airplane.

The 1977 Bartlett nestling (T04) left the nest area on 26 June 1977, but returned on 28 June. The juvenile's transmitter failed on 1 July, but the eagle apparently migrated on or shortly after that date. On 13 July 1977, T04 was found dehydrated and exhausted on the U.S. Marine Corps Base at Twenty-Nine Palms, California. T04 was returned to Phoenix on 20 July and rehabilitated at Liberty Wildlife Foundation by Dr. Kathy Ingram. On 26 July 1977, T04 was fitted with a new transmitter and released at the Bartlett breeding area, with fish placed out for the juvenile to feed on. T04 departed again on 29–30 July, and was located 12 mi upstream of his natal area on 31 July. On 3 August, T04 left the area, and was located on 10 August west of Yuma, Arizona. T04 proceeded to the Imperial Valley of southern California, then was found at an irrigation pond near Seeley, California on 11 August, where it remained until 23 October 1977. Another young eagle arrived at the irrigation pond on 21 October, and departed on 22 October. On 23 October 1977, T04 flew south into Mexico and was not tracked further (Hildebrandt 1981).

T04's signal was picked up by USFWS personnel conducting a waterfowl survey in January 1978, on the Rio Sinaloa, 80 km southeast of Los Mochis, Sinaloa, Mexico. T04 was observed for several days on

Table C5.1-1. Survivorship of juvenile bald eagles telemetered prior to 1986.

Year	Breeding Area	No.		USFWS Band	Comments
1977	Fort McDowell	T02	Right	629-04452	Drowned post-fledging. Humerous broken in sibling interaction.
	Bartlett	T04	Right	629-04454	Shot near Calgary, Alberta, Canada in 1980.
1978	Bartlett		Right	629-04460	Died post-fledging. Eaten by mammalian predator.
	Cibecue		Left	629-04461	Disappeared post-fledging.
1979*	Bartlett	1	Right	629-04462	Returned to Apache and Roosevelt Lakes. Transmitter failed July 1980.
	Fort McDowell	2	Right	629-04464	No data since dispersal.

* One of the 1979 birds nested at the Chino breeding area in 1985 and 1986, at Alamo in 1987, and was replaced prior to 1988.

the Rio Sinaloa in January, but aerial searches of the area in February and March 1978 failed to pick up T04's signal (Hildebrandt 1981). T04 was not heard from again until 4 September 1985 when Robert Ohmart (ASU) received a phone call from a wildlife biologist in Calgary, Alberta, Canada. T04 had been shot by a rancher 60 mi east of Calgary in 1980, but the rancher did not report the incident until 1985 (Ohmart 1985).

T04's dispersal to Mexico sparked much discussion about the migration of Arizona nestlings, and the final destination of these long range flights. T04's movements led Hildebrandt (1981) and Haywood and Ohmart (1983) to speculate that the Arizona population may be linked to bald eagles nesting in Baja California, Mexico, and that Arizona eagles may winter in Baja California and mainland Mexico.

C5.2 OBSERVATIONS OF PRE-MIGRATORY BEHAVIOR OF JUVENILES

Nestling bald eagles in Arizona generally fledge from 10–13 weeks of age; however, fledging age varies, and is apparently influenced by periods of high temperatures and nest parasites (see Section C3). Young have successfully fledged from Arizona bald eagle nests from 60 days (8.6 weeks) to 95 days (13.6 weeks) of age, when exact hatch and fledge days are known (see Section C2). We recorded juveniles remaining in the breeding area for periods ranging from 18–65 days, departing on their migrations from

9 June to 30 July. During the period from fledging to departure, the young learn to fly, land, assert their aggressiveness on other species, and occasionally forage.

After fledging, the juveniles are clumsy, and their first landings on cliffs or branches can result in injury, or even death. We observed an eaglet (JD33, Blue Point 1988) break his neck when he crashed into the face of the nest pinnacle while attempting to land after his first flight. The eaglets are also naive about cactus, and have attempted to land on teddybear cholla on initial flights. In one case, we spent 10 minutes picking cholla spines from the face, feet, and wings of JC51 (Bartlett 1989) which fledged into a teddybear cholla. The young gradually become adept flyers, and learn how to slow themselves down to perch. If the juveniles have fledged at a young age (less than 11 weeks), they may spend several days on the ground before acquiring the ability to fly. However, some eaglets fly well upon leaving the nest.

The fledglings usually remain near the nest for the first week or so, then begin venturing farther from the eyrie, although they remain within the home range of their parents. The adults continue to feed the young, and the eaglets often pursue adults that have captured prey. In order to avoid the large aggressive young, the adults initially drop off prey at the nest. The eaglets follow adults to foraging areas if perches are nearby and the distance is not overly far from the nest. If the eaglets are near the forage area, they often fly to the adult to acquire prey on the ground or at a perch. As we will see below, the 1989 Bartlett juveniles developed the behavior of flying directly at the adults while vocalizing, prompting the adults to forage. Although the bulk of the eaglet's food is provided by the adults, they occasionally eat carrion, and rarely kill their own food. The young "food-beg" throughout the day, and vocalize extensively when an adult returns with prey.

C5.2.1 Observations in 1987 at Orme, Fort McDowell, and East Verde Territories

In 1987 we radio-tagged two nestlings at Orme (JZ01 and JZ02), one at Fort McDowell (JM03), and one at East Verde. The Fort McDowell nestling (male) fledged on 1 May 1987, the Orme siblings on 3 and 5 May, and the East Verde nestling female on 30 May, all at 13 weeks of age.

At first, the birds perched near the nest, but after a few days became increasingly adventuresome. During the initial two weeks after fledging, the young eagles remained within about 1.5 km of the nest site, perching on rocky hill tops (Orme) near the nest and flying singly or together in the vicinity. The adults brought food to the nest area during this time. It was not until the third week after fledging, when the young began perching occasionally along the Salt River, that either of them was observed away from the nest area. They did not appear to follow the adults out of the territories.

About three weeks after fledging at Orme and Fort McDowell, we changed our observation location to a hill approximately 5 mi from the Orme territory and 3 mi from Fort McDowell. From the hill, it was apparent, based on the directions of telemetry signals, that the juveniles did not stray more than about 3 km from their nests until they departed on migration. The frequency and duration of flight/soaring signals increased as time went on and continuous flight signals often exceeded one hour during the two weeks prior to departure. Other than that tendency, however, none of the radio-tagged juvenile bald eagles from any of the three territories gave obvious forewarning of their departure.

C5.2.2 Observations of two 1989 Bartlett Juveniles

In 1989, we observed two radio-tagged juveniles (JC50 and JC51) at the Bartlett territory from the time the eaglets left the nest (10 and 11 May) until they departed the territory in mid-July. At first we observed the birds visually and on foot throughout the day, but once they began soaring, the use of a vehicle became necessary to track their flight. The radio of the juvenile JC51 stopped functioning on 28

June and the bird was last seen soaring in the area on 4 July 1989. Its sibling JC50 remained in the territory until 14 July, after which Hunt tracked its migration to Montana.

After fledging, the juveniles remained perched on a cluster of boulders below the nest, occasionally flapping their wings and hopping short distances. During the first days, the eaglets depended entirely on food brought in by the adults (up to four deliveries per day). Of the observed deliveries, 44 percent were made by the adult female and 56 percent by the adult male. Most of the delivered prey was caught in the riffles downstream of the nest, but the male occasionally foraged in the reservoir; 87 percent of the observed prey appeared to be suckers 20–30 cm in length.

By 27 May, the young eagles would vocalize while flying straight at one of the perched parents, who would eventually forage. As soon as the adult was eating its prey, the juvenile would join it at the feeding site, and the adult would immediately fly away, allowing the juvenile to eat the prey. Not until both chicks had finished eating, would the adults attempt to feed on the remaining prey. This pattern was repeated several times a day throughout the post-fledging period and represented the primary mode of food delivery for the fledglings.

We also observed the young finding and eating carrion. Large numbers of dead suckers were available, especially during days when the dam was closed and the river ceased flowing. Carrion was also left by fishermen in the area. We also saw the Bartlett juveniles picking up sticks and soda-pop cans and flapping their wings in efforts to fly away with their "prey."

The juveniles attempted to forage several times in shallow riffles by hopping about in the water, presumably trying to catch live fish. On 8 June when the dam was closed, the juvenile JC51 perched on a small boulder in a warm, shallow pool and suddenly hopped into the water. Flapping its wings vigorously, the eaglet returned to the top of the boulder dragging a pink-colored fish in its talons.

On 8 June, JC50 soared for the first time; it was aloft for 8 minutes to the east of the nest. The eaglets' longest soaring period was 27 June when it remained airborne for 164 minutes in the area northwest of the reservoir with a strong wind from the south. About half the time the siblings soared, they did so together and were occasionally observed locking talons in the air. Their favorite soaring area seemed to be the northern part of the territory where they spent a total of 330 minutes soaring. They escaped from attacking ravens and red-tailed hawks; great blue herons flew away when the eagles approached.

Diel activities were as follows: the juveniles usually spent the early morning in the vicinity of the nest or just downstream (Kms 34.0–34.5) and soared mostly between 0930 and 1200 hr. They generally spent the afternoon in the shade of the nest cliff area, and seemed to be more interested in food during the late evening. Their favorite roosting place was on the cliff face at Km 34.8 (see Section B4.1).

The eaglets' response to public users varied from watching to flushing at the sound of shooting. Despite the nest area closure before 30 June, the nest cliff area remained a popular fishing site. Although the eagles did not flush in the presence of fishermen, they did not attempt to forage while any public-users were present.

C5.2.3 Departure

BioSystems monitored the migratory departures of 11 juveniles during 1987–1989, which departed on migration from 9 June (JZ02, Orme 1987) to 30 July (JW31, "76" 1988). We were able to follow the

migrations of all but one of these birds, the Horseshoe eaglet (JO35), which departed its natal area in a northwesterly direction on 29 July. Ages of the eagles upon departure ranged from 16 to 21.5 weeks, varying from 18 days (JL20, East Verde 1987) to 65 days (JC50, Bartlett 1989) after fledging.

Typically, the juveniles began soaring a few weeks after fledging, often for long periods in mid-day. We recorded a 1989 Bartlett juvenile (JC50) soaring for 164 minutes (2 hours, 44 minutes) on one mid-day flight prior to migration. The latter, which cannot be anticipated by observers, follows a typical soaring flight. For example, JL20, a juvenile from the East Verde nest in 1987 departed at 16 weeks of age on 17 June, 18 days after leaving the nest. That morning from 0715 to 0755 hr, it perched on a small cliff 300 m downriver from the nest. At 0743 hr, the adult female flew upriver and perched on a small cliff 100 m downriver from the nest. The juvenile then flew to a perch 5 m below the adult female and vocalized every 3 to 4 minutes. The adult male was approximately 1.4 mi downriver from the nest until about 0900 hr, at which time it flew upriver to another favorite hunting area near the mouth of Fossil Creek. The juvenile flew upriver towards the male at 0913 hr. The young eagle soared with the male up to several thousand feet above the river for 10 minutes. The male then descended and perched approximately 1.4 mi downriver of the nest. The juvenile continued to glide out of sight up the Verde River. From radio signals, the juvenile appeared to fly north of Ike's Backbone, glide down Fossil Creek, and continue west over land. It was last seen at 0954 hr, 4 mi west of the nest soaring at about 3000 ft over Long Mesa. Ten minutes later the radio signal was no longer audible. At 1015 hr, the adult female and male perched 5 m apart on a small cliff 100 m downriver from the nest; they remained there for 45 minutes. The time of JL20's departure (ca. 1000 hr) was an hour our so earlier than was typical.

C5.3 NARRATIVES OF JUVENILE MIGRATIONS

Bald eagles in most of the Canadian provinces migrate to more southern latitudes in the winter, when inland waters freeze, waterfowl migrate south, and food becomes scarce. Bald eagles banded as nestlings at Besnard Lake, Saskatchewan, Canada, have been recovered, sighted, or radio-tracked throughout the plains and western states of the U.S, including one which wintered in Arizona (Snow 1973, Stalmaster 1987). Similarly, eaglets banded in the Great Lakes Region migrated south into the midwest and southern Mississippi Valley states, and also into Texas. Eagles from the Chilkat River, Alaska, mostly remained in Southeast Alaska, although some moved south along the coast of British Columbia and Washington (Stalmaster 1987).

Charles Broley, who was first to study bald eagle migrations, banded over 1,000 nestlings in Florida during the 1930s and 1940s (Sprunt 1955). Band recoveries showed that these juveniles migrated north throughout the states east of the Mississippi River, but most moved up the east coast, some all the way to Canada. Florida's adult eagles, however, remained at or near their breeding areas year round (Stalmaster 1987).

BioSystems (1985), studying nesting bald eagles on the Pit River in northern California, radio-tracked five post-fledging juveniles northward in summer; some and probably all went into Canada and may have reached coastal Alaska, where salmon carrion would have been abundant (Hunt *et al.* 1992b). The juvenile eagles we studied in Arizona also made northerly migrations, a behavior which is instinctive and probably adapted to the distribution of food in pristine times. We can only guess about the abundant food sources which likely guided and influenced the encoding of eagle migratory adaptation through the

centuries. The spawning runs of salmon and trout and the calving of herds of buffalo and elk no doubt played a part as bald eagle food sources, as did the thawing of winter-killed ungulates (see Section A4).

To learn about the migrations, we tracked the daily soaring behavior of radio-tagged juveniles from high, centrally located mountain peaks (Humboldt Mountain, Mount Ord, Pine Mountain), so several breeding areas could be monitored from one point. When a bird soared out of telemetry range, the tracker radioed the pilots to inform them that the eaglet had departed.

The young eagles, migrating north from their natal areas, roosted on first nights, for example, in the vicinities of Camp Verde, Flagstaff, Winslow, and the Little Colorado River. In succeeding days, they continued to migrate, covering up to 410 mi in a day (JI26, 5 July 1988), at still-air ground speeds of 20–25 mph, increased sometimes greatly by tailwinds. Although all 10 juveniles headed in a northerly direction, they fanned out northeast and northwest to span an area eastward to Swan Lake, Manitoba, Canada, and westward to coastal British Columbia, Canada, before reaching their destinations (Figure A4.1-1). In all, four went northwestward, four northward, and two northeastward. We tracked some of these migrating eagles to their apparent destinations, although others were still enroute when storms or visibility problems prevented airplane tracking (see Section A4 for discussion). Below are narratives of the movements of each of the 10 birds.

C5.3.1 Orme 1987 Juvenile Female—JZ02

On 9 June 1987, the day of its departure, JZ02 traveled about 74 mi northward to a cottonwood grove (or nearby cliff) near Camp Verde, Arizona, stopping before 1550 hr. The next day it traveled nearly 300 mi to Sevier Lake in southern Utah and by the next evening had reached the Ruby Mountains in Nevada. The following day, 12 June, it flew northwestward to roost near the three-state intersection of Nevada, Oregon, and Idaho. It roosted the next evening just south of La Grande, Oregon. Heavy thunderstorms with rain persisted in the region over the next 48 hours and prevented airplane tracking. The eagle apparently remained in the Blue Mountains of northern Oregon during this period. On 16 June, the bird traveled over the wheatlands of eastern Washington to roost north of Moses Lake. By 18 June, it had gone northwestward across the Cascade Mountains to the lowlands near Mt. Vernon, Washington, north of Seattle. The next day, the eagle passed over the city of Vancouver, British Columbia and traveled up the eastern shore of the Strait of Georgia. Deteriorating weather conditions prevented us from tracking the bird further. If it continued migrating in the same direction, it would have arrived in southeast Alaska in three or four days.

C5.3.2 Fort McDowell Juvenile Male—JM03

JM03 also traveled to the Camp Verde area on 12 June 1987, the first day of its migration. The following evening it roosted on the Kaibab Plateau, in a clearing along a creek. It moved the next day to the Wasatch Mountains overlooking Provo, Utah. Despite thunderstorms and heavy winds, it traveled into Idaho the following day and roosted along the Snake River north of Idaho Falls. The next morning, 16 June, it moved northward for a relatively short distance and stopped at mid-day at Lima Reservoir in southern Montana. It remained there for the next seven days, at first frequenting an extensive area of oxbows at the inflow of the reservoir where water had been isolated as a result of recent reservoir drawdown. A ground check showed that fish were stranded in the oxbows. Some of them had dried up, exposing numerous carcasses; those examined appeared to be whitefish. We saw the young eagle on a number of occasions, usually sitting on the sandy shore of the reservoir or perched on a small cut-bank. On one occasion we watched him chasing waterfowl. We twice observed him in the company of a pale subadult bald eagle. On 20 June, JM03 moved to the downstream end of the lake where it remained until

23 June. During the entire week the bird spent at Lima Reservoir, we only found it soaring once, despite what often seemed to us to be favorable conditions. On 25 June, we received a soaring signal indicating that the bird had moved to the area of Henry's Lake, Montana, east of its former position, traveling up the Red Rock River valley during conditions of low clouds and rain. The bird left this area by the morning of 27 June, and relocated about 55 mi to the southeast on the southeast arm of Yellowstone Lake in Yellowstone National Park, Wyoming. Ground and aerial tracking on 28 and 29 June confirmed that the bird stayed in the southeast arm area.

