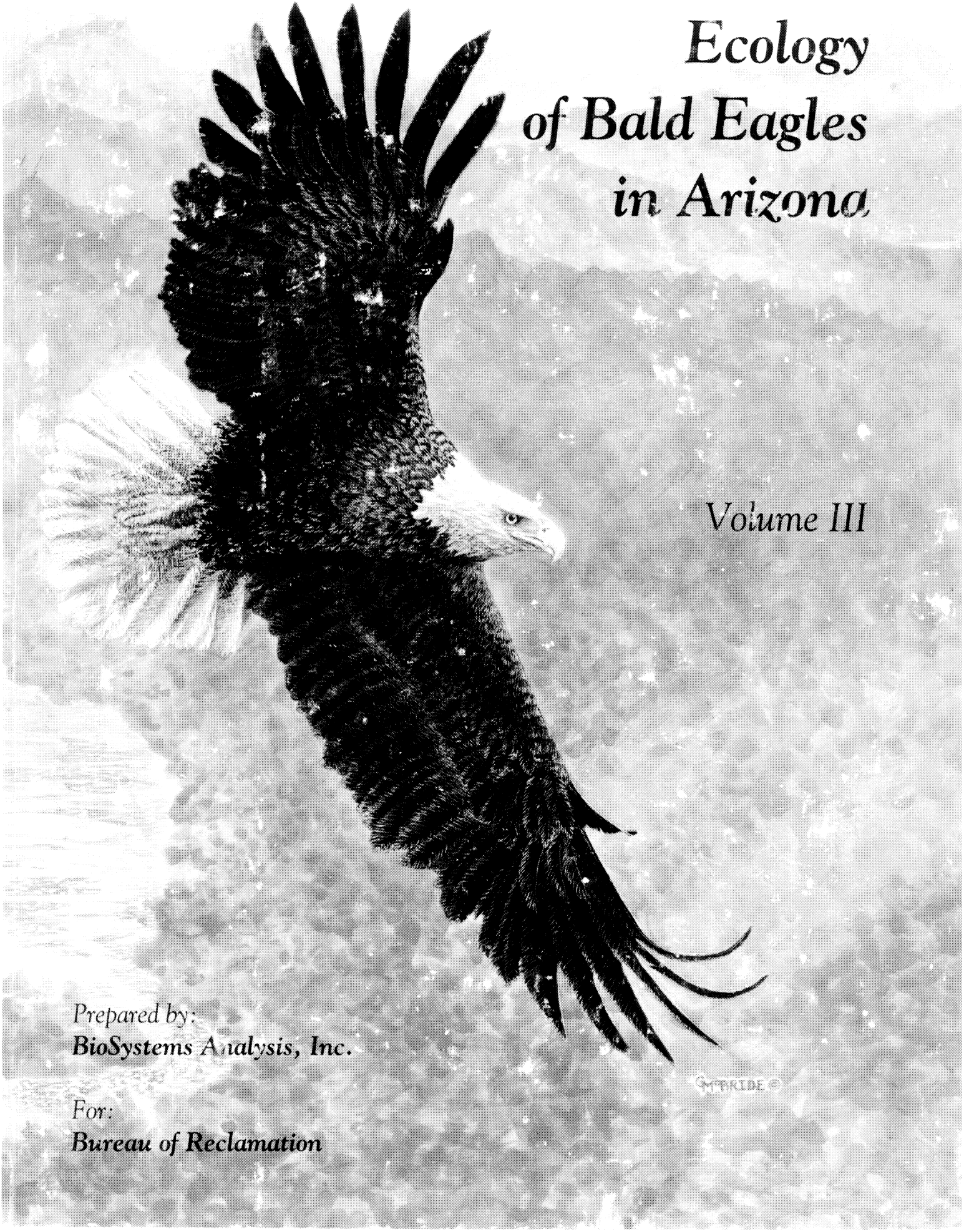
Ecology of Bald Eagles in Arizona

Volume III



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ECOLOGY OF BALD EAGLES IN ARIZONA

Part D

HISTORY OF NESTING POPULATION

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TABLE OF CONTENTS

D1 INTRODUCTION D-1

D2 HABITAT DESCRIPTION D-3
- D2.1 Woodland Formation D-3
- D2.2 Scrub Formation: Interior Chaparral Biome D-4
- D2.3 Grassland Formation: Semidesert Grassland Biome D-4
- D2.4 Desertscrub Formation D-5
- D2.5 Wetlands Formation D-6
- D2.6 Historical Aspects D-7
- D2.7 Dam and Reservoir Construction D-17
- D2.8 Drainages Supporting Breeding Bald Eagles D-26

D3 BREEDING AREA HISTORY D-36

D4 KNOWN BREEDING AREAS D-41
- D4.1 Alamo Breeding Area D-47
- D4.2 Ash Breeding Area D-55
- D4.3 Bartlett Breeding Area D-60
- D4.4 Blue Point Breeding Area D-71
- D4.5 Canyon Breeding Area D-83
- D4.6 Cedar Basin Breeding Area D-87
- D4.7 Chino Breeding Area D-93
- D4.8 Cibecue Breeding Area D-101
- D4.9 Cliff Breeding Area D-111
- D4.10 Coolidge Breeding Area D-121
- D4.11 Devil's Post Breeding Area D-127
- D4.12 East Verde Breeding Area D-130
- D4.13 Fort McDowell Breeding Area D-139
- D4.14 Horse Mesa Breeding Area D-152
- D4.15 Horseshoe Breeding Area D-162
- D4.16 Ive's Wash Breeding Area D-173
- D4.17 Ladders Breeding Area D-182
- D4.18 Lone Pine Breeding Area D-193
- D4.19 Mule Hoof Breeding Area D-199
- D4.20 Orme Breeding Area D-207
- D4.21 Perkinsville Breeding Area D-217
- D4.22 Pinal Breeding Area D-222
- D4.23 Pinto Breeding Area D-234
- D4.24 Pleasant Breeding Area D-243
- D4.25 Redmond Breeding Area D-250
- D4.26 "76" Breeding Area D-267
- D4.27 Sheep Breeding Area D-277
- D4.28 Table Mountain Breeding Area D-286

TABLE OF CONTENTS (cont.)

D5 KNOWN AND POTENTIAL HISTORICAL NEST SITES D-291
D5.1 Box Bar Nest Site D-295
D5.2 Bronco Nest Site D-296
D5.3 Cold Water Nest Site D-297
D5.4 Eagle Nest Site D-298
D5.5 Fort Whipple Nest Site D-299
D5.6 Grand Falls Nest Site D-300
D5.7 Havasu Nest Site D-301
D5.8 Hell Point Nest Site D-303
D5.9 LF Nest Site D-304
D5.10 Lower Mary Nest Site D-305
D5.11 Muldoon Nest Site D-306
D5.12 Natanes Nest Site D-307
D5.13 Needle Rock Nest Site D-308
D5.14 Red Hill Nest Site D-309
D5.15 Rock Creek Nest Site D-310
D5.16 Sawtooth Nest Site D-311
D5.17 Seven Mile Nest Site D-312
D5.18 Stoneman Nest Site D-313
D5.19 Sullivan Nest Site D-314
D5.20 Tower Nest Site D-315
D5.21 Upper Mary Nest Site D-316
D5.22 Willow Nest Site D-317

D6 POSSIBLE NEST SITES AND UNVERIFIED REPORTS D-318

D7 WILDLIFE OBSERVATIONS D-327
D7.1 Wildlife Interactions D-327
D7.2 Wildlife Sightings D-331

D8 PERSONAL COMMUNICATION D-343

LIST OF TABLES

Table D3.0-1. Current breeding areas containing the original 36 nest sites found by Duane Rubink, U.S. Fish and Wildlife Service, during the first Arizona bald eagle surveys, from 1972-1974 . . . . . D-39
Table D4.0-1. Discovery of bald eagle breeding areas in Arizona D-42
Table D4.0-2. Distribution of bald eagle breeding areas in Arizona, 1990 . . . . . D-44
Table D4.1-1. Nesting chronology of the Alamo breeding area D-49

LIST OF TABLES (cont.)

Table D4.1-2. Prey species observed taken by bald eagles or collected from the nest at the Alamo breeding area D-50
Table D4.2-1. Nesting chronology of the Ash breeding area D-56
Table D4.2-2. Prey species observed taken by bald eagles or collected from the nest at the Ash breeding area D-57
Table D4.3-1. Nesting chronology of the Bartlett breeding area D-62
Table D4.3-2. Prey species observed taken by bald eagles or collected from the nest at the Bartlett breeding area D-64
Table D4.4-1. Nesting chronology of the Blue Point breeding area D-73
Table D4.4-2. Prey species observed taken by bald eagles or collected from the nest at the Blue Point breeding area D-77
Table D4.5-1. Nesting chronology of the Canyon breeding area D-84
Table D4.5-2. Prey species observed taken by bald eagles or collected from the nest at the Canyon breeding area D-85
Table D4.6-1. Nesting chronology of the Cedar Basin breeding area D-88
Table D4.6-2. Prey species observed taken by bald eagles or collected from the nest at the Cedar Basin breeding area D-90
Table D4.7-1. Nesting chronology of the Chino breeding area D-96
Table D4.7-2. Prey species observed taken by bald eagles or collected from the nest at the Chino breeding area D-97
Table D4.8-1. Nesting chronology of the Cibecue breeding area D-103
Table D4.8-2. Prey species observed taken by bald eagles or collected from the nest at the Cibecue breeding area D-106
Table D4.9-1. Nesting chronology of the Cliff breeding area D-112
Table D4.9-2. Prey species observed taken by bald eagles or collected from the nest at the Cliff breeding area D-115
Table D4.10-1. Nesting chronology of the Coolidge breeding area D-122
Table D4.10-2. Prey species observed taken by bald eagles or collected from the nest at the Coolidge breeding area D-124
Table D4.12-1. Nesting chronology of the East Verde breeding area D-132
Table D4.12-2. Prey species observed taken by bald eagles or collected from the nest at the East Verde breeding area D-134
Table D4.13-1. Nesting chronology of the Fort McDowell breeding area D-141
Table D4.13-2. Prey species observed taken by bald eagles or collected from the nest at the Fort McDowell breeding area D-144
Table D4.14-1. Nesting chronology of the Horse Mesa breeding area D-153
Table D4.14-2. Prey species observed taken by bald eagles or collected from the nest at the Horse Mesa breeding area D-156
Table D4.15-1. Nesting chronology of the Horseshoe breeding area D-164
Table D4.15-2. Prey species observed taken by bald eagles or collected from the nest at the Horseshoe breeding area D-168
Table D4.16-1. Nesting chronology of the Ive's Wash breeding area D-175
Table D4.16-2. Prey species observed taken by bald eagles or collected from the nest at the Ive's Wash breeding area D-176

LIST OF TABLES (cont.)