On 30 June, we met with park biologist T. McEneaney and traversed Yellowstone Lake by boat to where telemetry signals indicated that the bird was located. Flights on 1 and 2 July also confirmed that the bird remained in the southeast arm. On 2 July, we accompanied one of Al Harmata's (Greater Yellowstone Ecosystem Bald Eagle Research Group) field assistants and determined that two of their radio-marked bald eagles were also in the southeast arm of Yellowstone Lake. This arm of the lake is about 11 km long and 2–3 km wide. The Yellowstone River flows through a valley 3 km wide and enters the lake at the south end of the southeast arm. The valley extends 16 km upriver to an area known as "The Thoroughfare" and on to the headwaters in the Absaroka Mountains. The lakeshore on both sides of the river mouth contains sand and gravel beaches, an alluvial delta, shallow backwaters, and marsh dominated by marsh grasses and willow with occasional dead snags. About one-half mile from the mouth, the river is bordered by coniferous trees that extend upstream about 3 km.

When we arrived at the end of the lake, we climbed a hill on the north side and picked up telemetry signals from the Fort McDowell eagle as well as one of Dr. Harmata's eagles; both signals came from an area upstream from the river mouth. While monitoring a flight signal we saw a dark-colored bald eagle flying over the river about one mile away. Its movements were consistent with the telemetry signal indicated of JM03. Because of a Park motor restriction we were unable to travel to the river and get a closer look at the habitat. During our flights, however, we could see that the river was slow-moving with numerous bends and oxbows.

During conversations with T. McEneaney and two biologists researching grizzly bear/fish biology, we learned that the tributaries of Yellowstone Lake are spawning areas for cutthroat trout during May and June. The Yellowstone River is the largest of these and it reportedly hosts an abundant run of trout. The Yellowstone Lake fisheries are managed both for sportfishing and to provide food for grizzly bears, ospreys, and bald eagles. There is a creel limit of two fish per day with a maximum size of 13 inches. This size limit was imposed in an effort to maximize the number of larger, breeding age fish which are prey for several wildlife species in the park community. The Yellowstone River valley also contains extensive marsh habitat which is used by molting waterfowl at this time of year. During our visit we observed hundreds of birds, mostly scaup (*Aythya* sp.) and Canada geese along the lakeshore.

The area upriver from the mouth (where we saw JM03) appeared to offer the best foraging habitat because the trees and snags along the river provided high perches within view of the river course. Although we were unable to travel the river and obtain first-hand observations, we did come away with the impression that JM03 had selected one of the best foraging areas in the greater Yellowstone region.

Al Harmata and Allen Bath reported that on 10 July the Fort McDowell juvenile was approximately 3 km southwest of Bridger Lake in the Bridger/Teton National Forest near the southeast corner of Yellowstone National Park. On 23 July at 1200 hr, Bath saw the eagle on a sand bar at the mouth of the

Yellowstone River on the southeast arm of Yellowstone Lake. Bath remarked that "... the bird appeared to be in excellent physical shape."

JM03 had returned to Arizona by 20 October and we tracked it periodically there until May.

While following another telemetered juvenile on 21 June 1988, we found JM03 back at Yellowstone Lake, Wyoming where it had traveled the previous summer. JM03 was the only Arizona juvenile that we found away from Arizona in its second summer. We never again detected its radio transmitter.

C5.3.3 Orme 1987 Juvenile Male—JZ01

The second juvenile to migrate from the Orme nest, JZ01, traveled to the San Francisco peaks, 10 mi north of Flagstaff on the first day, 12 June 1987. It arrived by 1500 hr and moved about locally for the next three hours before roosting on the east slope. The San Francisco peaks are wooded nearly to their summits; to the north the terrain slopes down into desert leading to the Grand Canyon. The marked changes in topography and vegetation north of these peaks appeared to have presented a physiographic barrier against northward continuation at that time of day. The San Francisco peaks are prominent on the horizon from as far as 50 mi to the south and they may have provided a reference for visual orientation. Total movement during this first day was 125 miles. The weather was clear with light winds from the southwest and light convective turbulence.

On the second day, 13 June, JZ01 migrated north across the Grand Canyon to the east side of the Kaibab Plateau then turned northeast and roosted on the southwest side of 11,522 foot Mt. Ellen, 25 mi south of Hanksville, Utah. The bird made a marked course change about mid-day and held that course to Mt. Ellen. This mountain is wooded and surrounded by lower, rolling and level terrain; like the San Francisco peaks it dominates the horizon and may have provided a visual cue for course guidance. During a 76-mi segment of its course, the bird had a groundspeed of 30.4 mph. Total distance traveled was approximately 207 mi with a net movement from roost to roost of 168 mi on an average course of 013 degrees from true north. The weather was clear with scattered clouds and calm winds.

During the morning of 14 June, JZ01 traveled north up the valley leading towards Price, Utah. At 1240 hr, we saw the bird from the ground from the Huntington, Utah airport. It was soaring and moving north at approximately 800 ft above ground level (AGL). Then the bird proceeded north and upon reaching the mountains north of Price, it roosted two and a half hours later some 20 mi away on the east side of the mountains east of Provo. Information on JZ01's movements on 15 June is incomplete because strong winds, rainshowers and thunderstorms prevented our flying in the afternoon. Two late morning readings indicated that the bird moved from its roost location in the Provo mountains, north along the mountains on the east side of the Salt Lake Valley for an undetermined distance.

On 16 June, JZ01 traveled north from the mountains east of Brigham City, Utah to a mountainous area 30 mi southwest of Bozeman, Montana. During the final readings at 1940 hr, the bird was still flying over the 10,000-foot mountains of the Lee Metcalf Wilderness Area. To the north of this area, the terrain slopes down into the Madison and Missouri River valleys leading north. We suspect that the bird roosted in this area because it is topographically similar to previous roost sites on the wooded slopes of tall mountains. On 17 June, JZ01 continued north to the mountains 20 mi north of Helena, Montana; there it turned northwest on a course that kept it over mountainous terrain. North of Helena, the relief changes to lower rolling foothills and prairies towards the north and east with the high mountains continuing 150 mi northwest to the Canadian border. It was obvious that the terrain directly influenced

the bird's flight path at this point, as it clearly departed from the northerly route that would have led it out over the prairies.

During mid-morning the next three days, 18-20 June, JZ01 remained in a triangular area roughly 40 mi on a side centered around the Scapegoat Wilderness Area 60 mi west of Great Falls, Montana. At this point the bird had ceased its migratory movement and was moving around locally in this region of high mountains. Afternoon cloud build-ups followed by rainshowers and thunderstorms over the mountains prevented tracking during the afternoons. After receiving a telemetry signal from an area about 5 mi south of the Benchmark airport on the morning of 20 June, we attempted unsuccessfully to locate the bird using a ground vehicle. Except for Gibson Reservoir, there were no large bodies of water or river systems that could provide aquatic foraging habitat for a bald eagle.

We were unable to locate JZ01 during a flight over this area on 21 June or during a 100-mi search northwest along the mountains to the Canadian border on 22 June. The bird may have resumed its migration through the mountains or it could have continued to move around locally where telemetry range was limited. We stopped tracking JZ01 after 22 June.

C5.3.4 East Verde 1987 Juvenile Female—JL20

Because all four radio-tagged juveniles migrated within eight days of one another, all three aerial tracking crews were in the northern states when JL20 departed on 17 June 1987. However, in the afternoon of 21 June, while returning from British Columbia, we intercepted JL20 33 mi northwest of Weiser, Idaho. Later that afternoon, 1529 hr, it had moved 22 mi to the northwest to a location 14 mi south of Baker, Oregon. At 1542 hr, we located the bird visually. The last signal of the day at 1650 hr indicated that it was on the eastern slope of the Elkhorn Mountains west of Baker, but low clouds prevented determination of an exact location. The next morning at 0934 hr, the eagle was located, near the site where it was estimated to have landed the previous evening. It appeared to be perched in steep, rocky cliffs in the northern recess of an amphitheater. We then landed in Baker. We returned to the location at 1121 hr but received no signal, then landed in LaGrande to wait for weather to clear. At 1438 hr, we detected a signal in the Blue Mountains, which may or may not have been JL20. Subsequent detections of the transmitter in this location over the next several days and conversations with local game biologists revealed that an elk in the area carried a transmitter with an identical frequency and pulse rate. JL20 had probably continued its northwestward migration undetected during this period.

Orme 1988 Juvenile Male (JZ24). We tagged JZ24, 8.5-weeks-old, on 21 April 1988. On 12 June, the day of its departure, JZ24 traveled 206 mi in a NNW direction, passing to the west of Prescott and crossing the western part of the Grand Canyon to roost 26 mi south of the Utah border at 1806 hr. The roosting site was in hilly, arid land near a dry tributary of Clayhole Wash, 87 mi SE of St. George, Utah.

On the following day by 1355, JZ24 traveled 149 mi from its roosting site and passed 5 mi east of the Fortification Range, 55 mi SE of Ely, Nevada. By 1730 it covered another 80 mi and crossed the Schell Creek Range northeast of Ely at an altitude above 10,000 ft On this leg it maintained a ground speed of 18 mph. By 1830 it had roosted in a grassy, tree-lined meadow at approximately 8,000 ft elevation, 35 mi NE of Ely.

On 14 June, the eagle departed its roosting site before 0930 hr and by 1042 it had flown a distance of 65 mi. It crossed the Ruby Mountain Range SE of Elko at an altitude above 9,000 ft, and at 1242 was flying 34 mi NW of Elko. On this leg it maintained a ground speed of 33 mph. It continued on its

NNW course, passing just east of the 10,437-ft peak of the Independence Mountains and then flew into southwestern Idaho. It roosted at 1859 hr just across the Oregon border and 7 mi east of Owyhee Reservoir. The roosting site was on a rocky hill overlooking a small river that passed through cultivated farmland. The eagle had flown a total distance of 280 mi that day.

The next morning, 15 June, the eagle departed before 0923 hr, but at 0950 it had moved only 6 mi from the roosting site. It appeared to be circling randomly without migratory intentions. JZ24 resumed its NNW route and at 1345 hr it passed 4 mi northeast of Brogan, Oregon. Because nearly four hours had elapsed during the 61-mi flight it would appear that the eagle flew in the vicinity of its roosting site for some time before continuing its migration. On the other hand, it may have interrupted its flight to feed or bathe. On the final leg of the day, it flew to the east of Baker and, at 1652 hr, roosted in the Wallowa Mountains on the west side of the Minam River Valley 7 mi south of the city of Minam, Oregon. It roosted in or near the trees surrounding a small clearing at an elevation of about 5,500 feet. That day it covered a distance of 147 mi, a considerably shorter distance than during the previous three days.

The next day, 16 June, the trackers flew over the eagle, still perched at 0940 hr. Ten minutes later it took flight and was immediately seen as it circled the clearing at low altitude. At 1235 hr, it was flying over the Blue Mountains and approached the Columbia Basin 15 mi SE of Walla Walla, Washington. Again its ground speed was low, only 13 mph in light and variable winds. At this point it made an abrupt departure from the NNW course it had maintained since leaving Arizona, and flew along the foothills in a northeasterly direction paralleling the Columbia Basin lowlands. At 1520 hr, it was 40 mi ENE of Walla Walla, again moving at a relatively slow ground speed of 10 mph. At 1730 hr, the eagle crossed the Snake River 22 mi west of Pullman. Sometime prior to 1830, it roosted on a cliff overlooking the Palouse River 7 mi NW of Colfax, Washington. That day, JZ24 traveled a distance of 114 mi with an average ground speed of approximately 13 mph.

By 0930 hr on 17 June, the eagle had departed and at 0951 was in flight 27 mi east of its roosting site and 11 mi north of Potlatch, Idaho. From this area it veered southeast and, at 1225 hr, flew over Dworschak Reservoir 8 mi north of Orofino, still traveling at a relatively slow ground speed of 16 mph despite westerly winds of about 15 mph. At 1345 hr, after departing from Orofino, a good signal was heard from the southeast in the direction of the Bitterroot Mountains. Intermittent signals were heard in an area 50 mi east of Orofino, and then no signals were heard during the next two hours. Towering cumulus clouds had developed over the mountains and it is possible that the eagle was on the ground in one of the many deep valleys on the west side of the Bitterroot Mountains. The roosting site of JZ24 was not determined on the night of 17 June.

On 18 June, from 12,000 ft east of Orofino in over 95 percent cloudcover, we heard JZ24's signal toward the east. At 1630 hr, the eagle had reached the Gallatin Mountains southwest of Bozeman, Montana, and at 1813 hr it roosted in rocky, sparsely-forested terrain 11 mi south of Gallatin Peak.

On what was to be the final day of JZ24's migration, 19 June, at 1005 hr it flew southeastward 18 mi from the previous night's roost. At 1218 hr, it perched just within the northwest boundary of Yellowstone National Park beside a stream flowing through a grassy meadow. At 1500 it flew just north of Yellowstone Lake, and at 1510 it landed near low earthen cliffs on the north side of Pelican Creek about 2 mi from the north shore of Yellowstone Lake. By 1740 hr, the eagle had moved about 0.5 mi north of the previous perched site.

From 19 June–30 June (12 days), JZ24 remained within a 3-mi radius of its initial landing site. The majority of time it was perched, but occasionally it flew locally for short periods. Visual observations were not possible because of the 2,000-ft minimum altitude restriction over the national park, and no ground observations were possible because the eagle was within a grizzly bear closure. On the final over-flight on the morning of 30 June, a large grizzly bear was seen walking toward Pelican Creek within 1 mi of JZ24's perch.

JZ24 returned to Arizona by 16 November. On that day, it was found perched at a wooded lake just east of McNary. As this was the first time we visited the area in fall 1988, the bird could have reached the area earlier.

C5.3.5 Cliff 1988 Juvenile Female (JI26)

Unlike the other telemetered juveniles which were tagged prior to fledging, we captured the Cliff juvenile female (JI26) on 15 June 1988 after it had been flying for over two weeks. JI26 had an eye infection (probably avian pox) when captured, although it had not shown signs of this ailment during banding when we noted the infection on her sibling. We also removed a fishing hook from the middle toe on the left foot. The hook had worked its way completely inside the toe, with only a smoothly-ground end exposed.

On the day of its departure, 3 July, JI26 traveled 80 mi northeastward and, at 1745 hr, it roosted in rolling, wooded terrain 28 mi SE of Flagstaff, Arizona. At 1222 hr on 4 July, the eagle was perched in a waterless canyon 31 mi SE of Grand Canyon Airport, 58 mi from the previous night's roosting site. At 1503 the eagle had flown to 9 mi east of Page, Arizona as it approached Powell Reservoir. It continued its northward flight across Powell Reservoir and a short time later crossed the rugged, desolate Kaiparowits Plateau (elevation 7,461 ft); it finally roosted for the night at 1745 hr on the north face of Mt. Hillers at approximately 9,000 feet. Mt. Hillers, 35 mi south of Hanksville, Utah, is forested at higher elevations with some grass cultivation along its lower flanks and with numerous rocky outcrops. The eagle selected a roost on one of the rock ledges amid forested terrain. On the final leg of this day, JI26 had flown 75 mi in 2.75 hr for a ground speed of 27 mph in light southerly winds. Because it appeared to be circling locally for approximately 0.5 hr before selecting its roosting site, it is probable that the point-to-point ground speed was faster than 30 mph. The total distance flown by JI26 that day was 203 mi.

On 5 July, the eagle departed its roosting site on Mt. Hillers at 0910 hr, and passed just to the west of the Hanksville airport. At 1138 hr, it passed 7 mi east of Price. By this time it had flown 117 mi in 2.47 hr and, aided by a 15-mph tailwind, had maintained a ground speed of 48 mph. It crossed the 9,300-ft Patmos Mountains north of Price and soon afterward crossed the Uinta Range at an altitude above 12,000 feet. At 1440 hr, it flew over the Flaming Gorge Reservoir 27 mi SW of Rock Springs, Wyoming. By this time the southerly wind had increased to 20–22 mph and during the 3.0-hr period since it had passed Price, Utah, it maintained a ground speed of 37 mph. The eagle continued flying in a NNE direction making excellent ground speed. At 1658 hr, it flew 27 mi south of Lander, Wyoming, at a ground speed of 40 mph. It continued flying on its NNE course for another 86 mi and roosted at 1845 hr in the badlands 19 mi east of Thermopolis, Wyoming. This was the longest daily distance covered during its migration.

The following day, 6 July, the eagle departed its roosting site at 0858 hr, and within 2 hr had crossed the Bighorn Mountains at an altitude above 12,000 feet. At 1300 hr, it passed 3 mi east of Sheridan. Instead of following the Bighorns, JI26 continued its flight in the same northeasterly direction as terrain

steadily dropped and flattened as it approached the Yellowstone River Valley. At 1418 hr, it flew 46 mi south of Forsyth, Montana; by this time it had flown 62 mi since leaving Sheridan, a ground speed of 23 mph. In the late afternoon a large thunderstorm developed in the vicinity of Miles City, directly in front of the eagle, and it made the first major deviation from the NNE course it had kept to since departing Arizona. It turned to an ESE direction and flew about 45 mi, roosting in a clearing in rolling, forested terrain 17 mi west of Broadus, Montana. There was a conspicuous rocky outcrop near the center of the clearing upon which the eagle appeared to roost. The total distance flown by JI26 that day was 196 miles.

The following morning, JI26 resumed its NNE course and was located visually at 1006 hr 1 mi west of Powderville on the Powder River. The eagle was flying at an altitude of approximately 4,800 ft MSL and about 1,800 ft above ground level. The eagle appeared to be flying effortlessly, wings outstretched without apparent movement as it soared along in a light, southerly tailwind. At 1240 hr, it flew over Fallon Creek, a tributary of the Yellowstone River 26 mi west of Baker, Montana. On this leg it flew 53 mi in 2.57 hr for a ground speed of 21 mph.

At 1500 hr, the eagle crossed into the western North Dakota badlands, and at 1550 it landed on the north side of the Little Missouri River 24 mi SW of Watford City, North Dakota. Here the river, carrying a good volume of water, runs through a 2-mi-wide vegetated floodplain with tree growth. The eagle appeared to be perched very close to the water. The variable pulse rate suggested that the eagle was either feeding or bathing. On this leg, it flew 96 mi in 3.16 hr for a ground speed of 30 mph. The eagle resumed flight at 1600 hr and proceeded along the course of the Little Missouri River for 34 mi to a point 1 mi west of its confluence with the SW arm of the 120-mi-long Lake Sakakawea. It roosted for the night at 1814 hr very near the river in dense tree growth. On this leg its ground speed was only 15 mph in light and variable winds. On 7 July the eagle flew a total distance of 218 mi.

On 8 July, JI26 departed its roosting site between 0900–1000 hr; it flew northeast across Lake Sakakawea and passed over New Town at 1237 hr. At 1524 hr, the eagle flew 6 mi north of Kenmore, a distance of 55 mi in 2.78 hr for a ground speed of 20 mph. At 1609 hr, it roosted 1 mi across the international boundary in Saskatchewan, 11 mi east of Westgate. The roosting site was in a tree-lined meandering tributary of the Souris River which flows through agricultural land, within 1 mi of farm buildings. On this final leg on 8 July, it maintained a ground speed of 22 mph over a distance of 106 mi.

On 9 July, JI26 flew a relatively short distance of 87 mi to the vicinity of Oak Lake, 37 mi SW of Brandon, Manitoba. At 1546 hr, it roosted on a small, rocky hill about 2 mi east of the lake. A final over-flight was made at 1638 hr and the eagle was seen still perched on the rocky outcrop.

On the morning of the following day, 10 July, the cloud ceiling had lowered to less than 500 feet. JI26 had moved westward and was now perched on the north shore of the lake 7 mi from the previous night's roosting site. Late that afternoon we monitored from the ground and learned that the eagle was flying near the lake 37 mi away. Because of bad weather and the late hour, the precise roosting location on the night of 10 July was not known.

At 1224 hr, on 11 July, we observed the eagle flying 35 mi east of Kamsack, Manitoba at an altitude of 2,700 ft MSL (1,300 ft AGL). The eagle was 128 mi from its roosting site of the night of July 9, and undoubtedly had flown a significant distance from Oak Lake before roosting July 10. From this point the eagle flew across the heavily forested, lake-studded Duck Mountains (elevations of 2,390 ft and

lower). At 1624 hr, it roosted on the west shore of Swan Lake 34 mi NE of Swan River, Manitoba. The eagle roosted on the densely-vegetated inlet delta on the west side of the lake.

On 12 and 13 July, JI26 remained on the inlet delta, moving less than 1 mi between observations. On 14 July it was still on Swan Lake, but had moved 8 mi to the east shore. Radio-telemetry tracking of the eagle was terminated on this day.

Swan Lake is a large, shallow lake 20 mi long and 8 mi wide that empties into Lake Winnepegosis. Cultivated farmland extends almost to the shoreline of the tree-fringed lake. The inlet delta on the west shore is wooded, swampy and difficult to reach from the ground. Only one shed-like building, probably a fishing camp, was seen in the area.

In past years the lake has provided "excellent" fishing conditions (described by one wildlife spokesman as "incredible"), and Canadian natives, by government treaty, are permitted to fish commercially using gill nets. Fish of commercial value are lake trout, pickerel, carp and white fish. The rough fish (burbot, moria, and suckers) are considered "trash" fish; they are routinely discarded and float ashore, where they become available to bald eagles as carrion. This area and adjoining parts of Manitoba, including Lake Winnepegosis and Cedar Lake, appear to be excellent bald eagle habitat.

C5.3.6 Ladders 1988 Juvenile Male—JP23

The migration of JP23, the telemetered juvenile male from Ladders nest, was like that of JZ24 in that it shifted unexpectedly. After several weeks of frequent soaring around the territory, it seemed to be departing on 3 July 1988, only to be turned back by a wall of thunderstorms just north of Camp Verde. Finally, on 7 July it left the natal area and soared north of the Colorado River to roost on the plateau northwest of Page, Arizona. The next day it turned northwest over the area of Bryce Canyon, Utah, and into eastern Nevada where it stopped for the night northwest of Sevier Lake. On 9 July it reached an area about 40 mi southwest of McDermit, Oregon, where it roosted on a canyon cliff. The next day it contended with estimated 15 mph direct headwinds, as it had the afternoon before, to pursue a course northwest to the Silver Lake valley in Oregon. It stopped just before noon as headwinds increased. For the rest of the day it moved locally around a drying marsh and cattle pasture where it may have found food. The next morning at 1010 hr, a variable telemetry pulse rate suggested it might be eating on the dry bed of Silver Lake. It began soaring at 1033 hr and slowly moved northward, and by about 1530 hr it had passed to the west of Lake Chinook near Madras, Oregon. It roosted in a steep canyon west of Madras on the edge of the steeply rising Cascade Mountains. The next morning (14 July), it crossed the Cascades just north of Mt. Jefferson and continued WNW, finally roosting near the ocean port of Tillamook, Oregon.

Just before noon the next day, JP23 surprised us by moving south along the coast rather than north as expected. It continued to follow the western slopes of the coastal mountains, usually a few miles inland, until it stopped to roost at Florence, Oregon by 1848 hr. The next day, 16 July, it maintained the same pattern of movement and stopped by 1706 to roost at the mouth of the Klamath River. At this time, monitoring of JP23's movements was terminated when the tracker returned to Arizona to intercept the apparent departure of another telemetered juvenile.

C5.3.7 Horseshoe 1988 Juvenile Male—JO35

We monitored the pre-migratory signals of the 1988 Horseshoe juvenile, JO35, from the tops of Humboldt and Ord mountains. The bird fledged on 2 June and was first detected soaring on 17 June.

It often traveled upstream a few kilometers to perch along the Verde River but returned the same day to the nest area. On 26 July, it soared north-northwest to the area east of Pine, Arizona, where there were large thunderstorms along the Mogollon Rim. By 1515 hr, it had backtracked to perch in the foothills of the Mazatzal range not far downstream of the mouth of the East Verde River. It was still in this area on 27 and 28 July (about 17 mi north of the nest) and on the morning of 29 July, but it returned to the nest area later that day. Still later that same day (1427–1537 hr) we detected it soaring from our position on top of Mt. Ord, but we lost its signal in the direction of the upper end of Horseshoe Reservoir. At this time, it was really departing on migration, but we believed it had only dropped below Chalk Mountain to perch in the area of the nest, as was typical.

We have deduced that the departure angle of JO35 lay between about 300–360° True North. If it had gone at all eastward, for instance 030°, we would have picked up its signal as it passed the northern end of the Mazatzals later in the afternoon. An aerial search of the region the following day was unsuccessful, although at 1515 hr we may have heard faint pulses from our position 10,500 ft above Camp Verde in the direction of 315° True North. Massive thunderstorms discouraged investigation.

C5.3.8 "76" Juvenile (1988) Female—JW30

The "76" juvenile female (JW30) first departed the "76" territory to the northeast during the afternoon of 18 July 1988. Thunderstorms along its route over the Mogollon Rim prevented tracking, but it was found 55 mi NNE (true) the next morning at 0936 hr perched in a canyon on a tributary of Chevelon Fork about 25 mi south of Winslow, Arizona. The bird returned to its natal territory by that afternoon, probably assisted by light surface winds from the northwest.

On 26 July, JW30 departed again to the northeast. We were unable to follow it because of afternoon thunderstorms but located it the next morning soaring west of Show Low. It continued migrating through the day amid scattered but impressive thunderstorms and roosted 18 mi south of Farmington, New Mexico. The bird's projected course was leading to the high terrain of the Colorado Rockies, but instead it followed the western edge of the mountains where huge thunderstorms still prevented close tracking. That night JW30 roosted at Telluride, Colorado in a narrow canyon rimmed by 13,000-ft peaks. It traveled 102 mi that day.

Shortly after 1000 hr the next morning (29 July), JW30 emerged from the mountains about 12 mi north of Telluride and continued on a course of approximately True North. While waiting at the Montrose, Colorado airport we sighted JW30 as it crossed over at 1138. It was slowly soaring north at an altitude of about 500 ft above ground. It had covered approximately 25 mi in 1.5 hr for a ground speed of 17 mph under calm conditions.

The next location was about 4 mi east of Blake, Colorado airport at 1318 hr. JW30 moved 20 mi northwest in 1.6 hr for a ground speed of 12.5 mph. Grand Mesa, an 11,000-ft plateau, was directly along JW30's course. We were unable to reestablish contact with the bird that day. Convective activity prevented us from flying over the mesa so we flew around its west side and landed at Grand Junction. Severe thunderstorms developed later in the evening. Winds of 50–60 mph damaged several aircraft at the Grand Junction Airport.

The following morning at 1010 hr, we picked up a flight signal in the mountains about 50 mi northeast of Grand Junction. It appeared that JW30 travelled about another 60 mi after the last known position

early the previous afternoon. We suspect it stopped along the Colorado River valley north of Grand Mesa when the thunderstorms developed in the late afternoon.

We landed at Meeker, Colorado, airport and waited about 1.5 hr before proceeding north. We could not relocate the signal north of Meeker even though the terrain was more favorable to long range reception. We finally received a signal to the north from a position about 15 mi northwest of Craig, Colorado, at 1601 hr. It was over one hour before we passed the signal and determined its position approximately 25 mi north of Rawlins, Wyoming at 1711 hr. We estimate that we received the signal at a range of 80 mi. The average groundspeed between the morning and afternoon fixes (170 mi) was 24 mph. At 1913 hr that evening, we located JW30 perched along the North Platte River downstream of Alcova Reservoir 25 mi southwest of Casper, Wyoming. We were surprised that JW30 flew over Pathfinder and Alcova reservoirs just to the south of its roost and instead stopped along a section of river. Using a general location for the previous night's roost, we estimated that JW30 migrated about 225 mi on 30 July.

At 0908 hr of 31 July, we received perched and variable signals from a position about 5 mi east of where the bird had been the previous evening. We later received a signal from the ground as the bird passed by east of the Casper, Wyoming, airport. We tracked the bird northeast and established its position 25 mi south of Gillette, Wyoming, at 1305 hr. We were unable to fly again that afternoon due to strong thunderstorms east of Gillette. The bird moved about 120 mi that day and roosted at an undetermined location northeast of Gillette.

The next morning we determined that JW30 was northeast of Gillette but we were unable to obtain a precise fix because of lingering storm clouds. At 1118 hr, we located the bird 20 mi southwest of Baker, Montana. The last fix for the day was at 1558 hr, 40 mi southwest of Dickinson, North Dakota. Once again, afternoon and evening thunderstorms prevented us from flying and determining a roost location. The bird moved about 170–190 mi on 1 August.

On the morning of 2 August we located JW30 about 50 mi south of Lemmon, South Dakota. The bird had turned 90° from its northeasterly course and had moved over 120 mi to the southeast. We were unable to get a precise fix because of low clouds and drizzle in the direction of the signal. We searched unsuccessfully for the bird for the next two days both in the area where we last had a signal and northeast to Bismarck, North Dakota in the event the bird had resumed its northeasterly heading. The weather to the north was clear, but there was a stationary front in the area where we last had received a signal and we were unable to do any effective high altitude searching. If the bird had resumed its northeasterly bearing we should have picked it up on the flight to Bismarck. We suspect that the bird continued on its southeasterly course and stopped in the stalled front somewhere in the vicinity of Oahe Reservoir, South Dakota. We discontinued searching for JW30 after 4 August.

C5.3.9 "76" Juvenile (1988) Female—JW31

JW30's sister, JW31, also migrated, but first traveled southeastward to the Salt arm of Roosevelt Reservoir on 30 July 1988. It soared all that day and the next around the mouth of Cherry Creek and the Pinal territory, roosting on the night of 31 July in Ash Creek canyon not far from the Salt River. The next morning, with a south wind, scattered cumulus clouds, and excellent (for soaring) thermal activity, it traveled northward to roost between Holbrook and Tuba City.

The next day (2 August), JW31 proceeded to about 26 mi ENE of Vernal, Utah where it spent the night. On 3 August it crossed the Uinta Mountains and journeyed to roost 24 mi ENE of Kemmerer, Wyoming.

From there, it travelled northwestward to Blackfoot Reservoir in southeastern Idaho, arriving on 5 August.

The next day, still at Blackfoot Reservoir, we searched for JW31 from the ground and sighted it perched on the east lake shore near another juvenile bald eagle. JW31 flew south along the shore approximately 100 m and landed next to a fish carcass laying on a mudflat about 10 m from the water. The eagle displaced three turkey vultures and two American crows which had congregated around the fish. JW31 stood about 2 m from the fish for 0.25 hr before moving over to eat. After 0.5 hr, it flew about 50 m north along the shoreline. A few minutes later it flew further north when a pickup truck approached. The fish was a carp about 0.6 m long with about 33 percent of the flesh consumed. Several other carp carcasses were scattered around at various distances from the shore but were dehydrated and appeared inedible.

We spoke about Blackfoot Reservoir with two biologists from the Idaho Department of Fish and Game and with several local fishermen. Carp are apparently abundant in the shallow north arm of the reservoir and are probably vulnerable to eagle predation during surface feeding in the morning and evening. Blackfoot Reservoir also contains a productive trout fishery which attracts considerable numbers of fishermen. There were boats on the reservoir, but not as many as on Arizona reservoirs; most of the fishermen we saw were fishing from the shore. We believe the fishermen discarded the carp carrion on the shore, rather than the carp becoming stranded in shallow water.

On 7 August, we conducted a carrion survey along 1 mi of the east shoreline. We counted eight dehydrated sucker (*Catostomas* sp.) carcasses ranging in size from 10–14 in. They were lying at various distances from the waterline and like the carp, were probably discarded by fishermen. Two days later we saw two dead cattle along another section of shoreline. The water level in the reservoir was low and there were wide mudflats in the northern half. It appeared that the lower water level provided shallow water foraging opportunities for bald eagles.

JW31 appeared to be resuming its migration when it moved off the reservoir to the north during the afternoon of 7 August. It encountered a rain-shower and stopped in the hills just beyond the north end of the reservoir. While searching for it we spotted an adult bald eagle perched on a rock outcrop. JW31 remained in the hills for the next 24 hr before returning to the reservoir. We discontinued ground tracking of JW31 after 9 August.