Table D4.17-1. Nesting chronology of the Ladders breeding area D-184
Table D4.17-2. Prey species observed taken by bald eagles or collected from the nest at the Ladders breeding area D-186
Table D4.18-1. Nesting chronology of the Lone Pine breeding area D-194
Table D4.18-2. Prey species observed taken by bald eagles or collected from the nest at the Lone Pine breeding area D-195
Table D4.19-1. Nesting chronology of the Mule Hoof breeding area D-201
Table D4.20-1. Nesting chronology of the Orme breeding area D-208
Table D4.20-2. Prey species observed taken by bald eagles or collected from the nest at the Orme breeding area D-211
Table D4.21-1. Nesting chronology of the Perkinsville breeding area D-219
Table D4.21-2. Prey species observed taken by bald eagles or collected from the nest at the Perkinsville breeding area D-219
Table D4.22-1. Nesting chronology of the Pinal breeding area D-224
Table D4.22-2. Prey species observed taken by bald eagles or collected from the nest at the Pinal breeding area D-228
Table D4.23-1. Nesting chronology of the Pinto breeding area D-236
Table D4.23-2. Prey species observed taken by bald eagles or collected from the nest at the Pinto breeding area D-237
Table D4.24-1. Nesting chronology of the Pleasant breeding area D-245
Table D4.24-2. Prey species observed taken by bald eagles or collected from the nest at the Pleasant breeding area D-246
Table D4.25-1. Nesting chronology of the Redmond breeding area D-252
Table D4.25-2. Prey species observed taken by bald eagles or collected from the nest at the Redmond breeding area D-259
Table D4.26-1. Nesting chronology of the "76" breeding area D-268
Table D4.26-2. Prey species observed taken by bald eagles or collected from the nest at the "76" breeding area D-272
Table D4.27-1. Nesting chronology of the Sheep breeding area D-279
Table D4.27-2. Prey species observed taken by bald eagles or collected from the nest at the Sheep breeding area D-281
Table D4.28-1. Nesting chronology of the Table Mountain breeding area D-287
Table D4.28-2. Prey species observed taken by bald eagles or collected from the nest at the Table Mountain breeding area D-288
Table D7.2-1. Avian species encountered in Arizona bald eagle breeding areas, 1986–1990 . . . . . D-332
Table D7.2-2. Mammalian species encountered in Arizona bald eagle breeding areas, 1986–1990 . . . . . D-340
Table D7.2-3. Herptile species encountered in Arizona bald eagle breeding areas, 1986–1990 . . . . . D-342

LIST OF FIGURES

Figure D2.8-1. Major drainages and their tributaries within Arizona D-27
Figure D3.0-1. Major river systems in central Arizona D-38
Figure D3.0-2. Current names and locations of the original 36 nest sites found by Duane Rubink, USFWS, during the first Arizona bald eagle surveys, from 1972–1974. . . . . D-40
Figure D4.0-1. Known bald eagle breeding areas in Arizona D-43
Figure D5.0-1. Known and potential historical Arizona bald eagle nest sites D-293
Figure D6.0-1. Possible Arizona bald eagle nest sites and unverified reports D-319

LIST OF PLATES

Plate D1. Prickly pear cactus (flowering) on Chalk Mountain above Horseshoe Reservoir, May 1991 (photo by D. Driscoll) D-6
Plate D2. The Roosevelt Diversion Dam, completed in 1906, provided irrigation and also diverted water during the construction of Theodore Roosevelt Dam (photo by D. Driscoll, July 1986) D-19
Plate D3. The Roosevelt Diversion Dam was reconstructed in 1989 to reduce the risk of drowning, yet still serve as a barrier to fish migrating upstream out of Roosevelt Reservoir (photo by D. Driscoll, April 1990) D-19
Plate D4. Theodore Roosevelt Dam, a National Historic Monument, was constructed from 1903-1911. The stones were cut and shaped from nearby cliffs by Italian stonemasons, and the road to the dam built by Apache Indians and members of the U.S. Calvary (photo by D. Driscoll, September 1986) D-20
Plate D5. The crest of Theodore Roosevelt Dam, showing artwork of stone-cutting, also served as a bridge for vehicles traveling Highway 188 until 1991. A new bridge now spans Roosevelt Reservoir just east of the dam (photo by D. Driscoll, November 1986) D-20
Plate D6. Apache Reservoir at the crest of Horse Mesa dam. The dam has pumpback storage capabilities, where by reversing the hydroelectric turbines, water is pumped from Canyon Reservoir (below the dam) back up into Apache Reservoir. Note the concrete gate on the right abutment that releases water into the spillway tunnel (photo by D. Driscoll, February 1986) D-23
Plate D7. Horse Mesa dam, constructed during 1924-1927. Note the spillway tunnel on the left (photo by D. Driscoll, February 1986) D-23
Plate D8. Stewart Mountain Dam, constructed during 1928-1930, is the fourth and final hydroelectric dam on the Salt River. The regulated Salt River flows from the dam to the Verde River confluence, then on to Granite Reef Diversion Dam where the river is diverted into canals (photo by D. Driscoll, September 1986) D-24

LIST OF PLATES (cont.)

Plate D9. Location of Orme Dam, proposed in the 1970s but never built, at the Salt and Verde River confluence (photo by D. Driscoll, September 1987) D-24

Plate D10. Horseshoe Dam releasing water into the regulated Verde River. The two dams on the Verde River are for water storage and flood control, and do not produce hydroelectric power (photo by D. Driscoll) D-25

Plate D11. Horseshoe Dam is smaller than other impoundment dams on the Salt and Verde rivers, and creates a shallow reservoir (Horseshoe) without a hypolimnion layer, thus water releases are warmer than those from other dams (photo by D. Driscoll, June 1986) D-25

Plate D12. Bartlett Dam, constructed during 1936-1939, releases cool water from the reservoirs hypolimnion layer into the regulated Verde River (photo by D. Driscoll, August 1991) D-26

Plate D13. Coolidge Dam, a National Historic Monument, was completed in 1931. The dam stores water from the Gila River in San Carlos Reservoir (photo by D. Driscoll, April 1987) D-28

Plate D14. Coolidge Dam, showing artwork on crest and face (eagle) (photo by D. Driscoll, April 1987) D-28

Plate D15. Tonto Creek flowing through the "76" bald eagle breeding area, 8 September 1986 (photo by D. Driscoll) D-35

Plate D16. Alamo cottonwood snag nest (2) containing two 7.5-week-old eaglets, April 1991 (photo by D. Driscoll) D-47

Plate D17. Ash ponderosa pine nest (2) containing two eaglets, May 1985 (photo by D. Driscoll) D-55

Plate D18. Bartlett cliff nest (1) with adult perched on top, June 1988. This nest has been present since at least the 1940s, and was nearly 5 m tall in 1990 (photo by D. Driscoll) D-60

Plate D19. Blue Point pinnacle nest (6) containing three nine-week-old eaglets and the adult female, May 1988 (photo by D. Driscoll) D-71

Plate D20. Canyon nest pinnacle (left) along Canyon Creek, July 1986. Note the rubble on the slope from the decomposition of cliff substrate (photo by D. Driscoll) D-83

Plate D21. Cedar Basin sycamore tree nest (4) containing one egg, May 1988 (photo by D. Driscoll) D-87

Plate D22. Chino nest trees along the dry Big Sandy riverbed, May 1987 (photo by D. Driscoll) D-93

Plate D23. Cibecue pinnacle nest (1), May 1987 (photo by D. Driscoll) D-101

Plate D24. Cliff pinnacle nest (4), containing two 6.5 to 7-week-old eaglets, along the regulated Verde River, April 1988 (photo by D. Driscoll) D-111

Plate D25. Coolidge cliff nest (3) containing two eaglets, April 1988 (photo by D. Driscoll) D-121

Plate D26. Devil's Post breeding area along Burro Creek, February 1988 (photo by T. Tibbitts) D-127

LIST OF PLATES (cont.)

Plate D27. East Verde cliff nest (6) containing two seven to eight-week-old eaglets, April 1989 (photo by D. Driscoll) D-130
Plate D28. Fort McDowell cottonwood tree nest (11) along the regulated Verde River, March 1987. Note tractor plowing field adjacent to nest tree (photo by D. Driscoll) D-139
Plate D29. Horse Mesa pinnacle nest (2) containing two 11-week-old eaglets, April 1986 (photo by D. Driscoll) D-152
Plate D30. Horseshoe nest (8) cliff, May 1991 (photo by D. Driscoll) D-162
Plate D31. Ive's Wash nest cliff along the regulated Bill Williams River, May 1987 (photo by D. Driscoll) D-173
Plate D32. Ladders cliff nest (3) along the free-flowing Verde River, October 1986 (photo by D. Driscoll) D-182
Plate D33. Lone Pine cliff/ground nest (4), containing two 4 to 4.5-week-old eaglets along free-flowing Salt River, May 1988 (photo by D. Driscoll) D-193
Plate D34. Mule Hoof pinnacle nest (1) which has been present since at least 1935, and is still in good condition, May 1987 (photo by D. Driscoll) D-199
Plate D35. Orme pinnacle nest (1) containing one 8 to 8.5-week-old eaglet, April 1988 (photo by D. Driscoll) D-207
Plate D36. Perkinsville breeding area along the free-flowing Verde River, June 1989 (photo by D. Driscoll) D-217
Plate D37. Pinal nest (1, 2) cliff along Pinal Creek, July 1986 (photo by D. Driscoll) D-222
Plate D38. Pinto cottonwood tree nest (2, arrow), built on top of a great blue heron nest, in secondary branches, June 1989 (photo by D. Driscoll) D-234
Plate D39. Pleasant nest cliff along the Agua Fria River, October 1986 (photo by D. Driscoll) D-243
Plate D40. Redmond breeding area on free-flowing Salt River, February 1985 (photo by D. Driscoll) D-250
Plate D41. "76" cottonwood tree nest (3) containing two seven-week-old eaglets, May 1988 (photo by D. Driscoll) D-267
Plate D42. Sheep nest (1) in dying cottonwood along Tonto Creek, November 1987 (photo by D. Driscoll) D-277
Plate D43. Table Mountain cliff nest (4) containing one eight-week-old eaglet, May 1991. Note prickly pear cactus and jojoba bush growing out of nest (photo by D. Driscoll) D-286

D1 INTRODUCTION

We provide this section as a compilation and baseline reference of existing knowledge on Arizona's breeding population of bald eagles to: (1) augment with historical information the data and interpretation obtained by BioSystems in the course of field work; and, (2) provide a basis of organization for archiving future data on the population. We begin with a description of the habitats surrounding bald eagle breeding areas in Arizona (Section D2) and the historical events which brought about changes in the habitat. The latter compliments Section E1 which describes habitat changes principally as they relate to prey fish populations.

Section D3 contains historical accounts of bald eagles in Arizona, and is followed by detailed information on Known Breeding Areas (Section D4), Known and Potential Historical Nest Sites (Section D5), and Possible Nest Sites and Unverified Reports (Section D6). Section D7 describes wildlife observations incidental to our study of bald eagles in Arizona.

The Known Breeding Areas section (D4) includes information on 28 breeding areas which in recent years have contained nesting pairs and are annually surveyed for productivity data. In some cases, this section augments information given in Part B of this report which describes studies by BioSystems of habitat selection and foraging at seven territories.

The section on Known and Potential Historical Nest Sites (D5) notes additional areas which have or may have contained breeding pairs in the past. Using published sources, information received during interviews with landowners and agency personnel, and nest locations found while studying Arizona bald eagles during 1985-1990, 22 potential historical nest sites have been documented.

The Possible Nest Sites and Unverified Reports section (D6) contains locations where adults have been sighted during the breeding season, although a nest has not been found to date, and areas where nests or eagles have been reported by the public. The 60 possible nest sites and unverified reports are presented to archive past reports of nests or breeding activity, and to aid in future nest search efforts.

Data to create this document stemmed from many sources and personal contacts. Major contributions were made by Duane Rubink and Robert Mesta, U.S. Fish and Wildlife Service (USFWS), Teryl Grubb, Larry Forbis, and Wade Eakle, U.S. Forest Service (USFS), and the research of Robert Ohmart, Arizona State University (ASU). Site specific sources and contacts are listed under Personal Communication, Section D8.

In the past, terminology used to describe the status of bald eagle breeding areas in Arizona varied with the author. We have attempted to standardize data from past reports by using the terminology of Postupalsky (1974) as follows:

1. **Breeding Area**—An area containing one or more nests within the range of one mated pair of birds.

2. **Occupied Breeding Area**—An area containing a nest at 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;
f. Recent repairs (fresh sticks or lining), mute, or feathers were visible at or near the nest.

3. **Unoccupied Breeding Area**—An area containing a nest at which none of the above indicators were observed.

4. **Active Nest**—A nest in which eggs have been laid.

5. **Failed Nest**—An active nest in which eggs did not hatch, or young died before reaching an advanced stage of development.

6. **Successful Nest**—An active nest in which at least one young survived to an advanced stage of development.

Bald eagles in Arizona utilize habitats managed by a variety of federal and state agencies as well as private land. The Southwestern Bald Eagle Management Committee (SWBEMC) held its first meeting on 1 December 1984 to bring all agencies involved with the management of Arizona's desert nesting bald eagles together to make decisions concerning the future of this small population. Represented agencies included the Arizona Game and Fish Department (AGF), USFWS, U.S. Bureau of Reclamation (Reclamation), USFS, U.S. Bureau of Land Management (BLM), U.S. Bureau of Indian Affairs (BIA), U.S. Army Corps of Engineers (ACE), and Salt River Project (SRP), a local utility which manages the watershed. In addition, the Salt River Pima-Maricopa Indian Community, White Mountain Apache Nation, San Carlos Indian Community, and the Mohave Apache Community Council are represented on the committee.

D2 HABITAT DESCRIPTION

Arizona provides a diversity of habitats, from the alpine tundra of the San Francisco Peaks (12,670 ft) and the subalpine conifer forests and subalpine grasslands of the White Mountains (11,590 ft), to the desert scrub surrounding Phoenix (1092 ft) and Yuma (141 ft MSL). The wide range of habitats stimulated the studies of Clinton Hart Merriam in 1889, who mapped six "life zones" based on vertical and latitudinal zones of plants and associated animals from the San Francisco Peaks to the deserts of Arizona. Decreasing in elevation, the life zones occur in Tundra (Arctic–Alpine Life Zone), Forest (Hudsonian, Canadian, and Transition Life Zones), Woodland and Grassland (Upper Sonoran Life Zone), and Desert Biotic Communities (Lower Sonoran Life Zone) (Lowe 1964).

The breeding range of bald eagles in Arizona spans 1080 to 5640 ft in elevation and encompasses the Upper Sonoran and Lower Sonoran Life Zones described by C. H. Merriam (1890, 1898; in Lowe 1964). Within these life zones, vegetative biotic communities are diverse and often overlapping. Arizona's rugged terrain and drastic elevation changes compound the diversity of plant life by intersecting a variety of soil types with differing precipitation levels. Large cliffs terminate desertscrub habitat at their peaks, while riparian vegetation proliferates at their base. Deep narrow canyons of steep gradient and whitewater open up into lush valleys with slow, calm rivers.

Brown (1982) divided the biotic communities of the southwest into seven formations, Tundra, Forest, Woodland, Scrub, Grassland, Desertscrub, and Wetlands. Each of these formations are made up of separate biomes, "plant and animal community responses to integrated climatic factors, more or less regional in scope," the limits of which are determined by climate. A biome can be broken down into subdivisions, each of which can contain different series or communities of vegetation. The boundaries of each biome vary, being influenced by elevation, longitude, slope exposure, geomass, temperature inversions, cold air drainages, soil porosity, and other local factors.

The Tundra and Forest formations of Brown (1982) exist outside the known breeding range of bald eagles in Arizona (Brown and Lowe 1980). The remaining five formations, their biomes, subdivisions, and series compose the habitat within and surrounding bald eagle nesting areas.

D2.1 WOODLAND FORMATION

Two biomes of the Woodland formation, the Great Basin Conifer Woodland and the Madrean Evergreen Woodland, occur within or around bald eagle breeding areas in Arizona.

D2.1.1 Great Basin Conifer Woodland Biome

The Great Basin Conifer Woodland is a cold-temperate woodland composed primarily of juniper (*Juniperus*) and pinyon (*Pinus*) trees less than 12 m in height and openly spaced, reaching maximum development on mesas, plateaus, piedmonts, slopes, and ridges. Important associated plant species are Gambel oak (*Quercus gambelii*) in shrub form, mountain-mahoganies (*Cercocarpus*), skunkbush sumac (*Rhus trilobata*), saskatoon serviceberry (*Amelanchier alnifolia*), snowberries (*Symphoricarpos*), and currants (*Ribes*). Subdominant shrub species include cliffrose (*Purshia mexicana*), apache plume

(*Fallugia paradoxa*), mormon-tea (*Ephedra*), barberry (*Berberis*), fourwing saltbush (*Atriplex canescens*), small soapweed (*Yucca glauca*), and datil (*Yucca baccata*). Other species may also occur locally. Several species of grasses and cacti can be important understory species.

D2.1.2 Madrean Evergreen Woodland Biome

The Madrean Evergreen Woodland is a warm-temperate woodland containing primarily ponderosa pine (*Pinus ponderosa*), Apache pine (*P. engelmannii*), and several other pine species, together with emory oak (*Quercus emoryi*), Arizona white oak (*Q. arizonica*), and other oak species. Associated understory species include many grasses, cacti, leaf succulents, and shrubs which can be locally abundant.

D2.2 SCRUB FORMATION: INTERIOR CHAPARRAL BIOME

Within the Scrub formation, only one biome, Interior Chaparral, is represented in the vicinity of breeding bald eagles in Arizona. Interior Chaparral is a warm-temperate scrubland with shrub live oak (*Quercus turbinella*) as the most common dominant species. Other shrubs present include birchleaf mountain-mahogany (*Cercocarpus breviflorus*), skunkbrush sumac, silktassels (*Garrya*), and desert ceanothus (*Ceanothus greggii*). Species which may be locally important are Hollyleaf buckthorn (*Rhamnus crocea*), cliffrose, desert olive (*Forestiera neomexicana*), sophoras (*Sophora*), Arizona rosewood (*Vauquelinia californica*), lowell ash (*Fraxinus anomala*), barberry, and manzanita (*Arctostaphylos*). Herbaceous cover in the intershrub spaces is reduced due to grazing of domestic livestock.

Associated species vary with precipitation and elevation. Dry, rocky, open sites may contain thornscrub species such as wait-a-bit (*Mimosa biuncifera*) or catclaw (*Acacia greggii*), and scrub elements of jojoba (*Simmondsia chinensis*), crucifixion thorn (*Canotia holacantha*), banana yucca (*Yucca baccata*), agaves (*Agave*), beargrass (*Nolina microcarpa*), sotol (*Dasylirion wheeleri*), snakeweed (*Gutierrezia sarothrae*), and false mesquite (*Calliandra eriophylla*). Pringle manzanita (*Arctostaphylos pringlei*) grows at higher elevations, and juniper, emory oak, pinyon, or other shrubs may form a scattered, open overstory.

D2.3 GRASSLAND FORMATION: SEMIDESERT GRASSLAND BIOME

The Semidesert Grassland biome is the only biome in the Grassland Formation that occurs within the range of breeding bald eagles in Arizona. It is a warm-temperate grassland with a biseasonal to summer precipitation pattern. The original perennial bunch grass cover in this biome has been largely replaced or altered by people and livestock, and the consequential invasion of cacti, leaf succulents, and shrubs. Dominant species are tobosa grass (*Hilaria mutica*) and black grama (*Bouteloua eriopoda*), although many other grasses may be locally important.

Leaf succulents in this biome may include sotols, bear-grass, agaves, and yuccas. Shrubs which can be present are one-seed juniper (*Juniperus monosperma*), mesquites (*Prosopis*), lotebush (*Zizyphus obtusifolia*), allthorn (*Koeberlinia spinosa*), mormon tea, mimosa (*Mimosa biuncifera*), false mesquite, catclaw acacia, desert hackberry (*Celtis pallida*), barberry, ocotillo (*Fouquieria splendens*), and others of local importance. Drainages in the area may harbor western soapberry (*Sapindus saponaria*) and desert willow (*Chilopsis linearis*). Cacti in many communities include fish-hook barrel cactus (*Ferocactus wislizenii*), chollas and prickly pears (*Opuntia*), hedgehogs (*Echinocereus*), and pincushions (*Mammillaria*).

D2.4 DESERTSCRUB FORMATION

Arizona bald eagles nest in two biomes of the Desertscrub formation, the Mohave Desertscrub and Sonoran Desertscrub. These two biomes contain distinct species, although representatives of both communities may be present where their fringes meet.

D2.4.1 Mohave Desertscrub Biome: Joshua Tree Series

The Mohave Desertscrub biome is a warm-temperate desertland characterized by predominantly winter rainfall. Dominant plants include creosotebush (*Larrea tridentata*), all-scale (*Atriplex polycarpa*), brittlebush (*Encelia farinosa*), desert holly (*Atriplex hymenelytra*), white burrobush (*Hymenoclea salsola*), shadscale (*Atriplex confertifolia*), and blackbrush (*Coleogyne ramosissima*). One of the best examples of a Mohave endemic species is the Joshua tree (*Yucca brevifolia*), although it is not always present. Understory species are diverse and vary with locality.

D2.4.2 Sonoran Desertscrub Biome: Arizona Upland Subdivision

The Sonoran Desertscrub biome is a tropical–subtropical desertland of unreliable biseasonal rainfall, separated by periods of spring and fall drought. Brown (1982) describes six subdivisions of this biome, although Arizona Upland is the one of importance to nesting bald eagles. It is the best watered and least desert-like desertscrub in North America, containing blue palo verde (*Cercidium floridum*), foothill palo verde (*Cercidium microphyllum*), mesquites, ironwood (*Olneya tesota*), catclaw acacia, and crucifixion thorn (*Canotia halocantha*). Most of the woody plants are spiny, or possess aromatic terpenes to discourage use by herbivores.

Cacti are of major importance in this subdivision, and include buckhorn cholla (*Opuntia acanthocarpa*), cane cholla (*O. spinosior*), staghorn cholla (*O. versicolor*), chain fruit cholla (*O. fulgida*), teddy bear cholla (*O. bigelovii*), desert christmas cactus (*O. leptocaulis*), pencil cholla (*O. arbuscula*), klein cholla (*O. kleiniae*), devil's club ground cholla (*O. stanlyi*), saguaro (*Carnegiea gigantea*), organ pipe (*Stenocereus thurberi*), fish-hook pincushion (*Mammillaria microcarpa*), Thornber pincushion (*M. thornberi*), compass barrel cactus (*Ferocactus acanthodes*), and fish-hook barrel cactus.