JW31 had returned to central Arizona by 4 October when we found it soaring in the vicinity of Salome Bay. In November and early December, it frequented the Redmond and Pinal territories.

C5.3.10 Bartlett 1989 Juvenile Male—JC50

Two 1989 Bartlett juveniles (JC50 and JC51) were telemetered, but JC51's transmitter failed on 5 July. JC50 departed during mid-day on 14 July and flew north to within one mile of the Ladder's bald eagle nest at km 162 on the Verde River. At this point, the bird reversed its course and flew south to roost in the vicinity of Table Mountain around km 107.

The next morning at 1100 hr, we found JC50 soaring about 2 mi south of Table Mountain, but by mid-afternoon it had passed San Francisco Peak north of Flagstaff. It roosted in the canyon of the Little Colorado River about 15 mi from the confluence. At 1220 the next day (16 July) JC50 was soaring in

Utah 30 mi north of Page, Arizona, and by 1742 it had reached the high mountains north of Price where it roosted in conifers and aspens, 277 mi from where it had started that morning.

The next day at 1113, we saw the eagle soaring about 500 ft above the ground about 12 mi southwest of Duchesne. At 1223 we found it perched along a river 22 mi north of Duchesne in the vicinity of a weir dam. The bird remained along a 5-mi stretch of this river throughout the afternoon foraging but moved about 20 mi NNW to the crest of the Uinta Mountains by 1738 where it roosted above timberline over 12,000 ft above sea level.

The next morning (18 July), we found JC50 traveling 25 mi south of Fort Bridger, Wyoming and at 1346 we visually observed the bird 26 mi west of Kemmerer, Wyoming soaring about 1000-ft above ground level. By 1830, it had settled in to roost on a west-facing slope overlooking a stream about 8 mi southwest of Bancroft, Idaho. The next morning at 1057, we saw it perched on a boulder in the river channel a few miles upstream of the roost, probably eating or bathing, or both. By 1103 it was soaring in the same area, and by 1445 it was perched in the trees along the Snake River a few miles upstream of Blackfoot, Idaho.

It remained there for two days, but at mid-day on 21 July it began soaring off to the north among numerous thunderstorms. By 1654, the bird had apparently crossed into Montana in the vicinity of Monida Pass (north of Dubois, Idaho), but we were unable to continue tracking because of big thunderstorms.

The next day at 1248, we found JC50 soaring near the southeast corner of Red Rock Reservoir in Montana and the bird was still in the vicinity at 1530. Storms prevented further airplane tracking that day and the next, and a trip to Henry's Lake and the Red Rock Reservoir area by road vehicle on 23 July was unsuccessful in relocating the bird. On 24 July at 1025, we located JC50 soaring about 14 mi north of Lima Reservoir and at 1308 we saw it soaring along a creek about 24 mi southeast of Dillon, Montana. For the next four days, it remained in a 7-mi-diameter circle about 18 mi southeast of Dillon. The habitat seemed typical for golden eagles, being hilly, open ranchland about 6000 ft above sea level with scattered rocky outcroppings and a small creek. Our last fix was at 0901 hr on 28 July.

C5.4 NARRATIVES OF THE MOVEMENTS OF RADIO-TAGGED NON-BREEDERS IN CENTRAL ARIZONA

Eight of the radio-tagged juvenile bald eagles returned to Arizona, some by late September, and we monitored their movements with radio telemetry. We augmented the sample of birds by telemetering an additional eight subadults and near-adults. Each individual in this collection of non-breeders moved throughout the central part of the state and elsewhere, utilizing a variety of habitats, including rivers, creeks, reservoirs and natural lakes (see Figure A4.2-1). In the Verde River drainage, habitats included the East Verde River, West Clear Creek, Horseshoe Reservoir, and the Lower Verde River. On the Salt River drainage, they visited Saguaro Reservoir, Canyon Reservoir, Apache Reservoir, Roosevelt Reservoir, Salome Bay, the upper Salt River, Tonto Creek, Pinal Creek, Canyon Creek, Cibecue Creek, and Carrizo Creek. San Carlos Reservoir and Eagle Creek were visited on the Gila River drainage. In addition, one juvenile used the highland lakes near Flagstaff, and another was sighted on Imperial Reservoir and Martinez Reservoir on the California border. The eagles appeared to remain in the southwest all winter, but none was apparent in central Arizona after late May. At least one of the 1987

nestlings (JM03) migrated to the same location in summer 1988 (Yellowstone Lake, Wyoming) as he did on his first migration. A discussion of the movements and habitat selection of radio-tagged juvenile bald eagles is provided in Section A4. Below are narratives of the movement of each of the juveniles in the sample.

C5.4.1 Fort McDowell Juvenile Male (JM03)

We found the Fort McDowell juvenile (JM03) back in Arizona on 20 October 1987 at Tremaine Lake, southeast of Mormon Lake, and it remained around the highland lakes until at least 3 November. We detected it soaring near Horseshoe Reservoir on 3 January, and the next day it was near Needle Rock on the Verde River downstream of Bartlett Reservoir. From then through 7 February, it frequented the Salt and Verde rivers between Fort McDowell and Blue Point, including Saguaro Reservoir. A few days later, we found it at Canyon Reservoir and then at Apache Reservoir. On 4 March, JM03 was on Pinal Creek about 0.25 mi from the active nest containing one young. From then through 4 May, we found it in other parts of the Pinal territory and on the north shore of Roosevelt Reservoir where it frequented Campaign and Salome bays. We twice found it on Tonto Creek in or near the "76" territory during this period. On 7 May, JM03 was on the East Verde River between the two ranches. After that date, its signal was no longer detectable in central Arizona. However, we relocated the bird at Yellowstone Lake, Wyoming on 21 June 1988 where it had summered the year previously.

C5.4.2 Orme Juvenile Female (JZ02)

The Orme juvenile female's (JZ02) return to Arizona was first documented on 26 September 1987 when we found it perched at Horseshoe Reservoir. The next detection was on 15 December 1987 at the Imperial Wildlife Refuge north of Yuma following notification by D. Vongonten that she had sighted a radio-tagged juvenile there a week before. A number of other bald eagles were sighted in the area with JZ02. We collected prey remains on shore and below perches at Ferguson Lake and other parts of the Imperial Wildlife Refuge; prey items included six unidentified Centrarchidae, three black bass spp., two crappie spp., one carp, one largemouth bass, one Tilapia sp., one gadwall, two grebe spp., and one unidentified rodent.

On 4 March 1988, JZ02 was in its natal territory, not far from the nest and it roosted just across the river that night. From then until the end of May, it moved unpredictably throughout the Salt and Verde systems. We found it near the Tonto Creek mouth (14 March), on the Salt River upstream of Pinal (16 March), upper Canyon Creek (17 March), very near the Fort McDowell nest (25 March), 5 mi west Pine (2 April), on the East Verde River (3 April), near Tonto Creek mouth (19 April and 3 May), East Verde River (4 May), Tonto Creek (19 May), and Meddler Point in the Pinal territory on 26 May. It apparently left central Arizona after that date.

A year later, we again detected the presence of JZ02 in central Arizona when on 4 October 1988 we found JZ02 at Talkalai Reservoir just north of San Carlos. On 10 December 1988, JZ02 was soaring just east of the Ladders nesting territory and on 1 January 1989 we found it flying in the vicinity of the upper Salt River. The next day it perched on the Black River, 14 mi WSW of the town of White River. On 31 January, it was in the hills one mile northwest of Gleason Flat where we again found it perched on 12 February. It roosted in the Goldfield Mountains near Saguaro Reservoir on the night of 27 February. On 10 March we found it on the Salt River just downstream of Carrizo Creek where a dozen or so eagles are sometimes seen during helicopter surveys at this time of year (see Section A4). On 13 March JZ02 was on Canyon Reservoir about 0.5 mi downstream of the Horse Mesa dam, very near the bald eagle nest; its transmitter pulse was erratic, possibly indicating a failing battery. However, on 25

March we found JZ02 in the company of its sibling (born in 1987) on Carrizo Creek about two airline miles upstream of its confluence with the Salt River.

Among the juveniles whose movements we studied, we maintained contact with JZ02 for the greatest amount of time. We tracked it north into British Columbia in June of 1987 and we subsequently monitored its movements in Arizona from September 1987 through May 1988 when it may have again migrated from central Arizona (see JM03). We redetected its presence in central Arizona in January 1989 and last located it near the end of March 1989. At this time its transmitter had been functioning for about 23 months.

C5.4.3 East Verde Juvenile Female (JL20)

The East Verde juvenile (JL20), who eluded us near LaGrande, Oregon, during its northward migration in June 1987, had returned to central Arizona by 27 October. We found it that day in the area between Bartlett Dam and the Bartlett nest. Unlike the other telemetered juveniles, it carried a transmitter with a battery life of only 5-6 months, and when we detected it, its pulse characteristics indicated impending battery failure. We never again heard the transmitter.

C5.4.4 Orme Juvenile Male (JZ24)

The juvenile male, JZ24, tagged at the Orme nest in 1988 and which migrated to Yellowstone Lake had returned by 16 November 1988 when we found it just east of McNary, Arizona, perched along a creek near the highway. On 2 January 1989 it was perched on Eagle Creek about 4 mi west of the Morenci, and on 14 January we found it flying west of Safford. On 3 February we found it was perched on Eagle Creek about 8 mi northwest of Morenci, and again on 27 February about 10 mi northwest of Morenci. It was still in the area on 15 March when we detected it soaring about 4 mi west of the Clifton Airport. On 25 March it was on Carrizo Creek, a tributary of the upper Salt River, with the Orme juvenile JZ02 (see above).

C5.4.5 Ladders 1988 Juvenile Male (JP23)

The 1988 Ladders juvenile, JP23, which migrated to the northern coast of Oregon and then down to the mouth of the Klamath River in California, had returned to Arizona by 27 September 1988, when we found it just downstream of its natal territory on the Verde River. We failed to again locate JP23 in our air surveys in central Arizona until 2 December 1989, when we found it perched on a mountain overlooking the lower portion of the East Verde River from the north. On 27 February, JP23 perched at Horseshoe Reservoir. It was again near the Ladders territory on 9 March, when we found it flying along West Clear Creek a few miles from its confluence with the Verde River. Four days later, it was still there perched 1.5 mi from the mouth of West Clear Creek and was again in the area on 25 March. On 10 April, it soared in the vicinity of Tonto Basin.

C5.4.6 "76" Juvenile Female (JW30)

The 1988 telemetered juvenile, JW30 from the "76" nest which we followed to South Dakota in early August, had returned to Arizona by 2 January 1989. On that day it perched in conifers on the snow covered hills about 8 mi east of the town of White River. On 27 February, we detected it soaring on the southern edge of the White Mountains.

C5.4.7 "76" Juvenile Female (JW31)

The 1988 juvenile, JW31, from the "76" nest was soaring in the vicinity of Salome Bay on the Salt arm of Roosevelt Reservoir on 4 October 1988. We had previously tracked this bird to Blackfoot Reservoir

in Idaho where we had last detected it on 9 August 1988. On 14 November, it soared in the vicinity of Roosevelt Reservoir and two days later was perched at Campaign Bay on the Salt arm of Roosevelt Reservoir. On 10 December, it perched near the mouth of Pinal Creek near the nest of the Pinal pair. On 2 January 1989 it was again on Campaign Bay on Roosevelt Reservoir. On 14 January, it perched on a mountain overlooking Canyon Creek about one mile east of the Salt River. On 31 January, it was one mile downstream of Gleason Flat on the Salt River and, on 12 February, it soared around the mouth of Cherry Creek in the Redmond bald eagle nesting territory.

It is interesting that during the last few days of July, before JW31 departed for Idaho, it frequented the Salt River from the eastern end of Roosevelt Reservoir to the Canyon Creek/Ash Creek area. It seems an extraordinary coincidence that we detected this bird in this area (and only this area) in the fall and winter.

Plate C19. Greg Beatty with "76" nestling JW31, May 1988 (photo by Daniel Driscoll).

C5.4.8 Bartlett 1989 Juvenile Male (JC50)

The Bartlett juvenile, JC50, which migrated to near Dillon, Montana, in July 1989, had returned to Arizona by 15 November 1989 when we found it soaring along the San Carlos River about 3 mi south of San Carlos. On 18 November, JC50 was perched on San Carlos Reservoir near Coolidge Dam. On 30 December, it perched in the inflow area of San Carlos Reservoir and was there again on 9 and 13 January 1990. This area frequented by JC50 was characterized by extensive shallows reminiscent of Campaign Bay at Roosevelt Reservoir and contained numerous waterfowl and several other bald eagles on 13 January. These shallows, which are good bald eagle habitat, apparently develop when San Carlos Reservoir is lower than normal, in contrast to Campaign Bay at Roosevelt Reservoir which disappears at low reservoir elevations.

C5.4.9 San Carlos Subadult Female (SF01)

A rafting group on the Salt River observed an injured eagle on 21 June 1987 at the Canyon Creek confluence. Upon reaching a phone on 22 June they reported the incident. We flew to the area and found the bird perched on a boulder next to the river. Fluids were administered upon capture and during transport to the Phoenix Zoo. X-rays revealed a broken radius in the right wing that had partially calcified, indicating the break occurred 10–14 days earlier (Dr. Hood pers. comm.).

This subadult female bald eagle (SF01), most likely 3.5 years old (McCollough and Krohn 1986), displayed white flecking on a predominantly brown head, a white breast mottled with brown, and an inverted white triangle on her back. Rehabilitated, banded, and telemetered at the Phoenix Zoo, SF01 was released at San Carlos Reservoir on 9 October 1987 after a ceremony by the San Carlos Apaches.

SF01 remained at San Carlos reservoir through the end of November. We found her on 7 December on Pinto Creek near Roosevelt Reservoir, and on 2 and 20 January she was still in the general area.

She was west of Schoolhouse Point on Roosevelt Reservoir on 27 January, roosting that night near the cliff dwellings at Tonto National Monument. On the night of 13 February she roosted near the snow-covered forested summit of Breadman Mountain in the Salome Wilderness. During 4–17 March, she continued to frequent the Salt arm of Roosevelt Reservoir and Meddler Point and soared on the slopes of the Sierra Anchas. Also during this period we found her soaring over the Salt River upstream of Cherry Creek, and again 13 km southwest of Seneca. On 25 March, she perched at Canyon Creek about 10 km upstream of its mouth.

SF01 apparently drowned in a cylindrical stock tank around 1 April. This style of stock tank has a wire grid on top and is discussed in Section C3.

C5.4.10 Salome Bay Near-Adult Male (NM01)

We captured a near-adult male (NM01) bald eagle in Salome Bay of Roosevelt Reservoir on 2 March 1988, using a noosed fish. Most likely a four-year-old (McCollough and Krohn 1986), NM01 retained much brown flecking in his white head and a sepia band on the distal margin of the tail, with stripes running up the retrices. The bird also displayed a large white patch on its back.

On 11 March, NM01 was flying over Sycamore Creek southeast of the Fort McDowell territory, and on 14 and 25 March he perched near the mouth of Tonto Creek at Roosevelt Reservoir. On 2 April, we found him perched on a mountain west of Canyon Creek about 3 mi upstream of its confluence with the Salt River. We found him perched along the East Verde River on 4 and 7 May, and he apparently departed the central Arizona study area soon after. On 14 November, we heard his signal in the direction of Picacho Reservoir but the exact location was unverified. We also received a signal on 16 November but could not locate its source. On 10 December, we found him perched below Morman Flat Dam upstream of Saguaro Reservoir.

NM01's signal was again detected in Arizona on 14 November 1988 toward Picacho Reservoir from the Salt/Verde confluence. We heard it again two days later to the south of our position 20 mi WSW of Show Low. On 10 December, he perched on upper Saguaro Reservoir when the reservoir was very low. On 14 January 1989, NM01 was on a mountain between Cherry Creek and Canyon Creek about 10 mi from the Salt River. On 4 February, he perched on a small lake about 22 mi north of San Carlos, and on 12 February, he perched on the north shore of the Salt arm of Roosevelt Reservoir just west of Campaign Bay ("Subadult Flats"). On 18 February, he was still on Roosevelt Reservoir on Windy Hill. On 10 April, we received a faint signal toward the northeast from the Mule Hoof Bend area on the Salt River but were unable to locate the bird.