The Arizona Upland subdivision contains three series, Paloverde-Cacti-Mixed Scrub, Jojoba-Mixed Scrub, and Creosotebush-Crucifixion-thorn. Paloverde-Cacti-Mixed Scrub is the most extensive series, dominated by foothill palo verde and saguaro cactus, and to a lesser extent ironwood. Triangle-leaf bursage (*Ambrosia deltoidea*) and white bursage (*A. dumosa*) are common along drainages. Associated species include ocotillo, jojoba, desert hackberry, little-leaved ratany (*Krameria parvifolia*), fairy feather duster (*Calliandra eriophylla*), bush buckwheat (*Eriogonum fasciculatum*), prickly pear (*Opuntia phaeacantha*), and fendler hedgehog (*Echinocereus fendleri*). Other species may be of local importance.

The Jojoba-Mixed Scrub series is dominated by jojoba, and is best developed at the desert's upper limits and in transition areas between Sonoran Desertscrub and Interior Chaparral. The Creosotebush-Crucifixion-thorn series is also found at upper level ecotones and is especially common on limestone substrates. As indicated by its name, creosotebush and crucifixion-thorn are dominant species. Either of the above communities can be found in association with the Paloverde-Cacti-Mixed Scrub series.

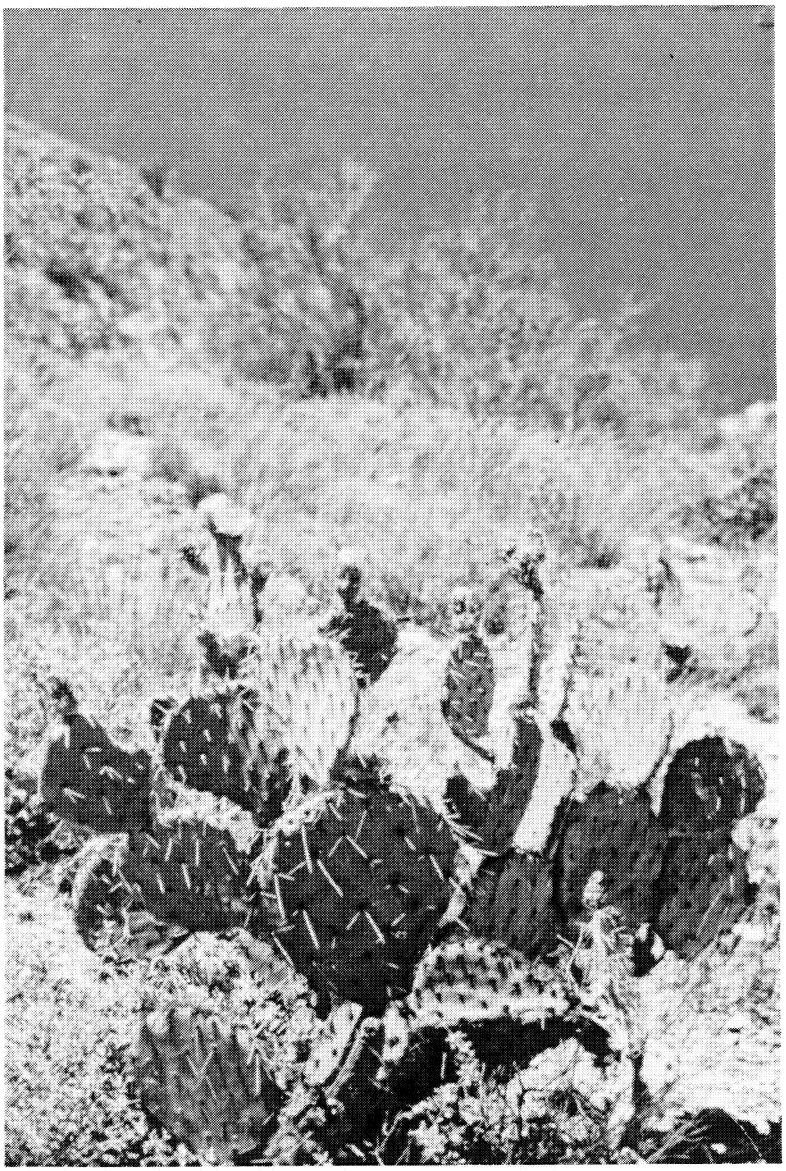

Plate D1. Prickly pear cactus (flowering) on Chalk Mountain above Horseshoe Reservoir, May 1991 (photo by D. Driscoll).

D2.5 WETLANDS FORMATION

Within the Wetlands formation, bald eagle nest sites occur in three tropical-subtropical wetland biomes, Sonoran Riparian Deciduous Forest and Woodlands, Sonoran Riparian Scrubland, and Sonoran Interior Strands. Vegetation within the three biomes often overlaps, depending on the amount of water present. Various species of grasses compose the ground-cover in riparian areas, influenced by canopy cover, grazing practices, and water levels.

D2.5.1 Sonoran Riparian Deciduous Forest and Woodlands Biome

The Sonoran Riparian Deciduous Forest and Woodlands biome commonly contains tree species of Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), and to a lesser extent Arizona sycamore (*Platanus wrightii*). Mesquite bosques are frequently present, and reach their maximum development here. However, mesquite cannot utilize ground-water below 14 m, and has been literally wiped out in some areas by ground-water pumping and stream diversions. Firewood cutting and clearing bosques for agriculture has also contributed to the decline of mesquites in Arizona. Associated species include hackberry, Mexican elder (*Sambucus mexicana*), velvet ash (*Fraxinus pennsylvanica*), blue palo verde, catclaw, graythorn (*Zizyphus obtusifolia*), and ironwood. An introduced species which is usually present in, and has taken over many, riparian areas in Arizona is salt cedar or tamarisk (*Tamarix pentandra*).

D2.5.2 Sonoran Riparian Scrubland Biome

The Sonoran Riparian Scrubland biome occurs in and along drainages within the Sonoran desert and contains dominant species of seepwillow (*Baccharis salicifolia*), desert broom (*B. sarothroides*), mule fat (*B. viminea*), desert willow, arrow-weeds (*Tessaria sericea*) and (*Pluchea*), burrobrush, and salt cedar.

D2.5.3 Sonoran Interior Strands Biome

The Sonoran Interior Strands biome is typically located along stream channels, and composed of open stands of seepwillow and tree tobacco (*Nicotiana glauca*), with associated plants like thorn apple (*Datura*), nightshade (*Solanum*), and dock (*Rumex*).

D2.6 HISTORICAL ASPECTS

Habitat is influenced by elevation, temperature, precipitation, soil types, topography, fire and other natural events, as well as many more factors which can change over time. Local changes subsequently alter the density and diversity of plant species in an area, which in turn modifies the animal species that inhabit the area. Prior to human influence, shifts in habitat types and composition likely occurred slowly (over a number of years, decades, or centuries). The habitats of North America have no doubt been seriously altered since the arrival of man, with drastic changes occurring over relatively short periods. Such is the case in Arizona, where drastic habitat changes have taken place, especially since the 1800s.

D2.6.1 Indian and Spanish Cultures (1500–1810)

Early habitat conditions in the Southwest (what is currently Arizona and Mexico) remain sketchy (due to no written records) prior to 1519, when Hernando Cortes dropped anchor off what is now Vera Cruz. Even then, the conquistadors impinged very little on the life of the desert, until after 1600, when missionaries reached the Yaqui River. Hastings and Turner (1965) point out that "The Indian cultures of the Sonoran Desert as they existed about 1600 were the product of many thousands of years of slow evolution," and they "... likely had little impact on the environment." Three groups of Indian peoples inhabited the Sonoran desert then: the nomadic bands (Seris), the mainly nomadic tribes which had favored locations they recurrently settled (Apaches), and peoples who lived in basically permanent villages (Yumans, Pimans, Yaquis, and Opatas) (Hastings and Turner 1965).

The Spanish missionaries began concentrating the Indians into settlements along the Yaqui River around 1600, to teach them the ways of Christianity, as well as the imperial policies of Spain. The Jesuit missionary activity continued north up the Yaqui to the current United States boundary by 1650, and

extended into the area south of the Gila River by 1695. In 1699, Eusebio Francisco Kino (a Jesuit priest) wrote of the Gila, or River of the Holy Apostles, as he called it: "All its inhabitants are fishermen, ... sustaining themselves with the abundant fish and with their maize, beans, and calabashes" (Hayden 1965). The Jesuit policy of amassing the Indians in mission settlements rendered the population more dependent on cultivated foods, and adversely impacted local game populations and wild plants (Hastings and Turner 1965). The Spanish also introduced domestic grazing animals (cattle, sheep, and goats) and distributed these animals to new settlements as they were founded.

The 1700s brought a period of conflict between missionaries, Spanish settlers, and the Indians. Apache raids, beginning in about 1680, as settlements and missionaries pushed north, focused principally on the growing herds of livestock. The raids increased into the 1700s, causing settlers to retreat to safer territory farther south in what is now Mexico. The Yaquis, Pimas, and Seris also rebelled. However, settlement still continued, and by 1750, individual secular herds of four to five thousand cattle were common. The Santa Cruz and San Pedro River Valleys saw occasional agricultural activity as far north as what is currently Tucson. Mining settlements cut extensive stands of trees for smelters, timbering shafts, and fuel, while overgrazing reduced grass cover and induced erosion (Hastings and Turner 1965).

D2.6.2 Mexican Independence (1810–1846)

The Mexican Independence Movement began in 1810, and by 1821 Mexico was established. With the decrease in Apache raids in the early 1800s, larger scale stock-raising began in Mexico and migrated north into what is now Arizona. Herds of 40,000 to 80,000 cattle, as well as large numbers of horses and mules were reported (Hastings and Turner 1965). Apache raids increased again in the 1830s, and by 1846 all estates in what is now Arizona were abandoned. The cattle not eaten by the Apaches roamed free in wild herds. Hastings and Turner (1965) document large herds of wild cattle, and state that cattle-raising was "...the severest cultural stress yet imposed on the region."

D2.6.3 American Exploration (1824–1835)

The first English-speaking Americans to set foot on what today is Arizona were 14 beaver trappers, one of whom was James Ohio Pattie. Pattie entered the state on 14 December 1824 on the Gila River (which he called Helay), and during 1824-1828 he trapped the Gila, San Francisco (St. Francisco), San Pedro (Beaver), and Colorado (Red) rivers, and also Bonita Creek. As Pattie traveled down the Gila, he described catching 30-40 beavers per night (Davis 1982). Pattie and Company arrived at the San Francisco River on 1 January 1825, catching 37 beaver that night, and by 14 January they had caught 250 beaver (Hayden 1965). Pattie arrived at the mouth of the San Pedro River on 3 March 1825, and by 10 March they had caught 200 beaver there (Davis 1982). He also noted catching a river otter on the Gila (apparently near Safford Valley). Other animals noted in Pattie's journal included bighorn sheep, mountain lions, grizzly bears, black bears, deer, javelina, and turkeys. On the upper Gila, he noted that the bottoms extended a mile on each side, covered with large cottonwoods and willows. Pattie also wrote that "... we were fatigued by the difficulty of getting through the high grass, which covered the heavily timbered bottom" (Davis 1982).

Upon arriving at the Salt River (which he called the Black River), Pattie described the confluence of the Salt and Gila as about 200 yards wide, with heavily timbered bottoms, and nearly the same flow in each river. He also tells of a bloody, hostile battle with the "Papwar" Indians at the mouth of the Salt. Travelling up the Salt, Pattie noted the river abounded with beaver and was surrounded by high rich bottoms. At the confluence of the Salt (right fork of Black) and Verde rivers (left fork of Black), Pattie and his company split into two groups, and during 1–16 February 1826, one explored the Verde River

and the other explored the Salt. Pattie mentions reaching the rivers heads in snow covered mountains, although he gave no description of habitat or animals encountered (Davis 1982).

Pattie traveled down the Gila to the Colorado River, where he remarked that, "The river, below its junction with the Helay, is from 200 to 300 yards wide ... and its timber chiefly cottonwood, which in the bottoms is lofty and thick set. The bottoms are from 6 to 10 mi wide ..." (Davis 1982). On the Colorado he noted a multitude of beavers, catching as many as 60 in one night, as well as ducks, geese, swans, pelicans, deer, mountain lions, fox, bobcats, and a jaguar. Continual harassment by indians forced Pattie and company to cease trapping on 16 February 1828. The party travelled overland into the Mexican settlements of Baja California, where they were imprisoned by Mexican authorities. Upon release, Pattie explored California, then travelled through Mexico City and Vera Cruz, arriving in New Orleans in August 1830 (Davis 1982).

By the mid-1830s, the price of beaver fur had crashed, and most trapping ceased. Davis (1982) concludes that "The trappers who worked the rivers of Arizona had no permanent impact on the land. They doubtless suppressed beaver populations in parts of Arizona for a time, but their activities were sporadic and short lived. The next wave of Americans to enter the Southwest would find no evidence that the Patties and like adventurers had been there."

D2.6.4 Mexican War (1846–1848)

The Mexican War broke out in April 1846, and in order to supply troops in California, a secure route was needed across Arizona. This brought U.S. troops (many of which kept journals) into Arizona, and Manifest Destiny also lured English-speaking Americans from the east into the west in this period. On 24 October 1846, mountain man and explorer Kit Carson noted a wolf on the Gila River (Davis 1982). Later accounts would describe both wolves and coyotes in Arizona. During the war, Davis (1982) cites many interactions between soldiers and wild cattle, which roamed the area since the Apache raids during 1830-1846. Hastings and Turner (1965) also document large herds of the animals.

The Mexican War ended with the ratification of the Treaty of Guadalupe Hidalgo on 4 July 1848, in which the United States purchased Mexico's northern holdings for $15,000,000 (Davis 1982). Under this treaty, the U.S. acquired all of Arizona north of the Gila River.

D2.6.5 Settlers, Miners, Surveyors, and Soldiers (1849–1870)

As the war came to an end, gold was discovered at Sutter's Mill in California in 1848. Gold fever swept the United States, and many wagon trains crossed Arizona as the "Forty-niners" made their way to California in 1849. During this same period, the U.S. sent boundary surveyors into the Arizona Territory. John R. Bartlett was placed in charge of the Boundary Commission, and along with Colonel James Graham described assemblages of wildlife, similar to those first mentioned by James Ohio Pattie. Some species noted by Bartlett included leopards (jaguars), cougars (mountain lion), ocelot, lynx (bobcat), panther (mountain lion or jaguar), brown (black) and grizzly bears, fox, antelope, deer, lobos (wolves), coyotes, Rocky Mountain sheep (bighorn sheep), beaver, and elk (north of the Gila). The party collected and preserved many specimens on their travels, and noted that bears were abundant, with one grizzly weighing 700–800 pounds. Along with wildlife, Bartlett also noted large numbers of wild cattle (Davis 1982).

The habitat described by Bartlett was similar to that detailed by Pattie; however, some changes had apparently taken place. Bartlett noted thick mesquite stands along some drainages (and also described

cienegas, treeless marshes of the southwest, in several valleys and in grassy areas near rivers). The rivers themselves had also changed since Pattie's exploration. Describing the San Pedro River following a torrential rain in 1852, Graham states, "The San Pedro runs here through a soft, alluvial soil, and its rapid current has worn a deep bed for it, leaving steep banks on either side." Bartlett also noted the San Pedro was 20 ft across, two ft deep, and quite rapid (Davis 1982). On 30 June 1854, 15 mi below the Salt River confluence, Bartlett found the Gila River completely dry. The Indians had diverted the entire flow onto their fields. Reaching the Salt River on 3 July 1854, Bartlett wrote, "The river we found to be between 80–120 ft wide, from two to three ft deep, and both rapid and clear. ... Along the immediate margin of the stream large cotton-wood trees grow" (Davis 1982).

On 30 December 1853, James Gadsden signed the "Gadsden Purchase," in which the United States paid $10,000,000 to Mexico for the area that includes most of Arizona south of the Gila River, to the present International Boundary. More explorers and troops entered Arizona to search for railroad and wagon routes, one such party was led by Lt. A.W. Whipple and H.B. Mollhausen. The group ventured across northern Arizona and down the Big Sandy and Bill Williams rivers to the Colorado River during 1853–1854. In February 1854, as they traveled down the Big Sandy River, Whipple wrote, "Big Sandy Creek abounds in antelope, deer, rabbits, and partridges [quail], feeding upon the rich gramma-grass, and the seed which it yields. Wolves (coyotes and lobos) are also numerous ..." (Davis 1982). Bighorn sheep were also common on the adjacent slopes. Near the present site of Wikieup, Whipple noted "... the stream changed its character, from alternate fertilizing rills and beds of sand, to a continuous rivulet, clear, rapid, and several feet in depth. Many fresh beaver dams existed upon this portion of the river, enlarging it so as to make the crossing difficult" (Davis 1982). Just above its confluence with the Santa Maria, beaver dams had inundated the narrow valley and the river became dense with willow brush.

The Bill Williams River supported marshes and abundant waterfowl. Moving down the Bill Williams, Mollhausen describes the river habitat of the 1850s:

> Sometimes we were stopped by the windings of the now deep and full river, sometimes by the marshy grounds formed by its overflow; here the thick wood and tangled business stopped the way, and there an almost impenetrable growth of canes, and other obstacles, requiring time and toil to overcome. Slowly we made our way over the marshy ground covered with innumerable waterfowl, and more slowly still passed places where every foot of our way had to be cleared with an axe. (Davis 1982)

From 1853 to 1864, settlers and miners began moving into and across Arizona. Encounters with grizzly and black bears, wolves, jaguars, and mountain lions increased with the flow of settlers into the area. Harvests of antelope, bighorn sheep, and deer continued, and quail were mentioned more often than in previous records. The Apaches had been raiding ranches and settlements since the Mexicans began moving into Arizona in the 1830's. With their surprise attacks and "hit and run" tactics, the Apaches basically controlled the Arizona wilderness and likely prevented rapid settlement.

The occupation of Arizona was further hampered by the Civil War (1861 to 1865), Hastings and Turner (1965) explain that: "The outbreak of the Civil War brought to a close the American development of the Gadsden Purchase, such as it had been. ... The Santa Rita Mining Company closed its doors; the territory's first newspaper ceased publishing; Tucson, a center of secessionism, stayed within its walls while the Apaches ruled without, if indeed their reign had been interrupted at all."

On 24 February 1863, President Lincoln signed into law a bill organizing Arizona as a territory. Construction of Prescott, the first territorial capital of Arizona, began in April 1864. Soldiers occupied Fort Whipple, near Prescott, in May 1864, to offer the settlers some relief from hostile Indians. As more settlers began traveling west, the soldiers escorted wagon trains across Arizona, most of which was still the domain of the Apache, Navajo, and Yavapai raiding parties. One such escort brought First Lieutenant Dr. Elliott Coues, a surgeon and naturalist, into Arizona on 7 July 1864. He collected numerous zoological specimens and added a wealth of knowledge to the natural history of Arizona before departing the state on 30 October 1865 (Davis 1982).

In 1864, King S. Woolsey, a frontiersman, led several expeditions in search of Apaches who had stolen livestock from ranches in the Prescott area. In March 1864, Henry Clifton, a volunteer, described a tributary to the Agua Fria River which they called Ash Creek, due to "... the abundance of fine ash timber that grew on its banks." Clifton continued, "The creek at this place is some ten ft in width and crossed by innumerable beaver dams, making it quite deep" (Davis 1982). In June 1864, another party traveled down Tonto Creek, reaching the confluence of the Salt River on 14 June. Here F.A. Cook, a chronicler, wrote, "We made a willow drag and caught about 200 fish. The largest ones looked very much like Cod but had no teeth, and would weigh between 10 to 20 pounds." Moving up the Salt to Grapevine Springs on 21 June he noted, "Made 4 or 5 hauls with our willow drag and caught about fifty fish all suckers, but very sweet. I think the best I ever tasted" (Davis 1982).

D2.6.6 Overview of Habitat Conditions Prior to 1870

Arizona supported large expanses of grasslands prior to 1870, and Hayden (1965) offers cogent testimony to this fact. Major John C. Cremony first visited the headwaters of the Gila River in 1850, and noted: "This gramma grass is beyond all comparison the most nutritious herbage ever cropped by quadrupeds. I give it the very first rank among all sorts of hay, believing it to be superior to clover, timothy, alfalfa, or all three together. From Dragoon Pass eastward the whole vast region inhabited by the Apaches is covered with this species of grass. ..." In a similar description of the area, Lt. Sylvester Mowry, who came to Arizona in 1858 wrote of the upper Gila River: "The sun never shone on a finer grazing country. The traveler has before him throughout the entire distance a sea of grass, whose nutritious qualities have no equal, and the stock raiser in January sees his cattle in better condition than our eastern farmer in his stall-fed ox." The upper Gila basin still supported grasslands in 1870, as observed by Captain John G. Bourke: "As for grasses, one has only to say what kind he wants, and lo! it is at his feet."

Habitat surrounding the Sam Simon River in 1859 was described by Samuel W. Cozzens, in Hayden (1965):

> The valley of the San Simon is about 25 mi in width, and contains much fine grazing land, as well as some good agricultural districts. It is covered with a species of grass called gramma, which for its nutritious qualities is rivalled only by the celebrated mesquite grass of Texas. In the region where it grows the settler requires no grain for his mules or horses ... and the stock-raiser who has fed his cattle upon gramma during the entire winter, finds them in quite as good condition in the spring as does the eastern farmer his stall-fed animals.

Heavy rains in the mountainous regions of the Southwest flowed off the vegetated slopes slowly, in thin even sheets (Davis 1982, Hastings and Turner 1965, Hayden 1965). Thus, the soil absorbed the water as it flowed and a natural irrigation was provided to the grasslands and valley floors. In 1857, Major William H. Emory, in Olmstead (1919), described the Gila River at its confluence with the Colorado,

as a clearer stream carrying about one third the flow of the Colorado. Beginning about the mid-1880s, however, the frequency and severity of floods increased.

D2.6.7 Cattle Industry (1870–1900)

By 1867, settlers had again moved into the San Pedro Valley, and as the army suppressed the Apaches through the 1870s, farming and mining increased. In 1870, there were 5000 cattle in Arizona, but government contracts for beef to supply the military and Indian reservations brought large cattle drives out of Texas and Sonora. Wagoner (1952) noted, "In 1872 Hooper and Hooker alone brought in four herds totaling 15,500 head." By 1880, 8000 cattle and 10,000 to 12,000 sheep grazed the San Pedro Valley, there were 20,000 cattle south of the Gila, and a total of 35,000 in Arizona (Hastings and Turner 1965).