C5.4.11 Salome Bay Near-Adult Female (NF01)

We captured a near adult female (NF01) bald eagle in Salome Bay of Roosevelt Reservoir on 4 March, using a radio-controlled powersnare. The four-year-old NF01 had been banded as a nestling in 1984 at the East Verde breeding area by T. Grubb (Grubb 1986a). The eagle displayed brown flecking in the head, a brown eye-stripe, and a brown band on the distal margin of the tail, typical of four-year-old bald eagles (McCollough and Krohn 1986). The brown eye-stripes converged into a vertical stripe down the nape.

On 11 March, we found NF01 at the confluence Carrizo Creek and the upper Salt River (see Figure A4.2-1). As described in the introduction to this section, there were at least a dozen bald eagles at this location a few days later (T. Gatz pers. comm.). Obviously some event involving prey was taking place, although we were unable to conduct an investigation at the time.

NF01 flew along the southern slope of the Sierra Anchas on 14 March and just east of Weaver's Needle in the Superstition Mountains on 17 March. She returned to the Salt River at Highway 60 on 25 March and we found her on the East Verde River on 2 April. This bird had apparently died in April or early May in the area just downstream of Gleason Flat on the Salt River (see Section C3).

C5.4.12 Near-adult Female (NF02)

We captured NF02 near Beasley Flat on 24 January 1989. We relocated NF02 five times during our air surveys beginning on 31 January 1989, when she perched on a mountain overlooking the East Verde River from the north. On 12 February, she soared in the vicinity of Rye Creek, a tributary of Tonto Creek. On 27 February, she was in the mountains to the north of the East Verde River, and on 9 March, she perched on lower East Verde River. On 13 March, she perched on a plateau north of the East Verde River, and on 15 March she perched about 10 mi southeast of the town of White River.

C5.4.13 Subadult Male (SM01)

We also caught SM01 near Beasley Flat on 23 January 1989. SM01 was on West Clear Creek about 5 mi east of Camp Verde on 31 January 1989 and was perched on West Clear Creek near the Ladder's territory on 12 February. On 18 February he was on a mountain top overlooking the East Verde River from the north. On 27 February he soared southeast of Payson and soared north of West Clear Creek on 13 March. On 25 March, he was flying near the mouth of West Clear Creek.

C5.4.14 Subadult Male (SM02)

We caught SMO2 at Beasley Flat on 26 January 1989. On 31 January 1989, SM02 perched on West Clear Creek about 12 east of Camp Verde. He soared near West Clear Creek on 12 February and again on 18 February. On 9 March he soared on the plateau between Fossil Creek and West Clear Creek. He

perched on 13 March in the mountains east of Childs (between the Ladders and East Verde territories) on the Verde River.

The following winter, on 30 December 1989, SM02 perched on a frozen lake 20.4 mi NNW of Payson. On 8 February 1990 he was just north of Pine Mountain between the Ladders and East Verde nests.

C5.4.15 Subadult Male (SM03)

SM03 was captured on 1 February 1989 at Beasley Flat. We found SM03 on 12 February 1989 perched on the Verde River near the mouth of West Clear Creek. A year later, on 9 January 1990, he perched at Beasley Flat where he had been originally captured and radio-tagged.

C5.4.16 Subadult Male (SM04)

Also tagged at Beasley Flat on 2 February 1989, we subsequently found SM04 only twice. It soared over Rye Creek, a tributary of Tonto Creek, on 12 February 1989 and on 13 March it soared near Young, Arizona.

C5.5 SIGHTINGS AND RECOVERIES OF BANDED JUVENILES

From 1987–1990, we banded 62 nestling bald eagles in Arizona with silver (aluminum) USFWS bands on the right tarsus and color anodized Visual Identification (VID) bands on the left. We banded nestling eagles with single symbol blue VID bands in 1987, green in 1988, and purple in 1989. Beginning in 1990, eaglets were banded with blue VID bands containing two symbols, one printed above the other. These double symbol blue VID bands will continue to be used in the future. Nine nestling bald eagles were also banded on the Rio Yaqui, Sonora, Mexico, as part of a study being conducted by Bryan Brown in cooperation with the Mexican government, USFWS, SRP, and Reclamation. Young eagles in Mexico were banded with USFWS bands on their right tarsus, and gold VID bands on their left.

Since we began banding nestling bald eagles in Arizona in 1987, seven Arizona juveniles have been identified by their color VID bands (Table C5.5-1). We sighted three non-telemetered juveniles banded in 1987 during our 1987–88 field season. Of these two were young from Horseshoe: JO15 (VID symbol G) was observed on Saguaro Reservoir on 20 October 1987, and its sibling, JO14 (VID symbol H) was on Roosevelt Reservoir at the confluence of Tonto Creek on 24 November 1987. We saw one of the Horse Mesa juveniles, J505 (VID symbol V), near the diversion dam (now a fish barrier) on the Salt River at Roosevelt Reservoir on 24 February 1988.

The sighting of a juvenile bald eagle with a blue band on its left tarsus was reported by California Department of Fish and Game personnel on 31 January 1988 at Point Mugu Naval Air Base, on the coast 30 mi west of Los Angeles, California. The 1987 cohort of Arizona juvenile bald eagles is so banded.

From 25–31 May 1989, a subadult bald eagle with a blue VID band on its left tarsus (a 1987 nestling) was observed on Roosevelt Reservoir, at Campaign Bay. A 1989 eaglet (purple VID band on left tarsus) was seen at the Ladders breeding area on 10 April 1990. On 17 April 1990, JO14, a 1987 Horseshoe nestling, was found dead on the Salt River, just below the Verde River confluence. The three year old eagle was found with feet, tail, and wings missing, likely a victim of shooting.

Table C5.5-1. Sightings of southwest bald eagles banded as nestlings from 1987–1989.

Code	Breeding Area	Sex	Color	Band Year	Symbol	Tarsus	Date	Location
Arizona Juveniles								
JO15	Horseshoe	F	Blue	1987	G	L	20 Oct. 1987	Saguaro Lake.
JO14	Horseshoe	M	Blue	1987	H	R	24 Nov. 1987	Roosevelt Lake, at confluence of Tonto Creek.
Immature Bald Eagle		?	Blue	1987	?	L	31 Jan. 1988	Point Mugu Naval Air Base, California.
J505	Horse Mesa	M	Blue	1987	V	L	24 Feb. 1988	Roosevelt Lake, Near Diversion Dam.
Subadult Bald Eagle		?	Blue	1987	?	L	25-31 May 1989	Roosevelt Lake, Campaign Bay.
Immature Bald Eagle		?	Purple	1989	?	L	10 April 1990	Ladders breeding area.
J014	Horseshoe	M	Blue	1987	H	R	17 April 1990	Found dead on Salt River near Verde River confluence.
Mexico Juveniles								
J-05 or J-06	Rio Sahuaripa	F	Gold	1989	?	L	7-15 Sept. 1989	USFWS band 629-3264? read on juvenile which spent 8 days at Tongue Point, Clatsop County, Oregon.

A juvenile bald eagle with a gold VID band on its left tarsus and USFWS band 629-3264? on its right tarsus was observed during 7–15 September 1989 at Tongue Point, Clatsop County, Oregon (D. Bystrack, Bird Banding Lab, pers. comm.). The eagle was either J-05 or J-06, which we banded in 1989 at the Rio Sahuaripa nest on the Rio Yaqui, Sonora, Mexico.

C5.6 WINTERING EAGLES

In addition to the native population, Arizona receives an inflow of migrant eagles from northern states and Canada in winter. Early surveys for wintering eagles consisted of weekly counts in various regions of the state from October to April during the winters of 1972-1977. Only 16 bald eagles were counted during the winter of 1972-1973; however, the number of eagles tallied grew as survey locations and

observers increased. During the 1973-1974 winter 156 bald eagles were counted, 214 in 1974-1975, 214 in 1975-1976, and 81 in 1976-1977 (Todd 1978). In a separate assessment, Stumph and Creighton (1977) estimated the number of wintering bald eagles in Arizona at 10-20 in 1975, and about 50 in 1976 and 1977.

To eliminate overestimation of the wintering population by counting individual eagles two or more times, the survey methods changed in 1977 to flights that censused the state over a few days. On 3 and 4 March 1977, 46 bald eagles were counted, 26 adults and 20 subadults (Todd 1978). This number increased to 100 in 1978, consisting of 54 adults and 46 subadults (Ohmart and Sell 1980). Survey methods changed again in 1979, to a two week period in January, in accordance with the National Wildlife Federation Mid-Winter Bald Eagle Survey. In 1979, 58 bald eagles were counted, of which 42 were adults and 16 subadults. In 1980, 128 wintering bald eagles were counted in Arizona, composed of 80 adults and 48 subadults. The number of wintering eagles appeared to increase again in 1981, with 165 eagles sighted, of which 103 were adults, 60 subadults, and 2 with no recorded age (Todd 1981). In 1982, 210 bald eagles were sighted, consisting of 135 adults, 72 subadults, and 3 eagles of unknown age. In 1983, 158 eagles were counted, of which 105 were adults and 53 were subadults. In 1984, 225 eagles were recorded, 159 adults, 63 subadults, and 3 of unknown age (Todd 1985). In 1985, 118 wintering eagles were counted, of which 78 were adults and 40 subadults (National Wildlife Federation 1985). Because the survey methods for the National Wildlife Federation winter bald eagle surveys (which began in 1979) changed significantly in 1986, data for 1986 and 1987 are not equivalent to those of previous years (National Wildlife Federation 1988a). In the nine years (1977-1985) that wintering eagles were recorded by age, 65 percent were adults and 35 percent were subadults.

The actual number of wintering eagles is likely much greater than the surveys indicate. The number of eagles wintering in Arizona in any one year is undoubtedly influenced by the severity of winter weather in northern states and Canada, since food becomes scarce when lakes and streams freeze and heavy snow covers carrion. Likewise, the severity of winter weather in northern Arizona would influence the distribution of these eagles within the state. In addition, the number of eagles counted is influenced by the areas surveyed and weather conditions on survey dates. Finally, it would be impossible to differentiate eagles of Arizona origin from those wintering in Arizona from other populations.

It was once thought that wintering bald eagles selected different habitats than those occupied by Arizona breeding pairs (Grubb and Kennedy 1982). Although we did not intensively study the wintering population, we did capture and radio-tag non-native wintering bald eagles (identified on the basis of measurements) in the Ladders breeding area (near Camp Verde). These traveled to Fossil Creek, the East Verde River, Tonto Creek, Cherry Creek, and the White River (see Section C5.4). We had the impression from plumage characteristics that some of the wintering bald eagles we observed on Roosevelt Reservoir during 1987-1989 may have been from northern areas, but we are far from certain of this assessment. See sections C5 and A4 for details on the movements of wintering bald eagles telemetered from 1987–1989.

C6 SURVIVORSHIP ESTIMATES THROUGH BANDING AND TELEMETRY

One way of acquiring information on mortality is through banding nestlings. However, the conventional aluminum USFWS bands are extremely difficult to read in the field, although one is occasionally read. The eight-digit number identifying an individual bald eagle, for example 629-26473, is hard to see through a spotting scope at 100-200 m, especially if the band is covered with "grunge" (accumulation of dirt, blood, prey oils, *etc.*). Most USFWS bands are only read when the eagle is in hand, either found dead or captured.

However, a color-anodized Visual Identification (VID) band (placed on the leg opposite the USFWS band), with one or two large symbols on it, is more visible and far easier to read. Banding nestlings with VID bands allows for future identification of an eagle throughout its life. When birds banded as nestlings reach breeding age and acquire a territory, reading the band supplies information on survivorship, age structure of the breeding population, and movement from the eagle's natal area. As an adult, the banded eagle allows us to monitor replacement and infer mortality within the breeding pair. VID bands, placed on Arizona and Mexico nestlings since 1987 have been sighted in California, Oregon, Wyoming, and Arizona.

To gain perspective on mortality of non-breeding bald eagles in Arizona (post-fledging juveniles, subadults (ca. 1-3 years old), and near-adults (ca. 4 years old), which range over vast areas, telemetry is also a valuable tool. By radio-tagging nestlings and other nonbreeding eagles, we were able to monitor their movements, habitat use, and survivorship while they remain in Arizona. Transmitter battery life can limit the use of telemetry for mortality studies. Bald eagles can safely carry a 65–70-gram transmitter, which has a projected three-year battery life. However, in actual field use, the transmitter may last from two weeks to 2.5 years.

C6.1 BANDING AND TELEMETRY OF NESTLINGS

The first research on Arizona bald eagles began in 1972, with Duane Rubink's (USFWS) nest surveys; however, young were recorded fledging as early as 1932 (see Section C2). A total of 232 known eaglets have fledged from Arizona bald eagle nests, of which 108 (47%) have been banded. Prior to 1977, when the first banding efforts began, 38 eaglets were known to have fledged from Arizona nests. From 1977–1982, under Robert Ohmart's (ASU) studies, 56 young fledged, of which 29 (52%) were banded and six were radio-tagged. During Teryl Grubb's (USFS) research from 1983–1985, 50 eaglets fledged, 17 (34%) of which were banded, although none was telemetered.

No research was conducted in the 1986 breeding season, except for nest monitoring by the ABENWP and nest climbs for prey remains collection following fledging. Over the four years of BioSystems' study, 1987–1990, 87 young hatched in Arizona bald eagle nests, of which 77 survived to banding age (6 weeks), and 71 fledged. We banded 62 (81%) of the 77 eaglets surviving to six weeks of age. Three of these young died in the nest, resulting in 59 (83%) of the 71 fledglings being banded. In addition, we radio-tagged 15 Arizona juveniles from 1987–1989.

Plate C20. Nestling bald eagle (seven weeks old) at Ive's Wash breeding area, showing green VID band on left tarsus, April 1988 (photo by D. Driscoll).

C6.1.1 Robert Ohmart's Research, 1977–1982.

In Robert Ohmart's studies from 1977–1982, six nestlings were radio-tagged (two each year) from 1977–1979. The juveniles were fitted with Telonics backpack transmitters on the 172 MHz frequency. The telemetry unit was housed in a nickel-plated stainless steel canister and weighed 185 grams in 1977, with an expected battery life of 14 months. The package was reduced to 168 grams by 1978 (Hildebrandt 1981). In 1979, Telonics transmitters with an expected battery life of 15 months, weighing 185 grams were used (Sell 1982). The transmitter was attached by two loops of wire enclosed in surgical tubing which were crimped around each wing. The two loops were then joined at the breast with cotton string (Hildebrandt 1981). It was assumed that the cotton string would decompose after several years, allowing the package to fall off (Hildebrandt 1981), but one of the nestlings radio-tagged in 1979 apparently carried its transmitter for over 7.5 years, before the unit fell off in late December 1986 or early January 1987. The crimped wire loops may have retained the unit on the eagle even after the separation of the string.

As mentioned previously, 29 eaglets were banded from 1977–1982 (Table C6.1-1). In addition to USFWS bands, the eaglets were also color marked using several methods. In 1977, six nestlings were marked with red Herculite-80 vinyl patagial wing markers and leg-band tabs coded T01–T06 in white (Hildebrandt 1981). The leg-band tabs were placed between the USFWS band ends before riveting. From 1978–1982, the eaglets were color banded on one or both tarsi using poly-vinyl chloride acrylic plastic leg bands, which were overlapped and glued using quick drying epoxy cement (Hildebrandt 1981).

Table C6.1-1. Juvenile bald eagles banded in Arizona during the studies of Dr. Robert Ohmart, ASU, 1977-1982.

Breeding Area	Bird Number	Aluminum* USFWS Band Leg/Number	Plastic Color Band Leg Color	Transmitter	Current Status
1977*					
Fort McDowell	T01	R/629-04451	R Red Tab	—	Unknown
Fort McDowell	T02	R/629-04452	R Red Tab	Yes	Died 1977
Bartlett	T03	R/629-04453	R Red Tab	—	Cibecue male died 1989
Bartlett	T04	R/629-04454	R Red Tab	Yes	Died 1980
East Verde	T05	R/629-04455	R Red Tab	—	Unknown
East Verde	T06	R/629-04456	R Red Tab	—	Unknown
1978					
Fort McDowell	—	R/629-04457	L Red	—	Unknown
Fort McDowell	—	R/629-04458	R Red L Red	—	Unknown
Cibecue	—	L/629-04459	R Red R White	—	Unknown
Bartlett	—	R/629-04460	R Red L White	Yes	Died 1978
Cibecue	—	L/629-04461	R Red R White	Yes	Unknown
1979					
Bartlett	—	R/629-04462	R Black L White	Yes	Sighted 1980**
Fort McDowell	—	R/629-04463	R Black L Red	—	Blue Point Male 1983-1990
Fort McDowell	—	R/629-04464	R White L Red	Yes	**
Pinal	—	R/629-04465	R Black	—	Unknown
Pinal	—	R/629-04466	R White	—	Unknown
Redmond	—	R/629-04467	R Black L Blue	—	Cliff Male 1984-1990
1980					
East Verde	—	R/629-04468	R Blue L Black	—	Unknown
East Verde	—	R/629-04469	R Blue L Black	—	Unknown
Bartlett	—	R/629-04470	R Blue L Black	—	Unknown
1981					
Bartlett	—	R/629-04471	R White L White	—	Died 1981
Bartlett	—	R/629-04472	R Red L White	—	Pinto Female 1987-1990
Redmond	—	R/629-04473	R White L Blue	—	Unknown
Pinal	—	R/629-04474	R Red	—	Unknown
Fort McDowell	—	R/629-04475	R White L Red	—	Unknown
Fort McDowell	—	R/629-04476	R Red L Red	—	Unknown
Redmond	—	R/629-04477	R Red L Blue	—	Unknown
1982					
Redmond	—	R/629-04478	R White L Blue	—	Unknown
Redmond	—	R/629-04480	R Red L Blue	—	Unknown

* Red tabs coded T01-T06 placed on USFWS bands of 1977 nestlings. Red patagial wing markers coded T01-T06 also placed on 1977 nestlings.

** One of these 1979 nestlings was the Chino/Alamo adult female from 1985–1987, and likely died in 1987.

Note: Nestlings banded from 1977–1982, whose bands have not been read, are breeding at four known territories.

Cliff Female	1984–1990	Band year likely 1977–1979
Pinal Male	At least 1987–1990	1977–1982
Sheep Female	At least 1987–1989	1977–1982
76 Male	1988–1990	1983 or prior

None of the 1977–1982 nestlings sighted or captured from 1986–1989 still carried their color bands, patagial markers, or band tabs. The patagial markers likely moved outward on the wing as the eagles molted their flight feathers, finally sliding off the wing-tip. The band tabs either wore off, or were torn off by the eagles. The plastic color bands were likely bitten off by the eagles. Similar plastic bands have been used on peregrine falcons, most of which soon took the bands off with their beaks. Also, prior to the creation of riveted USFWS bands, golden eagles easily removed non-riveted aluminum USFWS bands (M. Lockhart pers. comm.). A plastic band is no match for a bald eagle's beak.

The current status of many of the 29 young banded from 1977–1982 is unknown; however, we do know that six have died, one was sighted one year after banding, and three are members of breeding pairs. Of the six 1977 nestlings banded, three are known to have died. Radio-tagged T02 (629-04452) died shortly after fledging when it was displaced at a perch by its sibling and fell to the river, breaking its left humerus. The broken bone inspired water into the left lung, drowning the eaglet (Hildebrandt 1981). Another 1977 radio-tagged juvenile (T04, 629-04454) was shot 60 mi east of Calgary, Alberta, Canada in 1980 (Ohmart 1985). See Section C5 for further details on T04. A third 1977 eaglet (T03, 629-04453) survived 12.5 years. The eagle was rescued from the Salt River, below the Cibecue nest, on 21 November 1988, with his right wing broken in two places. We transported the eagle to Liberty Wildlife Foundation, and following rehabilitation he was released on 16 January 1989. The adult died of unknown causes in April 1989, north of Globe, Arizona (see Section C3.7 for further details on AM07). Five nestlings were banded in 1978, and one is known to have died. Eaglet 629-04460 died shortly after fledging and was eaten by a mammalian predator (Hildebrandt 1981).

Six nestlings were banded in 1979, of which radio-tagged 629-04462 was sighted in 1980 at Roosevelt Reservoir. In addition, one of the 1979 telemetered eaglets (629-04462 or 629-04464) bred at the Chino breeding area in 1985 and the Alamo breeding area in 1986 and 1987. The adult female carried its transmitter until late December 1986 or early January 1987. The female was replaced by an unbanded adult after the 1987 season and likely died. See sections D4.1 and D4.7 for more details on the Chino/Alamo female. We captured nestling 629-04463 in 1987 at the Blue Point breeding area, where he has been nesting since 1983. See Section D4.4 for further details on the Blue Point male (AM01). We captured nestling 6229-04467 in 1988 at the Cliff breeding area, where he has been nesting since the territory's discovery in 1984. See Section D4.9 for more details on the Cliff male (AM06). Three eaglets were banded in 1980, although no data are available on their current status. Another banded eaglet fell from the nest and died during a banding attempt at the Cibecue breeding area in 1980 (Haywood and Ohmart 1981).

The current status is known for two of the seven nestlings banded in 1981. Eaglet 629-04471 died shortly after fledging and was recovered by USFS personnel (Haywood and Ohmart 1983). We captured nestling 629-04472 in 1987 at the Pinto breeding area where she has nested since at least the 1988 season. See Section D4.23 for more details on the Pinto female (AF03). Two young were banded in 1982, although no data are available on their current status. Two other eaglets jumped from the nest during banding attempts at the Pinal and Bartlett breeding areas in 1982, although the young were returned to the nest and later fledged (Haywood and Ohmart 1983).

We do not know the current status of 20 of the 29 young banded from 1977–1982. A portion of these birds have no doubt died and not been recovered; however, three (and possibly four) of these eagles, whose bands have not been read, are part of breeding pairs. The Cliff female has been banded since the territory's discovery in 1984, and is possibly one of the 1977–1979 nestlings. The Pinal male and Sheep

female have been banded at least since 1987, and could be 1977–1982 eaglets. The "76" male has been banded since 1988, and would have been banded as a nestling in 1983 or before.

C6.1.2 Teryl Grubb's Research, 1983–1985.
Nestlings were not radio-tagged or color banded under Teryl Grubb's studies, although some USFWS bands were painted yellow (T. Grubb pers. comm.). None of the 1983–1985 nestlings sighted or captured from 1986–1989 retained the yellow paint on their USFWS band; however, small yellow paint specks were visible on 629-14560 when we captured her in 1988.

Six nestlings were banded in 1983, eight in 1984, and three in 1985. Of these 17 young, we know that two have died and one is part of a breeding pair (Table C6.1-2). Of these, we captured one of the 1984 eaglets (629-14560) at Salome Bay on Roosevelt Reservoir in 1988. The female (NF01) died in April 1988 near Gleason Flat on the Salt River, likely the victim of shooting (see Section C3.6). We captured another 1984 eaglet (629-14559) at the Bartlett breeding area in 1988, where he (AM04) has been nesting since 1988 (see Section D4.3 for details). Another 1984 nestling, the 1990 Ladders male (629-14562), was found dead in the Verde River, near the confluence of West Clear Creek, on 21 December 1990. The carcass was very decomposed, and not collected by the person who turned in the band, so cause of death remains unknown.

We do not know the current status of 14 of the 17 young banded from 1983–1985. A portion of these birds have no doubt died and not been recovered; however, assuming an Arizona origin, at least six (and probably seven) of these eagles, whose bands have not been read, are part of breeding pairs. The "76" male has been banded since 1988 and could be a nestling from 1983 or prior. After the Sheep male disappeared in 1988, he was replaced by a banded near-adult male which may be one of the 1984 nestlings. Banded females began breeding at Alamo and Fort McDowell in 1989, and would have been nestlings from 1984 or prior. A banded male began breeding at Alamo in 1990, and could be from 1985 or prior. A banded near-adult female was sighted in the Perkinsville pair in 1990, and would have been an eaglet from 1985. A near-adult was also part of the pair in 1989, and may be the same bird. The 1990 Pleasant female was also banded, and could be a nestling from 1985 or prior.

Grubb's research included the recording of bald eagle vocalizations (sonograms or "voice prints") from 1983–1985, as an alternative to banding for identification of individual eagles. Sonograms were recorded from 24 individuals at 13 breeding areas; however, data proved inconclusive in the identification of individual eagles (Grubb 1986a).

C6.1.3 BioSystems' Research, 1987–1990
Over the four years of BioSystems' study, 1987–1990, 87 young hatched in Arizona bald eagle nests, of which 77 survived to banding age (6 weeks), and 71 fledged. We banded 62 (81%) of the 77 eaglets surviving to six weeks of age, and 59 (83%) of the 71 which fledged. In addition, we radio-tagged 15 of these juveniles. Details concerning transmitter application are provided in Section E8.

C6.1.3.1 Summary of Banding and Telemetry—1987. We banded 20 (87%) of the 23 known nestlings which survived to six weeks of age in 1987 (Table C6.1-3). Reasons for not banding at three productive sites were as follows: (1) fledging occurred prior to discovery of the Ive's Wash nest and we decided not to trap the juvenile just for the purpose of banding; (2) rocks from the unstable cliff and pinnacle at the Canyon breeding area could have fallen onto the nest and injured the young; and, (3) at the Cibecue breeding area, BioSystems biologists canceled plans to band because the resident male and nestling were

Table C6.1-2. Juvenile bald eagles banded in Arizona during the studies of Teryl Grubb, USFS, 1983–1985.

Breeding Area	Bird Number	Aluminum* USFWS Band Leg/Number	Color Band Leg/Color	Transmitter	Current Status
1983					
Pinal	—	R 629-14551	—	—	Unknown
Fort McDowell	—	R 629-14552	—	—	Unknown
Fort McDowell	—	L 629-14553	—	—	Unknown
Horseshoe	—	R 629-14554	—	—	Unknown
Redmond	—	R 629-14556	—	—	Unknown
Redmond	—	L 629-14557	—	—	Unknown
1984					
Blue Point	—	R 629-14558	—	—	Unknown
Blue Point	—	R 629-14559	—	—	Bartlett male 1988–1990
East Verde	—	R 629-14560	—	—	Salome female died 1988
Horseshoe	—	R 629-14561	—	—	Unknown
Horseshoe	—	R 629-14562	—	—	Ladders male Died 1990
Cibecue	—	R 629-14563	—	—	Unknown
Cibecue	—	R 629-14564	—	—	Unknown
Cibecue	—	R 629-14565	—	—	Unknown
1985					
Ladders	—	R 629-14566	—	—	Unknown
Bartlett	—	R 629-14567	—	—	Unknown
Ash	—	R 629-14568	—	—	Unknown

* Some USFWS bands painted yellow.

Note: Nestlings banded from 1983–1985, whose bands have not been read, are breeding at six (and probably seven) known territories.

76	Male	1988–1990 Band year likely 1983 or prior	
Sheep ?	Male	1988	1984 (near-adult)
Alamo	Female	1989–1990	1984 or prior
Fort McDowell	Female	1989–1990	1984 or prior
Alamo	Male	1990	1985 or prior
Perkinsville	Female	1990	1985 (near-adult)
Pleasant	Female	1990	1985 or prior

Table C6.1-3. Juvenile bald eagles banded in Arizona in 1987.

Breeding Area	Bird Sex[1]	Bird Number	Aluminum USFWS Band *Right leg*	Blue Aluminum Visual ID Band *Left leg*	Transmitter	Current Status
Orme	M	JZ01	629-15184	Z	Yes	Unknown
Orme	F	JZ02	629-15185	Y	Yes	Sighted 1989
Fort McDowell	M	JM03	629-15186	X	Yes	Sighted 1988
Horse Mesa	M	J504	629-15187	W	—	Unknown
Horse Mesa	M	J505	629-15188	V	—	Sighted 1988
Coolidge	M	JK06	629-15189	U	—	Unknown
Coolidge	M	JK07	629-15190	S	—	Unknown
Ladders	M	JP08	629-15191	R	—	Died in nest
Ladders	M	JP09	629-15192	P	—	Died in nest
Blue Point	M	JD10	629-15193	O	—	Died 1987
Blue Point	M	JD11	629-15194	N	—	Unknown
Blue Point	F	JD12	629-15195	M	—	Unknown
Horseshoe 2	F	JO13	629-15196	K	—	Unknown
Horseshoe 2, 3	M	JO14	629-15197	H	—	Died 1990
Horseshoe 2	F?	JO15	629-15198	G	—	Sighted 1987
Redmond	F	JV16	629-15199	→	—	Unknown
Redmond	M	JV17	629-15200	2	—	Unknown
Pinal 4	?	JT18	629-26451	3	—	Unknown
Pinal 4	?	JT19	629-26452	4	—	Unknown
East Verde	F	JL20	629-26453	5	Yes	Sighted 1987

Canyon: Not banded—one young fledged prior to 6 May.
Cibecue: Not banded—one young died in nest 8-11 May.
Ive's Wash: Not banded—At least one young fledged prior to 6 May.

[1] Sexual differentiation based on body measurements.
[2] No measurements taken, birds visually sexed.
[3] USFWS band on left tarsus, VID band on right tarsus.
[4] No measurements taken.

Notes: One 1987 juvenile (blue band on left tarsus) sighted at Point Mugu Naval Air Base, California, on 31 January 1988.

One 1987 juvenile (blue band on left tarsus) sighted at Campaign Bay, Roosevelt Lake, Arizona, from 25–31 May 1989.

under stress (see Section D4.8). Single symbol blue anodized aluminum VID bands were placed on 1987 eaglets.

In addition to banding, we also radio-tagged four nestlings in 1987, two at the Orme breeding area, one at Fort McDowell, and one at East Verde. Movements and migration patterns for these juveniles are described in sections C5 and A4.

Of the 20 nestlings banded in 1987, four have died, and five were sighted in winter 1987 (following migration) or in 1988 or 1989. Two nestlings (JP08 and JP09) died in the nest at the Ladders breeding area, likely due to a severe infestation of Mexican chicken bugs (see Section C3.4). Another eaglet, JD10, was found dead 2.5 weeks after fledging near a dead red-tailed hawk. The two birds may have injured each other in an altercation or were possibly shot (see Section C3.2). A fourth juvenile (JO14) survived to three years of age, then was apparently shot and dismembered (feet, wings, and tail taken) along the lower Salt River, near the Verde River confluence (see Section C3.6). We also read JO14's band on 24 November 1987 at the confluence of Tonto Creek on Roosevelt Reservoir.

Two juveniles (JO15, JL20), one of which was radio-tagged, were sighted in winter 1987 following migration. We read JO15's VID band on 20 October 1987 on Saguaro Reservoir, and JL20 was found on the Verde River below Bartlett Dam on 27 October 1987. Another nestling (J505) was sighted on 24 February 1988 on Roosevelt Reservoir, near the Diversion Dam. Two other radio-tagged 1987 eaglets were tracked throughout Arizona in 1988 (JM03) and 1989 (JZ02). See sections C5 and A4 for details on the migration and movements of JZ01, JZ02, JM03, and JL20. In addition to the above sightings, a 1987 juvenile (blue band on left tarsus) was spotted at Point Mugu Naval Air Base, California (on the coast, 30 mi west of Los Angeles), on 31 January 1988. Another 1987 juvenile was sighted at Campaign Bay on Roosevelt Reservoir from 25–31 May 1989.

C6.1.3.2 Summary of Banding and Telemetry—1988. In 1988, we banded 19 (76%) of the 25 known nestlings which survived to six weeks of age (Table C6.1-4). The Bartlett and Canyon nests were not climbed due to the unstable structure of the cliff and pinnacle; climbing might have resulted in rocks falling and injuring the young. The Horse Mesa and East Verde juveniles fledged prior to scheduled climbs; fledglings were sighted in the nest area at both sites. All young appeared healthy when banded, with the exception of the Cliff male JI27 which had an eye infection, probably avian pox (USFWS 1987, K. Ingram pers. comm., D. Garcelon pers. comm.). We placed single symbol green anodized aluminum VID bands on 1988 eaglets.

In 1988, we telemetered nine juveniles from six breeding areas. Two young were radio-tagged at each of the Blue Point, Ladders, and "76" nests, and one each at Horseshoe and Orme. Due to the post-fledging mortality of the Blue Point young (see Section C3.2), we captured and telemetered a 14-week-old juvenile (JI26) at the Cliff breeding area. The Cliff female (JI26) had an eye infection when captured, probably avian pox (USFWS 1987, K. Ingram pers. comm., D. Garcelon pers. comm.). In addition, we removed a fishing hook, which had broken off and worked its way almost entirely inside the middle toe of JI26.

Of the 19 nestlings banded in 1988, six have died, and four were sighted in 1989. Two nestlings (JV38 and JV39) died at the Redmond breeding area, one in the nest and one after fledging, likely due to a severe infestation of Mexican chicken bugs and heat stress (see sections C3.4 and C3.5). The three Blue Point eaglets (JD32, JD33, and JD34) also may have been victims of heat stress (see Section C3.5), with

Table C6.1-4. Juvenile bald eagles banded in Arizona in 1988.