The transcontinental railroad arrived in Tucson in 1880 and, by 1881, connected Benson, Arizona, with Guaymas, Sonora (Mexico), by way of the San Pedro River and Nogales. The 1880s therefore saw rapid expansion of the cattle industry. Hastings and Turner (1965) reported, "A great ballyhoo campaign waged by railroad prospectuses, livestock journals, and territorial legislatures trumpeted to an eager public that the West held easy riches and that grass was gold." Osgood (1929) stated, "A good sized steer when it is fit for the butcher market will bring from $45 to $60. The same animal at its birth was worth but $5. He has run on the plains and cropped the grass from the public domain for four or five years, and now, with scarcely any expense to his owner, is worth forty dollars more than when he started on his pilgrimage. ... That is all there is of the problem and that is why our cattlemen grow rich." Thus, by 1884 every stream or spring was settled upon, and the ranges stocked with cattle.

By 1885, the Governor reported that 652,500 cattle grazed the Arizona Territory. Ranchers, through the Southwestern Stockman (a cattle newsletter), complained that the ranges were "... already stocked to their full capacity, ..." and demanded that the influx of cattle be controlled (Hastings and Turner 1965). Cattle numbers continued to increase, and the habitat became seriously overgrazed. By 1890, Arizona's human population had grown to 60,000, and from 315,000 to 630,000 cattle grazed the land south of the Gila. In 1891, the Governor wrote that there were 1,500,000 head of cattle in Arizona, and the Southwestern Stockman conceded that "... the malady of overcrowding is with us in an aggravated form ..." (Hastings and Turner 1965).

Overgrazing had left much of the former lush grasslands, as well as the adjacent slopes, bare, with the soil exposed to the elements. These conditions were perfect for widespread erosion, and as a result, the frequency and severity of floods increased. Two newspapers, the Arizona Weekly Enterprise and the Arizona Daily Star, documented the furious flood waters and severe damage to the land. In August 1886, the San Pedro River was higher than it was ever known to be, and a six foot high avalanche of water swept down to its confluence with the Gila. Sonoita Creek was 10 ft deep in places, and the Santa Cruz River overflowed its banks and covered the valley. In September 1887, the San Pedro was higher than the previous years flood, and the Santa Cruz was more than a mile wide and very deep at Tucson.

Floods again plagued the Southwest in 1888 and 1889, and climaxed in 1890. Within the first two weeks of August 1890, the Santa Cruz River carved a channel at Tucson. The arroyo was about 200 yards wide and 1.5 mi long on 7 August, before forking at the head and spreading into the agricultural fields, cutting the main channel even deeper. In this same period, the San Pedro River carved a channel 30 ft deep in places. Similar destruction occurred on the San Simon and Sonoyta rivers, digging channels so deep below the level of the surrounding land that irrigation became nearly impossible and agricultural villages

were abandoned (Hastings and Turner 1965). Hastings and Turner (1965), describing the Santa Cruz and San Pedro rivers, maintain that "... the continuous present channels of these two rivers can be definitely dated from August, 1890."

Drought struck during 1891–1893 and cattle died in great numbers, with the Governor reporting losses of 50–75 percent of the herds. Of the period, Hastings and Turner (1965) note:

> ... that the overgrazing leading to the disaster of [18]93 had an enormous impact on the ecology of the region can hardly be doubted. ... Thousands of square miles of grassland, denuded of their cover, lay bared to the elements. The cropping unquestionably weakened the old plant communities, leaving them open to invasion; it unquestionably upset the balance between infiltration and runoff, in favor of the latter.

D2.6.8 Condition of Habitat After 1900

As noted by Hastings and Turner (1965), the once lush and expansive grasslands were left bare and exposed to the elements. Erosion and arroyo cutting ran rampant through the Southwest, and virtually all of the creeks and rivers gouged deep scars into the earth. In 1875, a section of the Gila River channel was 139 ft wide, but by 1919, the channel had grown to 1935 ft (Olmstead 1919). In a report to Congress on flood control on the Gila River, Frank H. Olmstead (1919) described the large-scale severe erosion that occurred along the Gila and its tributaries. Large herds of goats had been introduced to the steep slopes of the rough broken country of the Apache Forest. Olmstead described the goats impact on the San Francisco River, "The entire agricultural area of these mountain streams has been swept away during the last 10 years. Erosion goes on at a terrific and ever accelerating rate and the forest growth itself so will soon be effected by the drying up of moist drainage lines and cienagas through the rapid run-off in deeply eroded gully lines." He notes similar damage to Dix Creek, a tributary of the San Francisco River.

Describing the Blue River, Olmstead wrote: "Thirty years ago the Blue River flowed through a sodded or cultivated bottom land and in the channel lined with tall pines and cottonwoods. ... White gramma grass, an excellent forage plant, attaining a height of 30 in.es, once grew luxuriantly over all the open country, and pine grass covered the woodlands." Conditions in 1919, however, were different: "The slopes of the Blue River have but little sod ..." and "... the entire watershed has suffered greatly from overgrazing. ..." Of the side drainages along the Gila, Olmstead states: "These streams throw large crests and great quantities of detritus into the Gila ..." and "... the majority of these streams have been eroded clear to their source, and each year sees an increased quantity of soil matter poured into the Gila." Olmstead gives similar descriptions of Little Blue Creek, Beaver Creek, Indian Creek, Corduroy Canyon, Sapillo Creek, Duck Creek, Bear Creek, Mangas River, Eagle Creek, Mineral Creek, Keller Canyon, Tularosa Creek, and Karuth Creek.

Vast changes also occurred on the San Simon River. In the location described by Cozzens (Section D2.6.6), settlers excavated a small channel, about 4 ft deep and 20 ft wide, for a short distance in 1883, so flood waters would be concentrated and flow into the Gila. The channel had grown, as described by Olmstead (1919) "... to-day there is a chasm, in many places 600 to 800 ft wide and from 10 ft to 30 ft deep, for 60 mi. ..." In his conclusion, Hayden (1965) stated, "A vast area which was once covered with a marvelous growth of grass has been damaged by livestock ..." and "... the nature of the Gila River has been so changed by overgrazing that, without reservoirs to store its flood waters, that stream is no longer dependable for irrigation."

As arroyos dug deeper into the earth, they eventually hit the ground water level and thus drained the land (much like the process of laying tile, currently used to drain marshland for agriculture). Once the water table was lowered, the plant communities and species composition, diversity, and density changed. From 1890 to the early 1900s, brush and woody-plants invaded large areas of formerly open grassland. Hastings and Turner (1965) document through paired photographs, taken at the same locations over time, that there has been an "... upward displacement of plant ranges along a xeric to mesic gradient ..." and "... the prevailing pattern has been a shift toward drier or hotter conditions." Mesquite began invading the area in the late 1890s (Griffiths 1903, 1910, Thornber 1910, Martin and Turner 1977), as did several Acacia species, including white thorn (*Acacia constricta*), (*Acacia vernicosa*), and catclaw (*Acacia greggii*) (Hastings and Turner 1965). Similar changes were noted by Davis (1982).

> In southern Arizona, mesquite (*Prosopis juliflora*) and other woody tropic-scrub plants have invaded large areas of formerly open grassland; the grasses have been replaced by burroweed (*Haplopappus tenuisectus*) and snakeweed (*Gutierrezzia sarathroe*). Elsewhere junipers (*Juniperus monosperma* and others) have moved into former grasslands, and in the north, snakeweed, sagebrush (*Artemisia tridentata*), and rabbitbrush (*Chrysothamnus* spp.) have proliferated at the expense of native grasses.

In general, the valleys were wetter and more open than today, and the overall tendency has been toward shrubbiness and a less open, less expansive landscape (Hastings and Turner 1965).

D2.6.9 Summary of Human Impact on Arizona Habitats

Rivers and perennial streams served as trails for early American trappers, explorers, and pioneers. Traveling close to water, they observed many species of wildlife, although mainly game species were documented. The rivers of Arizona abounded with beaver when the first trappers arrived in the 1820s (Davis 1982, Hastings and Turner 1965, Hayden 1965), and many drainages still supported numerous beaver as late as 1882. The beaver no doubt slowed streamflow and their marshes likely spread even heavy rains over large areas, preventing rapid runoff and channelization. The value of beavers is supported in financial terms by Hayden (1965).

Torrential rains were not uncommon in the mountainous regions of the Southwest, and 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, 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 during 1870–1893, much of the former lush grassland in Arizona lay in ruin; the earth left bare and compacted, especially along cattle trails. Soil compaction reduced infiltration rates, which, compounded by the loss of vegetation, allowed water to flow over the land much faster than previously. The trails created trenches, where rain waters concentrated, now flowing off the slopes faster due to vegetation loss. This path of least resistance allowed a larger volume of water to pour off the slopes in concentrated areas, and subsequently cut arroyos into the hillsides. These gullies grew larger and deeper with each heavy rain.

The principle of self-perpetuating erosion is stated by R. Reynolds in Hayden (1965), "Accordingly, as a gully increases in size the friction increases only in direct proportion to the dimensions of the channel, while the discharge increases as the product of the dimensions. Thus, if the dimensions of the gully are increased by 10 times, the friction is also increased approximately 10 times, while the volume of the discharge is increased approximately 100 times." Therefore, the rain waters concentrated into arroyos,

sped off the slopes, and caused severe floods and erosion in the valleys. The swollen creeks and rivers turned brown with sediment and cut deeper incisions into their channels. The increased rate of 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 only flotsam and jetsam in its wake.

Summarizing the disastrous changes to the landscape, Hastings and Turner (1965) state, "Not quite overnight, but certainly during the course of a single summer, many of the streams of the region underwent a striking change in their hydrologic regimes." The San Pedro River wound a sluggish course north through a wide marshy valley until August 1890, when it began carving a steep-walled trench which thereafter carried a rapid torrent into the Gila after rains, and remained dry over much of its length during most of the year (Hastings 1959). During the same period, most of the major drainages in southern Arizona fell prey to such catastrophe, and most of the better farm land was washed away. The arroyos cut deeper and deeper into the earth with each heavy rain, intersecting the water table, and thus draining the land, creating drier soil conditions. As the water table dropped, the riparian forests began to fall apart, being reduced to linear strips in many areas (Hastings and Turner 1965, Martin and Turner 1977, Davis 1982). One compensation was that malaria, a major plague among the early settlers, disappeared along with the marshes, beaver, and fish (Hastings and Turner 1965).

Antevs (1952) attributes the present cycle of arroyo cutting in Arizona to overgrazing, and he states:

> Clearly, if left alone, the native vegetation could have weathered the droughts during which the arroyo erosion set in during the 1880s. The impoverishment of the plant cover which permitted the channeling must have been caused by new and foreign detrimental agencies, and the new factors during the 1870s and 1880s were large herds of cattle and sheep and numerous settlers. Therefore, the reduction of the vegetal cover which allowed arroyo-cutting to begin during the 1880s in the Southwest was caused by livestock and man.

The impact that overgrazing had on the land from 1870 to 1900 is still with us today. Once awakened, the erosion monster refuses to sleep, and the condition of the land and habitat is still being degraded. Formerly perennial rivers and creeks are now intermittent or ephemeral, seasonally and locally drying up entirely. When heavy rains fall, flash floods continue the cycle of erosion and cut deeper into the earth. Assisted by groundwater pumping for irrigation and metropolitan areas, the growing ravines 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 riparian forests continue to dissociate. Further infected by continual grazing, resulting in the loss of regeneration (Rubink and Podborny 1976, Stumph and Creighton 1977, Hildebrandt and Ohmart 1978, Ohmart and Sell 1980, Hildebrandt 1981, Haywood and Ohmart 1981, BioSystems 1990), the riparian forests have completely disappeared in some areas, and become mere shadows of their former grandeur in others. Many riparian corridors now support only single lines of trees, or single isolated trees.