Breeding Area	Bird Sex[1]	Bird Number	Aluminum USFWS Band *Right leg*	Green Aluminum Visual ID Band *Left leg*	Transmitter	Current Status
Alamo	F	J121	629-26457	1	—	Unknown
Ladders	M	JP22	629-26462	2	Yes	Died 1988
Ladders	M	JP23	629-26468	3	Yes	Sighted 1989
Orme	M	JZ24	629-26469	4	Yes	Sighted 1989
Ive's Wash	M	J225	629-26464	5	—	Unknown
Cliff	F	JI26	629-26465	6	Yes	Unknown
Cliff	M	JI27	629-26466	7	—	Unknown
Coolidge	M	JK28	629-26467	8	—	Unknown
Coolidge	M	JK29	629-26470	A	—	Unknown
76	F	JW30	629-26471	B	Yes	Sighted 1989
76	F	JW31	629-26472	C	Yes	Sighted 1989
Blue Point	M	JD32	629-26473	D	—	Died 1988
Blue Point	M	JD33	629-26474	E	Yes	Died 1988
Blue Point	F	JD34	629-26475	G	Yes	Died 1988
Horseshoe	M	JO35	629-26476	H	Yes	Unknown
Lone Pine	M	JQ36	629-26477	K	—	Unknown
Lone Pine	M	JQ37	629-26478	M	—	Unknown
Redmond	F	JV38	629-26479	N	—	Died in nest
Redmond	F	JV39	629-26480	P	—	Died 1988

Horse Mesa: Not banded—one young fledged 25-29 April.
East Verde: Not banded—two young fledged prior to 7 May.
Bartlett: Not banded—two young fledged on 13 and 15 May.
Canyon: Not banded—one young fledged in May.
Pinal: Not banded—one young died in nest prior to 13 April.

[1] Sexual differentiation based on body measurements.

one breaking its neck on its maiden flight. Another eaglet, radio-tagged JP22, died four weeks after fledging, apparently killed by a great horned owl (see Section C3.2). Four other radio-tagged 1988 eaglets were tracked throughout Arizona in 1989 (JP23, JZ24, JW30, and JW31). See sections C5 and A4 for details on the migration and movements of JP23, JZ24, JI26, JW30, JW31, and JO35.

C6.1.3.3 Summary of Banding and Telemetry—1989. We banded 12 (80%) of the 15 known nestlings which survived to six weeks of age in 1989 (Table C6.1-5). The Bartlett and Canyon nests were not climbed due to the unstable structure of the cliff and pinnacle; climbing might have resulted in rocks falling and injuring the young. The Cibecue eaglet was not discovered until 12 weeks of age. No banding attempt was made due to the risk of the young fledging during the nest climb. Single symbol purple anodized aluminum VID bands were placed on 1989 eaglets.

We captured and telemetered two of the Bartlett juveniles after fledging in 1989. The third young died in the nest on 9 May, its siblings left the nest on 10 and 11 May. One of the Bartlett eaglets (JC51) fledged into a teddybear cholla cactus, so we spent 10 minutes pulling cholla spines out of the birds face, feet, and wings.

Of the 12 nestlings banded in 1989, one has died, and one was sighted in 1990. One nestling (J242) died at the Ive's Wash breeding area, breaking its wing after falling from the nest. The eaglet may have been a victim of heat stress (see Section C3.5). One radio-tagged 1989 eaglet (JC50) was tracked throughout Arizona in 1990. See sections C5 and A4 for details on the migration and movements of JC50 and JC51. One 1989 juvenile (purple band on left tarsus) was sighted at the Ladders breeding area on 10 April 1990.

C6.1.3.4 Summary of Banding—1990. In 1990, we banded 11 (79%) of the 14 known nestlings which survived to six weeks of age (Table C6.1-6). The Canyon nest was not climbed due to the unstable structure of the cliff and pinnacle; climbing might have resulted in rocks falling and injuring the young. Adults were incubating at the Table Mountain nest on 20 March. The nest was not checked again until 1 June. The large amount of mute on the nest cliff indicated at least one young survived to an advanced stage of development. The current status of all eleven 1990 nestlings remains unknown. Blue anodized aluminum VID bands with two stacked symbols were placed on 1990 eaglets.

C6.1.3.5 Summary of Mexico Banding—1988-1990. From 1988-1990, nine juveniles were banded from two nests on the Rio Yaqui River, Sonora, Mexico, as part of a study being conducted by Bryan Brown in cooperation with the Mexican government, Reclamation, SRP, and USFWS (Brown and Olivera 1988, Brown *et al.* 1989). Young were banded with USFWS bands on their right tarsus and single symbol gold anodized aluminum VID bands on their left tarsus (Table C6.1-7).

We banded four nestlings at the Fig Tree and Rio Sahuaripa breeding areas in 1988, one of which (J-01) died in the nest at 7-8 weeks of age. Two juveniles were banded from the Rio Sahuaripa nest in 1989. The third eaglet successfully fledged on the day of the nest climb. One of the 1989 juveniles (band 629-3264?, gold band on left tarsus) was sighted at Tongue Point, Clatsop County, Oregon, from 7-15 September 1989. An additional three juveniles were banded from the Rio Sahuaripa nest in 1990.

The current status of eight of the nine Mexico juveniles banded from 1988-1990 remains unknown. However, two of these eagles have been reported dead from shooting. The USFWS is currently attempting to retrieve the bands for individual identification of the birds (R. Mesta pers. comm.).

Table C6.1-5. Juvenile bald eagles banded in Arizona in 1989.

Breeding Area	Bird Sex[1]	Bird Number	Aluminum USFWS Band *Right leg*	Purple Aluminum Visual ID Band *Left leg*	Transmitter	Current Status
Alamo	M	J140	629-32602	1	—	Unknown
Ive's Wash	F	J241	629-32603	2	—	Unknown
Ive's Wash	M	J242	629-32604	3	—	Died 1989
Fort McDowell	F	JM43	629-32605	4	—	Unknown
Fort McDowell	F	JM44	629-32624	5	—	Unknown
East Verde	M	JL45	629-32625	6	—	Unknown
East Verde	F	JL46	629-32626	7	—	Unknown
Ladders	M	JP47	629-32627	8	—	Unknown
Ladders	M	JP48	629-32628	A	—	Unknown
Pinal	M	JT49	629-32629	B	—	Unknown
Bartlett	M	JC50	629-32630	C	Yes	Sighted 1990
Bartlett	F	JC51	629-32631	D	Yes	Unknown

Pinal:	Not banded—one young died in nest at ~1 week of age.
Bartlett:	Not banded—one young died in nest 9 May.
Blue Point:	Not banded—two young died in nest 16–19 March.
Horseshoe:	Not banded—one young died in nest 1–2 April.
Redmond:	Not banded—two young died in nest 6–7 April.
Cibecue:	Not banded—one young died in nest at ~5 weeks of age.
Cibecue:	Not banded—one young fledged 5–12 June.
Cliff:	Not banded—one young died in nest 5–12 April.
Canyon:	Not banded—one young fledged in May.

[1] Sexual differentiation based on body measurements.

Note: One 1989 juvenile (purple band on left tarsus) sighted at Ladders breeding area in 1990.

Table C6.1-6. Juvenile bald eagles banded in Arizona in 1990.

Breeding Area	Bird Sex[1]	Bird Number	Aluminum USFWS Band *Right leg*	Blue Aluminum Visual ID Band *Left leg*	Transmitter	Current Status
Alamo	F	J152	629-32653	1/A	—	Unknown
Alamo	F	J153	629-32654	1/B	—	Unknown
Horse Mesa	M	J554	629-32655	1/C	—	Unknown
Horse Mesa	M	J555	629-32656	1/E	—	Unknown
Horseshoe	F	JO56	629-32657	1/G	—	Unknown
Horseshoe	M	JO57	629-32658	1/H	—	Unknown
Pinal	F	JT58	629-32659	1/K	—	Unknown
Pinal	M	JT59	629-32660	1/M	—	Unknown
76	M	JW60	629-32661	1/N	—	Unknown
Orme	F	JZ61	629-32662	1/P	—	Unknown
Redmond	M	JV62	629-32663	1/R	—	Unknown

Canyon: Not banded—two young fledged in June.
Cibecue: Not banded—one young died in nest 14 April.
Table Mountain: Not banded—at least one young fledged in May.

[1] Sexual differentiation based on body measurements.

C6.2 BANDING AND TELEMETRY OF SUBADULTS AND NEAR-ADULTS

Prior to BioSystems' study, no Arizona subadult or near-adult bald eagles were banded or telemetered. However, Teryl Grubb, USFS, radio-tagged five wintering subadult eagles near Apache Maid on Coconino National Forest as part of a winter roosting study. Four of the wintering eagles were fitted with 65-gram Telonics backpack transmitters on the 172 MHz frequency with an expected battery life of 18 months (T. Grubb pers. comm., Grubb *et al.* 1989). One eagle in 1989 was fitted with a military test model satellite backpack transmitter, as well as a tail-mount transmitter. These winter visitors were captured using a modified rocket net system originally designed to catch wild turkeys and Canada geese in the eastern United States (Grubb 1988b).

From 1987–1989, we captured five subadult (1–3 years old) and three near-adult (ca. 4 years old) bald eagles in Arizona. We banded the nonbreeding eagles with red color anodized Visual Identification (VID) bands on the left tarsus and silver (aluminum) USFWS bands on the right tarsus (Table C6.2-1). Each eagle was also radio-tagged with a BioTrack 64-gram backpack This subadult female bald eagle, most likely 3.5 years old (McCollough and Krohn 1986), displayed white flecking on a predominantly brown head, a white breast mottled with brown, and an inverted white triangle on her back. transmitter in the fashion described in Section E8.

Table C6.1-7. Juvenile bald eagles banded on the Rio Yaqui, Sonora, Mexico, 1988-1990.*

Breeding Area	Bird Sex[1]	Bird Number	Aluminum USFWS Band *Right leg*	Gold Aluminum Visual ID Band *Left leg*	Transmitter	Current Status
1988						
Fig Tree	F	J-01	629-26458	1	—	Died in nest
Fig Tree	F	J-02	629-26459	2	—	Unknown
Rio Sahuaripa	M	J-03	629-26460	3	—	Unknown
Rio Sahuaripa	M	J-04	629-26461	4	—	Unknown
1989						
Rio Sahuaripa	F?	J-05	629-32641	5	—	2
Rio Sahuaripa	F?	J-06	629-32642	6	—	2
Rio Sahuaripa: Not banded—one young fledged 11 April.						
1990						
Rio Sahuaripa	F	J-07	629-32643	7	—	Unknown
Rio Sahuaripa	M	J-08	629-32644	8	—	Unknown
Rio Sahuaripa	M	J-09	629-32645	W	—	Unknown

[1] Sexual differentiation based on body measurements.

[2] One 1989 juvenile (band 629-3264?, gold band on left tarsus) sighted at Tongue Point, Clatsop County, Oregon, from 7–15 September 1989.

* Two Mexico eaglets (gold bands) have been reported dead from shooting. The USFWS is currently attempting to retrieve the bands for individual identification of the eagles (R. Mesta pers. comm.).

We rescued a subadult bald eagle (SF01) from the upper Salt River, near the Canyon Creek confluence on 22 June 1987. The eagle had a broken radius in the right wing that had partially calcified, indicating the break occurred 10–14 days earlier (Dr. Hood pers. comm.). Rehabilitated, banded, and telemetered at the Phoenix Zoo, SF01 was released at San Carlos Reservoir on 9 October 1987, after a ceremony by the San Carlos Apaches. The movements of SF01 throughout Arizona are described in sections C5 and A4. SF01 died around 1 April 1988, apparently drowning in a stock tank just north of Globe, Arizona (see Section C3.6).

In 1988, we captured two near-adult bald eagles in Salome Bay on Roosevelt Reservoir. We used a noosed fish to capture the male (NM01) on 2 March 1988, and our radio-controlled power snare to capture the female (NF01) on 4 March. NM01 displayed typical four-year-old plumage (McCollough and Krohn 1986), retaining much brown flecking in his white head and a sepia band on the distal margin of the tail, with stripes running up the retrices. NM01 also had a large white patch on his back. We

Plate C21. Three nestling bald eagles, "Aguiluchos" (10-10.5 weeks old), at the Sahuaripa breeding area along the Rio Yaqui, Sonora, Mexico, April 1991. Note the gold VID band on the closest eaglet's tarsus (photo by D. Driscoll).

tracked NM01 throughout Arizona in 1988 and 1989. Details on NM01's movements are provided in sections C5 and A4.

NF01 was banded as a nestling in 1984 at the East Verde breeding area (see Section C6.1.2). The four-year-old female displayed typical near-adult plumage (McCollough and Krohn 1986), with brown flecking in the white head, a brown eye-stripe, and a brown band on the distal margin of the tail. The brown eye-stripes converged into a vertical stripe down the nape. We tracked NF01 throughout Arizona in March and April 1988 (see sections C5 and A4 for details on NF01's movements). In early May we received her signal near Gleason Flat on the Salt River. We entered the area and found her transmitter had been cut off with a sharp knife, but could not locate the eagle. We surmised the eagle had likely been shot and removed from the area (see Section C3.6).

Table C6.2-1. Band numbers, symbols, and telemetry frequencies of near-adult and subadult bald eagles captured in Arizona from 1987-1989.

Year	Breeding Area	Sex[1]	Number	Frequency	Aluminum USFWS Band *Right Leg*	Red Aluminum Visual ID Band *Left Leg*	Current Status
1987	San Carlos	F	SF01	165.300	629-26454	A	Died 1988
1988	Salome Bay	M	NM01	165.274	629-26456	B	Sighted 1989
	Salome Bay[2]	F	NF01	165.214	629-14560	C	Died 1988
1989	Ladders (Winter)	F	NF02	165.502	629-26483	+	Unknown
	Ladders (Winter)	M	SM01	165.485	629-26482	D	Unknown
	Ladders (Winter)	M	SM02	165.524	629-26484	△	Sighted 1990
	Ladders (Winter)	M	SM03	165.543	629-26485	◇	Sighted 1990
	Ladders (Winter)	M	SM04	165.564	629-32601	X	Unknown

[1] Sexual differentiation based on body measurements.
[2] Banded as nestling in 1984 at East Verde breeding area by Teryl Grubb, USFS.

While trapping in the Ladders breeding area in 1989, we captured a near-adult and four subadult bald eagles using our radio-controlled bownet. Some of these eagles appeared larger than Arizona birds and may have been wintering from a northern state (see Section A5.4). The first subadult male (SM01) was captured on 23 January 1989. A near-adult female (NF02) was caught on 24 January, a subadult male (SM02) on 26 January, a subadult male (SM03) on 1 February, and a subadult male (SM04) on 2 February. We tracked all five eagles throughout Arizona in 1989. SM02 and SM03 returned with operating transmitters in 1990 and were again radio-tracked. Details on the movements of these five eagles are provided in sections C5 and A4.

C6.3 BANDING AND TELEMETRY OF BREEDING ADULTS

Prior to BioSystems' studies, no Arizona bald eagles had been banded or telemetered as adults. BioSystems biologists utilized a variety of methods to capture bald eagles, including a radio-controlled bow net, a radio-controlled power snare, and noosed fish, which are described in Section E8. Adults were banded with a black Visual Identification (VID) band on the right tarsus and a silver (aluminum) U.S. Fish and Wildlife Service (USFWS) band on the left. However, some captured eagles had been banded with USFWS bands as nestlings in previous studies (Haywood and Ohmart 1983, Grubb 1986a), in which case we placed the VID band on the tarsus opposite the USFWS band. The VID symbols have been read on Arizona bald eagles at considerable distances with Questar and other spotting scopes. Data recorded from adults included body measurements, plumage characteristics and information on blood and feather samples.

From 1987–1989, we captured 15 breeding adult bald eagles in Arizona. We banded and radio-tagged 12 individuals, four females and eight males, at ten breeding areas (Table C6.3-1). Two pairs of eagles were captured at the Ladders and Horseshoe territories. Three adults were later recaptured, two of which we fitted with new transmitters. Each adult was radio-tagged with a BioTrack 64-gram or Telonics 65-gram backpack transmitter as described in Section E8.

We captured five adults during the 1987 breeding season. The Pinal female (AF01) was captured on 13 December 1986, utilizing a noosed fish on Roosevelt Reservoir. Her transmitter fell off on 6 May 1987 when the single cotton thread stitch in the teflon ribbon used to attach the telemetry unit apparently broke. We used three stitches to fasten transmitters on all other eagles. We recaptured AF01 on the Salt River, above Pinal Creek, on 13 June 1987, again with a noosed fish, and replaced her transmitter. No signs of abrasion or wear were found from the transmitter or bands. On 20 March 1987 we caught the Blue Point male (AM01) on Saguaro Reservoir using a noosed fish. AM01 was banded as a nestling at the Fort McDowell breeding area in 1979 (see Section C6.1.1). The East Verde male (AM02) was captured on 25 March 1987, using our radio-controlled power snare, specially developed for this site. We caught the Horseshoe female (AF02) on 30 March 1987, using a noosed fish on Horseshoe Reservoir. All adults captured in 1987 were still breeding at their territories as of 1990.

Through the 1988 breeding season we captured seven adults. The Blue Point male (AM01) was recaptured on 7 December 1987, using a noosed fish on Saguaro Reservoir. We found no signs of abrasion or wear from the transmitter or bands. We caught the Pinto female (AF03) on 17 December 1987, with a noosed fish on Roosevelt Reservoir. AF03 was banded as a nestling at the Bartlett breeding area in 1981 (see Section C6.1.1). The Horseshoe male (AM03) was captured with the radio-controlled power snare on 13 January 1988, and the Bartlett male (AM04) on 28 March in the radio-controlled bow net. AM04, a near-adult (4 years old), was banded as a nestling in 1984 at the Blue Point breeding area (see Section C6.1.2). We captured the Ladders female (AF04) on 1 April 1988 in the radio-controlled bownet. The Redmond male (AM05) was captured with the radio-controlled power snare on 21 May

Table C6.3-1. Band numbers, symbols, and telemetry frequencies of Arizona adult bald eagles captured from 1986–1989.

Year	Breeding Area	Sex	Number	Frequency	Aluminum USFWS Band		Black Aluminum Visual ID Band		Current Status
1986	Pinal	F	AF01	165.752	Left	629-15181	Right	A	Breeding 1990
1987	Blue Point[1]	M	AM01	165.050	Right	629-04463	Left	B	Breeding 1990
	East Verde	M	AM02	165.632	Left	629-15182	Right	C	Breeding 1990
	Horseshoe	F	AF02	165.025	Left	629-15183	Right	D	Breeding 1990
	Pinal[6]	F	AF01	165.200	Left	629-15181	Right	A	Breeding 1990
1988	Pinto[2]	F	AF03	165.350	Right	629-04472	Left	G	Breeding 1990
	Horseshoe	M	AM03	165.250	Left	629-26455	Right	E	Breeding 1990
	Bartlett[3]	M	AM04	165.225	Right	629-14559	Left	R	Breeding 1990
	Ladders	F	AF04	165.342	Left	629-26463	Right	E	Breeding 1990
	Redmond	M	AM05	165.264	Left	629-26481	Right	d	Breeding 1990
	Cliff[4]	M	AM06	165.295	Right	629-04467	Left	G	Breeding 1990
1989	Cibecue[5]	M	AM07	165.791	Right	629-04453	Left	K	Died 1989
	Pinto[6]	F	AF03	164.585	Right	629-04472	Left	G	Breeding 1990
	Ladders	M	AM08	165.036	Left	629-32680	Right	H	Died 1989

Notes:

[1] Banded as nestling in 1979 at Fort McDowell breeding area by Dr. Robert Ohmart, ASU.

[2] Banded as nestling in 1981 at Bartlett breeding area by Dr. Robert Ohmart, ASU.

[3] Banded as nestling in 1984 at Blue Point breeding area by Teryl Grubb, USFS.

[4] Banded as nestling in 1979 at Redmond breeding area by Dr. Robert Ohmart, ASU.

[5] Banded as nestling in 1977 at Bartlett breeding area by Dr. Robert Ohmart, ASU.

[6] Recaptured and transmitter replaced.

1988, and the Cliff male (AM06) on 8 June in the radio-controlled bownet. AM06 was banded as a nestling in 1979 at the Redmond breeding area (see Section C6.1.1). All adults captured in 1988 were still breeding at their territories as of 1990.

During the 1989 breeding season we captured three adults. An adult male (AM07) was rescued in the Cibecue territory on the Salt River below nest 2 on 21 November 1988, with a section broken out of his ulna (wing). We transported the eagle to Liberty Wildlife Foundation, where he was rehabilitated. AM07, banded as a nestling in 1977 at the Bartlett breeding area (see Section C6.1.1), was released at the Tonto Estuary on Roosevelt Reservoir on 16 January 1989. We recaptured AM07 on 22 February 1989, while trapping with a noosed fish in the Pinal territory. He appeared to be in excellent condition, with well developed breast muscle. We recaptured the Pinto female (AF03) using the decoy eagle technique, and changed her telemetry unit on 30 March 1989. AF03 showed no signs of abrasion or wear from her transmitter or bands. We captured the Ladders male (AM08) on 2 April 1989, again using the decoy eagle method.

The Pinto female (AF03) was still nesting at her breeding area as of 1990. The Cibecue male (AM07) died of unknown causes in April 1989, north of Globe, Arizona (see Section C3.7). The Ladders male (AM08) died 6–10 May 1989, apparently of brain damage resulting from a blow to the head by a peregrine falcon (see Section C3.7). Further details on all of the adult bald eagles captured from 1986–1989 are provided under the appropriate breeding areas in Section D4.

C6.4 BANDED EAGLES IN BREEDING PAIRS

Nestling bald eagles have been banded in Arizona since 1977 (see Section C6.1.1), although no effort was made to band all nestlings until BioSystems' study (1987–1990). By banding all (or at least most) known Arizona nestlings with USFWS and VID bands, it will be possible to document the survivorship of individuals well into the future, especially when the eagles reach breeding age (4–5) and their VID bands can be read at nest sites with spotting scopes.

We have gained insight into bald eagle mortality through banding and telemetry. We have learned about ten juvenile deaths, four subadult mortalities, six adult replacements, and three adult mortalities (see Section C3) that would have gone unnoticed without the aid of banding and telemetry.

Band recoveries of nestlings from studies by Robert Ohmart (see Section C6.1.1) and Teryl Grubb (see Section C6.1.2) have also shed light on the age structure of breeding adults. We have sighted 18 eagles banded prior to 1986, 16 of which are breeding (Table C6.4-1). One of the two nonbreeding near-adults was sighted at the Sheep breeding area following the resident male's disappearance in 1988. The other nonbreeding near-adult (NF01) was captured at Salome Bay on Roosevelt Reservoir in March 1988 (see Section C6.2). We aged eight of these 18 birds; one bird was banded as a nestling in 1977, three were banded in 1979, one was banded in 1981, and three were banded in 1984. In addition, we have estimated band years for those breeding eagles whose USFWS bands have not been read. Three (and possibly a fourth) are from Ohmart's studies (1977–1982), and at least six (probably seven) are from Teryl Grubb's research (1983–1985).

From 1986–1990, BioSystems captured and banded seven previously unbanded adults, two near-adults, and five subadults. We captured and placed VID bands on five adults and one near-adult which were banded with USFWS bands as nestlings in earlier studies. In addition we banded 62 Arizona nestlings with USFWS and VID bands, and assisted Bryan Brown (Brown and Olivera 1988, Brown *et al.* 1989) in the banding of nine nestlings on the Rio Yaqui, Sonora, Mexico.

Table C6.4-1. History of known banded adults at Arizona bald eagle breeding areas.

Breeding Area	Sex	USFWS Band	Visual ID Band	Transmitter	Known Tenure[1]	Band Year	Estimated Band Year	Breeding Area Banded In	1990 Age (or age at death)
Blue Point	M	Right 629-04463	Left Black B	Yes	1983–1990	1979	—	Fort McDowell	11
Cliff	M	Right 629-04467	Left Black Ɔ	Yes	1984–1990	1979	—	Redmond	11
Cliff	F	Left ?	— — —	—	1984–1990	?	1977–1979	?	11–13
Chino/Alamo	F	Right 629-04462	— — —	Yes	1985–1987	1979	—	Bartlett	8 (1987)[3]
		or Right 629-04464	— — —	Yes	1985–1987	1979	—	Fort McDowell	8 (1987)[3]
Pinal	F	Left 629-15181	Right Black A	Yes	1986–1990	1986	—	—	—
Pinal	M	Right ?	— — —	—	1987–1990	?	1977–1982	?	8–13
Pinto	F	Right 629-04472	Left Black G	Yes	1987–1990	1981	—	Bartlett	9
Sheep[2]	F	Right ?	— — —	—	1987–1989	?	1977–1982	?	8–13
East Verde[2]	M	Left 629-15182	Right Black C	Yes	1987–1989	1987	—	—	—
Horseshoe	F	Left 629-15183	Right Black D	Yes	1987–1990	1987	—	—	—
Horseshoe	M	Left 629-26455	Right Black E	Yes	1988–1990	1988	—	—	—
Bartlett	M	Right 629-14559	Left Black Ꞁ	Yes	1988–1990	1984	—	Blue Point	6
Ladders	F	Left 629-26463	Right Black E	Yes	1988–1990	1988	—	—	—
Redmond	M	Left 629-26481	Right Black d	Yes	1988–1990	1988	—	—	—
76	M	Left ?	— — —	—	1988–1990	?	1983 or prior	?	7–13
Sheep[2]	M	? ?	— — —	—	1988 ?	?	1984 (near-adult)	?	6
Cibecue	M	Right 629-04453	Left Black K	Yes	1988	1977	—	Bartlett	12 (1989)
Ladders	M	Left 629-32680	Right Black H	Yes	1989	1989	—	—	— (1989)
Alamo	F	Right ?	— — —	—	1989–1990	?	1984 or prior	?	6–13
Fort McDowell	F	Left ?	— — —	—	1989–1990	?	1984 or prior	?	6–13
Alamo	M	Right ?	— — —	—	1990	?	1985 or prior	?	5–13
Ladders	M	Right 629-14562	— — —	—	1990	1984	—	Horseshoe	6.5 (1990)
Perkinsville	F	Right ?	— — —	—	1990	?	1985 (near-adult)	?	5
Pleasant	F	Left ?	— — —	—	1990	?	1985 or prior	?	5–13

[1] Known tenure at breeding area represents a minimum number of years, originating when band was first sighted or adult was captured and banded.
[2] Adults not present during band checks in 1990.
[3] One of these eagles bred at Chino/Alamo from 1985–1987, and was replaced prior to 1988.

Table C6.4-1 gives details on the known banded adults at Arizona bald eagle breeding areas up to 1990. Four of these adults have died: the Chino/Alamo female (629-04462 or 629-04464) in 1987; the Cibecue male (629-04453) in 1989; the Ladders male (629-32680) in 1989; and, the 1990 Ladders male (629-14562). One of the dead adults has since been replaced by another banded eagle, the Alamo female in 1989.

All of these breeding areas should be checked for banded adults each year in order to document replacement (mortality) within the pair. Nestlings banded in 1987 with VID bands may show up in breeding pairs as early as 1991. These bands can be read with a spotting scope and will shed considerable light on the survivorship of Arizona's juvenile and adult bald eagle populations. The banding efforts from Arizona bald eagle studies are just beginning to pay off in terms of data on the mortality of breeding adults and the survivorship of nestlings to breeding age. By checking the band status of each adult in each breeding area every year, we will acquire further information on the nestling, subadult, near-adult, and adult bald eagles banded in Arizona.

As noted in Section C2, many breeding areas have been occupied in years prior to their discovery by management agencies. In addition, adults have been sighted year-round in areas where we have not found nests, suggesting that more breeding areas exist than are currently known. Together with sites not entered for banding due to safety concerns for the young, these unknown nest sites provide a source of unbanded eaglets which may enter breeding pairs as adults and near-adults from 1991 onward.

C6.5 ESTIMATIONS OF SURVIVORSHIP

Assuming that bald eagles breeding in Arizona were born in Arizona (which is supported by bands read to date), of the 46 Arizona nestlings banded prior to 1986, a minimum of 39 percent (n = 18) survived to breeding age (4–5 years old) (Table C6.5-1). At least 20 of these young (43.5%) survived through their first year. This number is likely much higher, since survivorship in the 1–4 year old age classes is difficult to document. Nonbreeding bald eagles range over a vast area, and since they are not centrally located until they establish a territory, band sightings and recoveries are minimal. Most band recoveries in Table C6.5-1 are from breeding eagles trapped during our study, which accounts for the close percentage of survivorship for the 1–6 year age classes. Actual survivorship is likely much higher in the first four years of life than the table indicates. When young banded with VID bands from 1987–1990 begin breeding (their bands can be read with a spotting scope at considerable distances) a much better picture of survivorship will develop.

We recorded 10 banded adults in Arizona pairs who's bands have not been read to date; however, the ages of these eagles were estimated from the first year the band was sighted (see Table C6.4-1). Using the youngest possible age, we arrived at a minimum survivorship figure for these banded (unknown) eagles. Four eagles banded as nestlings (8.7%) survived through their twelfth year of life. One male eaglet banded in 1977 died at 12.5 years old (629-04453), although two other males (banded in 1979) were still breeding as 12-year-olds (629-04463, and 629-04467). An additional female, whose band has not been read, has been breeding at the Cliff territory since 1984, making her at least twelve years old (assuming she was at least five in 1984) at the end of 1990.

We banded 62 Arizona nestlings from 1987–1990. These data are not included in Table C6.5-1, since the young will not reach breeding age (4–5 years old) until the 1991 and 1992 breeding seasons. Survivorship (based on banding recoveries) prior to breeding age would be largely underestimated due to the vast ranges covered by non-breeding eagles, decreasing the chances of reading a band. First year

Table C6.5-1. The beginnings of a life-table on the Arizona bald eagle population, based on band recoveries, and the minimum survivorship of breeding adults whose bands have not been read, 1977–1990.*

Survived Through Year	Age	R. Ohmart 29 Banded 1977-1982	T. Grubb 17 Banded 1983-1985	Breeding, But Bands Not Read[1]	Minimum Survival of 46 Banded		Died During Year[2]	Age	R. Ohmart 29 Banded 1977–1982	T. Grubb 17 Banded 1983–1985	Breeding, but Bands Not Read[1]	Minimum Mortality of 46 Banded	
					Number	Percent						Number	Percent
1	1	7	3	10	20	43.5	1	0	3	—	—	3	6.5
2	2	6	3	10	19	41.3	2	1	—	—	—	—	—
3	3	6	3	10	19	41.3	3	2	—	—	—	—	—
4	4	5	3	10	18	39.1	4	3	1	—	—	1	2.17
5	5	5	2	10	17	37.0	5	4	—	1	—	1	2.17
6	6	5	2	10	17	37.0	6	5	—	—	—	—	—
7	7	5	1	6	12	26.1	7	6	—	1	—	1	2.17
8	8	5	—	4	9	19.6	8	7	—	—	—	—	—
9	9	4	—	2	6	13.0	9	8	1	—	—	1	2.17
10	10	4	—	1	5	10.9	10	9	—	—	—	—	—
11	11	3	—	1	4	8.7	11	10	—	—	—	—	—
12	12	3	—	1	4	8.7	12	11	—	—	—	—	—
13	13	—	—	—	—	—	13	12	1	—	—	1	2.17
14	14	—	—	—	—	—	14	13	—	—	—	—	—
15	15	—	—	—	—	—	15	14	—	—	—	—	—

[1] Ten nestlings banded from 1977–1985 were breeding, but their bands have not been read.

[2] First year mortalities are deaths prior to migration.

* BioSystems banded 62 Arizona nestlings from 1987–1990, although these data are not included since the young will not reach breeding age (4–5 years old) until the 1991 and 1992 breeding seasons. Survivorship (based on banding recoveries) prior to breeding age would be largely underestimated, due to the vast ranges covered by non-breeding eagles, decreasing the chances of reading a band. Of the 62 young banded from 1987–1990, 7 (11.3%) are known to have died in their first year, and 1 (1.6%) in it's fourth year (3 years old).

However, we telemetered 15 juveniles from 1987–1989, of which 3 died and 1 transmitter failed prior to migration. Of the 11 juveniles which migrated, a minimum of 8 (72.7%) survived their first year.

mortalities in the table are all deaths prior to migration, although only three (6.5%) have been documented from previous banding efforts. Of the 62 young banded from 1987–1990, seven (11.3%) are known to have died in their first year, and one (1.6%) in its fourth year (3 years old). However, we telemetered 15 juveniles from 1987–1989, of which three died and one transmitter failed prior to migration. Of the 11 juveniles which migrated, a minimum of eight (72.7%) survived their first calendar year of life.