Most terrestrial and avian wildlife populations have also suffered from the loss of habitat, although those which prefer dry, shrubby areas have increased. Grass-dependent species of birds, such as the masked bobwhite, disappeared almost immediately, and others, preferring open grass habitats, suffered considerable reduction (Phillips *et al.* 1964). Similarly, the loss of grasslands and lowering of the water

table has caused many species of plants and mammals to disappear. Heavy overgrazing has left little likelihood that some mammal species can ever occur now where they did previously (Hoffmeister 1986).

Fish species have also vanished as their habitat was destroyed by fast moving, sediment laden waters (see Section E1). This process is documented by Arthur W. Sampson, in Hayden (1965):

> After the breaking up of the vegetative cover caused by overstocking during the happy-go-lucky grazing period, many streams that had originally a steady, yearlong flow, and teemed with trout became treacherous channels with intermittent flow through which plunged the water from rainstorms. Most of the streams swelled suddenly and subsided as quickly according to the size and frequency of the storms; and many such flows carried so much sediment that fish and similar life could not exist in the water.

The destruction of fish populations is also described by Hayden from a U.S. Department of Agriculture Bulletin in 1911:

> In addition to the loss of property, the floods have resulted in the destruction of many fish. All the mountain streams were formerly of clear, cold water, and were fairly well stocked with trout. Residents state that in early days the water never became muddy after a storm, whereas the erosion has now become so great that on the western slope the streams are turbid after every rain. The fish have been killed in the thick mud brought down by floods, until at the present the trout fishing is very poor, and in some canyons no fish can be found except such as have been introduced. The total disappearance of native trout from streams known to have been well stocked in former years is in itself a significant fact, pointing to a fundamental disturbance of conditions in the run-off.

Davis (1982) noted "... occasionally very large fish (up to three ft in length and thirty pounds in weight) were reported from the Gila, Salt, and San Pedro rivers. These impressive "salmon-trout" as they were often termed by the pioneers were undoubtedly Colorado River squawfish (*Ptychocheilus lucius*), now extinct in Arizona." Of the native trout species Davis (1982) wrote: "None of the early expeditions reported the true native trout (*Salmo gilae* and *Salmo apache*). The rugged mountainous region of central and east central Arizona, the home of the native trout and the Apache Indian, was avoided by travelers and transportation route surveyors alike."

D2.6.10 Salt and Verde Rivers

There is an obvious lack of historical information for the Salt and Verde rivers, likely due to their occupation by the Apache Indians. Some settlers did enter the area after the 1870s, when U.S. soldiers had largely suppressed the Apache raids. Large Colorado River squawfish were still taken from the Salt River at the turn of the century, as evidenced by the photo on the first page of Minckley (1973). Although the very large squawfish (up to 30 pounds) described by Davis (1982) are now gone, catfish of similar size still inhabit the Salt and Verde rivers. At the location of the photo in Minckley, between Redmond Flat and Cherry Creek on the Salt River, from 1985–1989, we have sampled flathead catfish ranging between 3–35 pounds, many in the 8-15 pound size, and four weighing 25, 27, 28 and 35 pounds. We have also sampled channel catfish from 1–15 pounds in the Salt and Verde rivers, with one weighing 25 pounds.

Floods also occur on the Salt and Verde, even though the lower portions of the rivers are regulated by dams and their associated reservoirs. In recent times (1978 and 1983) floodwaters of 83,000 cfs destroyed bridges in Phoenix, where the river is usually dry. The upper Salt and Verde flow freely, and similar to Hastings and Turner's descriptions of the Gila, flood conditions on the Salt in mid-March 1985 sent a 12-foot wall of water past Cibecue Creek, which thinned to 4–6 ft as it passed Horseshoe Bend, before emptying into Roosevelt Reservoir. Such a volume of water sent large boulders smashing against one another, with a sound resembling gunshots echoing off the cliffs for several days as the water remained at high levels.

Grazing of domestic livestock, principally cattle, has had a serious impact on the native vegetation. In riparian areas, cottonwood, sycamore, and willow seedlings are highly palatable, and rapidly consumed by cattle, thus suppressing the growth of, if not killing, the small trees. When the large cottonwood, willow, and sycamore trees and snags fall, there will be few smaller trees to replace them. In many cases, the suppression of native species by grazing has led to vast expanses of salt cedar, an introduced species of low value to wildlife which spreads rapidly without competition.

In addition to the loss of riparian vegetation, the habitat adjacent to these streams has also been impacted by cattle. Overgrazing of upland habitats has left many slopes bare or with minimal ground cover, causing serious erosion problems. The Salt and Verde rivers turn red with sediment washed off upland slopes following rain showers, soil that is lost forever and which may adversely affect fish populations on its way to reservoirs downstream where it forms the basis of siltation problems. As topsoil is washed away, native plants give way to hardier exotics. In some cases the erosion is so bad it perpetuates itself, creating large gullies and ravines. In summary of the current condition of the land along the Salt and Verde rivers and their tributaries, it is obvious that overgrazing-induced erosion has been similar to that well documented on the Gila, although possibly to a lesser extent.

D2.7 DAM AND RESERVOIR CONSTRUCTION

Arizona's loss of soil through overgrazing and the resultant need for water storage, irrigation, and flood control, prompted the construction of dams on most of the major rivers in the state in the early 1900s. These dams, also valuable for hydroelectric power, dramatically altered the habitat in positive and negative ways. Although large reaches of riparian vegetation were inundated, the dams stored water which otherwise would have rushed downstream at a highly unnatural rate due to erosion and loss of ground cover (see Sections D2.6.7–9). The reservoirs supply recreation and allow many wildlife species which utilize large bodies of water to winter or become permanent residents in Arizona. Most reservoirs are utilized by at least one pair of breeding bald eagles, as well as non-breeding Arizona eagles, and wintering eagles from other states and provinces.

Irrigation of the Salt River Valley (near Phoenix) began about 1867. From then through 1902, a number of diversion dams and canals were built by private companies and communities to irrigate farmland in the valley. Disputes over water distribution, inadequate flood control, and the high cost of water storage dams, spawned the creation of the Salt River Valley Water Users' Association on 9 February 1903, which would provide water and power to approximately 4,800 individual landowners (Salt River Project 1983). All dams on the Salt and Verde rivers are now operated by Salt River Project.

D2.7.1 Salt River

Six dams were constructed on the Salt River for water storage, flood control, hydroelectric power, and irrigation. Two diversion dams were built prior to the large reservoir impoundment dams. The Roosevelt Diversion Dam, a concrete weir dam with embankment wings, was completed in 1906 for irrigation purposes and to divert water during the construction of Theodore Roosevelt Dam. The diversion dam, located on the upper Salt River at River Kilometer (Km) 110.8 (110.8 Km above Granite Reef Diversion Dam), was reconstructed from 1936 to 1937, and further modified during 1937–1938. The dam had a structural height of 12 ft, hydraulic height of 8 ft, total crest length of 862 ft, weir crest length of 500 ft, weir crest elevation of 2,180.25 ft, and a diversion capacity of 220 cfs (cubic ft per second) (Salt River Project 1983). Safety considerations of recreators near the Roosevelt Diversion Dam prompted its reconstruction in 1989. The hydraulics below the old dam, a straight concrete dam with pylons below, created a safety hazard for rafters and fishermen. The new design, a stair step concrete dam, reduces the risk of drowning yet continues to serve as a barrier to fish migrating upstream out of Roosevelt Reservoir.

The Granite Reef Diversion Dam, a concrete ogee weir dam with embankment wings, constructed in 1908, diverts the Salt River into canals just below the Verde River confluence, leaving the Salt riverbed through Phoenix dry for most of the year. Since this diversion dam virtually terminates all stream flow, we refer to its location as Km 0.0 on the Salt River. This dam, about 22 mi east of Phoenix, has a structural height of 29 ft, hydraulic height of 18 ft, total crest length of 1128 ft, weir crest length of 1000 ft, weir crest elevation of 1310.0 ft, and a diversion capacity of 2000 cfs on the north side and 1600 cfs on the south side (Salt River Project 1983).

In addition to creating water storage, the four reservoir impoundment dams on the Salt River produce hydroelectric power and are equipped with pumped storage, which allows water to be pumped from the lower reservoir, back into the upper reservoir, by reversing the turbines during periods of low energy demand. The Salt River flows naturally from its origin at the confluence of the Black and White rivers until it enters Roosevelt Reservoir, created by Theodore Roosevelt Dam at Km 79.1 on the Salt River.

Theodore Roosevelt Dam, a National Historic Monument, is a cyclopean masonry thick arch structure, constructed from 1903 to 1911 by the U.S. Bureau of Reclamation. The dam has a structural height of 280 ft, hydraulic height of 234 ft, top width of 16 ft, maximum base width of 184 ft, crest length of 723 ft, and crest elevation of 2142.0 feet. The spillways, modified by the U.S. Bureau of Reclamation at various times from 1913 to 1936, are unlined open channels at each abutment, with gate elevations of 2136.0 ft, crest elevations of 2120.3 ft, and a capacity of 150,000 cfs. In addition, two steel pipes through the right side of the dam have capacities of 1560 and 1600 cfs. The reservoir has an average annual inflow of 686,825 acre-ft (an acre of water one foot deep), total capacity of 1,381,580 acre-ft, and a surface area of 17,300 acres (Salt River Project 1983).

Theodore Roosevelt Dam is scheduled for renovation in the near future, which will include power and water storage modifications. Currently, the dam has only one 2400 cfs hydroelectric power turbine unit; however the unit is being replaced with a turbine that will have a generating capacity of 10,000 cfs (T. Gatz, pers. comm.). Water storage alterations involve removal of the top six ft of the dam to an elevation of 2136 ft, then rebuilding the structure to a crest elevation of 2218 ft (76 ft higher than the existing dam), and reconstructing the spillways. Upon completion, the maximum conservation pool would extend to Meddler Point on the Salt Arm, and to A-Cross Road on the Tonto Arm; however, in flood conditions reservoir levels could extend beyond the Highway 288 bridge (U.S. Bureau of Reclamation 1983).

Plate D2. The Roosevelt Diversion Dam, completed in 1906, provided irrigation and also diverted water during the construction of Theodore Roosevelt Dam (photo by D. Driscoll, July 1986).

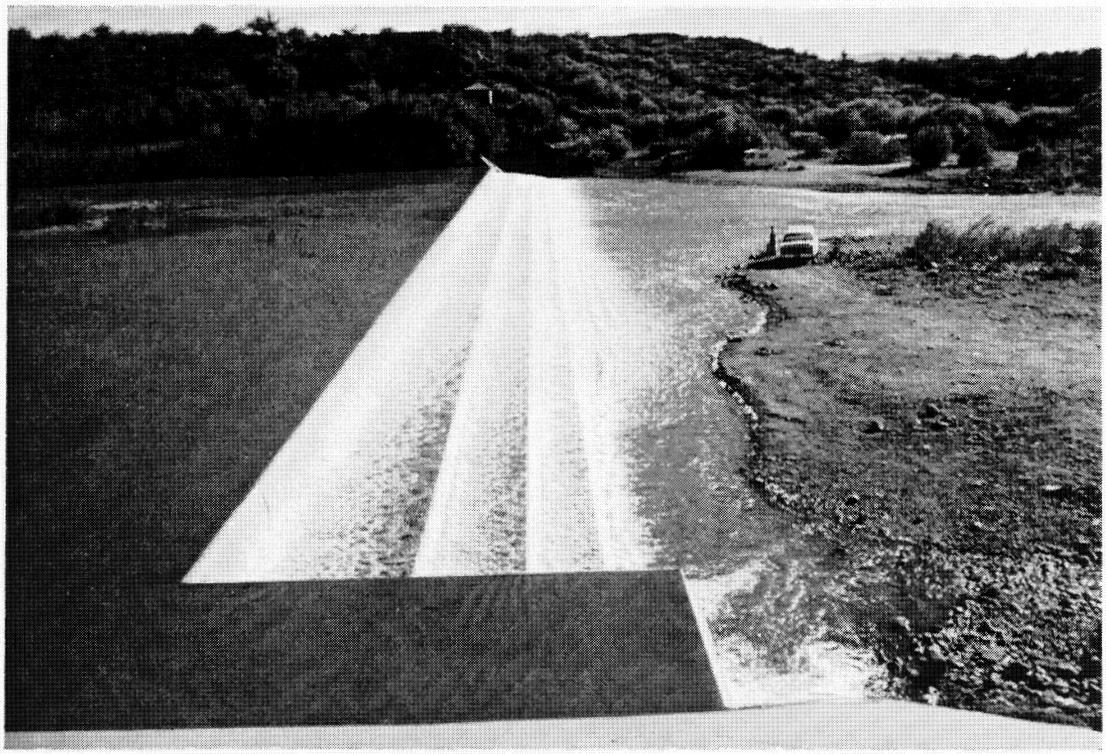

Plate D3. The Roosevelt Diversion Dam was reconstructed in 1989 to reduce the risk of drowning, yet still serve as a barrier to fish migrating upstream out of Roosevelt Reservoir (photo by D. Driscoll, April 1990).

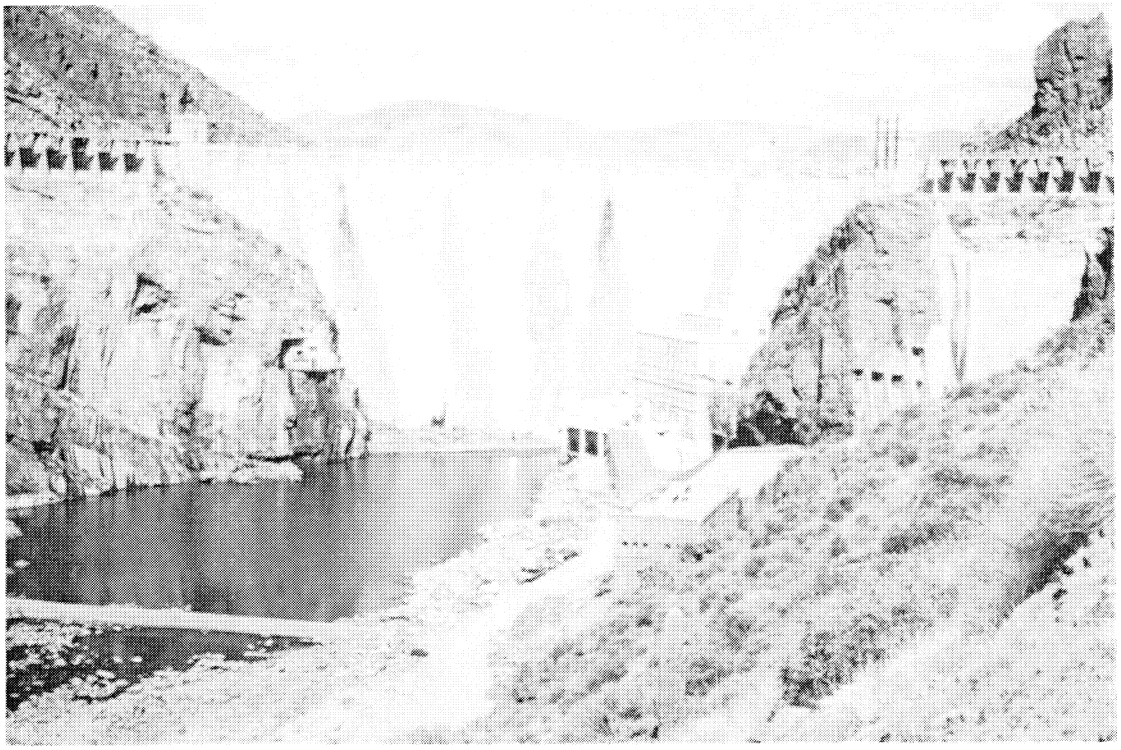

Plate D4. Theodore Roosevelt Dam, a National Historic Landmark, was constructed from 1903-1911. The stones were cut and shaped from nearby cliffs (photo by D. Driscoll, September 1986).

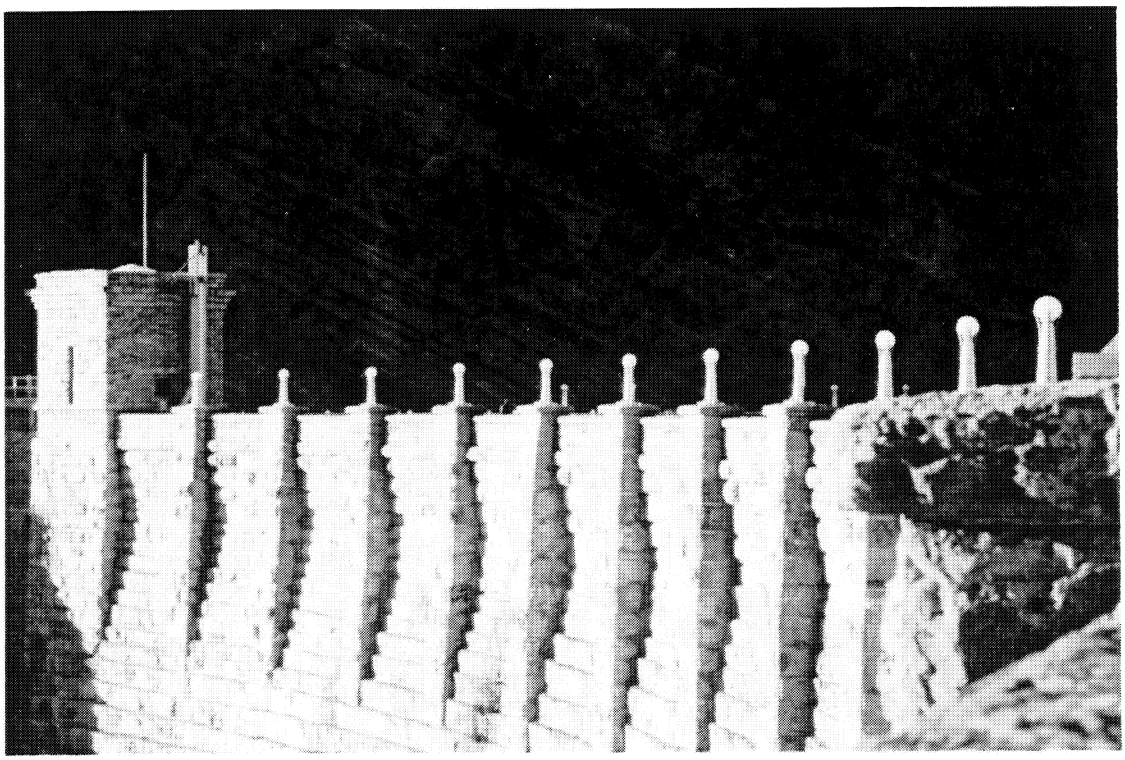

Plate D5. The crest of Theodore Roosevelt Dam, showing artwork of stone-cutting, also served as a bridge for vehicles traveling Highway 188 until 1991. A new bridge now spans Roosevelt Reservoir just east of the dam (photo by D. Driscoll, November 1986).

Below Theodore Roosevelt Dam the Salt River is regulated as it moves west toward Phoenix, flowing into Apache Reservoir, backed up by Horse Mesa Dam at Km 52.3. Horse Mesa Dam, constructed during 1924 to 1927 by the Salt River Valley Water Users' Association, is a concrete thin arch dam, with a structural height of 305 ft, hydraulic height of 266 ft, top width of 8 ft, maximum base width of 57 ft, crest length of 660 ft, and crest elevation of 1915.0 ft, with the parapet at 1920.0 feet. The spillways, modified by the U.S Bureau of Reclamation during 1936 to 1937, are concrete overall structures at each abutment, with gate elevations of 1914.0 ft, and crest elevations of 1891.0 feet. In addition, there is a concrete-lined auxiliary tunnel spillway through the right abutment, for an overall capacity of 150,000 cfs. The reservoir has a total capacity of 245,138 acre-ft, and a surface area of 2660 acres (Salt River Project 1983). Horse Mesa Dam has three hydroelectric power turbine units, with a combined generating capacity of 7000 cfs, and 4300 cfs pumpback storage capabilities.

Below Horse Mesa Dam the Salt River quickly enters Canyon Reservoir, created by Mormon Flat Dam at Km 36.6. Mormon Flat Dam, built by the Salt River Valley Water Users' Association during 1923–1926, is a concrete thin arch dam, with a structural height of 224 ft, hydraulic height of 142 ft, top width of 8 ft, maximum base width of 20 ft, crest length of 380 ft, and crest elevation of 1666.0 feet. The spillway, modified by the U.S. Bureau of Reclamation during 1937–1938, is a concrete-lined channel at the right abutment, with a gate elevation of 1660.5 ft, a crest elevation of 1610.5 ft, and a capacity of 150,000 cfs. In addition, two 72-in.-diameter penstocks control river flow under low reservoir conditions. The reservoir has a total capacity of 57,852 acre-ft, and a surface area of 950 acres (Salt River Project 1983). Mormon Flat Dam has two hydroelectric power turbine units, with a combined generating capacity of 6500 cfs, and 4100 cfs pumpback storage capabilities.

From Mormon Flat Dam the Salt River flows into Saguaro Reservoir, created by Stewart Mountain Dam at Km 21.8. Constructed by the Salt River Valley Water Users' Association from 1928–1930, Stewart Mountain Dam is a concrete thin arch dam, with a structural height of 207 ft, hydraulic height of 114 ft, top width of 8 ft, maximum base width of 33 ft, crest length of 1260 ft, and crest elevation of 1530.0 feet. The spillway, modified by the U.S. Bureau of Reclamation in 1936, is a concrete weir and concrete-lined open channel at the left abutment, with a gate elevation of 1529.0 ft, a crest elevation of 1506.0 ft, and a capacity of 105,000 cfs. In addition, one 84-in.-diameter steel pipe controls river flow under low reservoir conditions. The reservoir has a total capacity of 69,765 acre-ft, and a surface area of 1260 acres (Salt River Project 1983). Stewart Mountain Dam has one hydroelectric power turbine unit, with a generating capacity of 3800 cfs. Pumpback storage capabilities are planned for addition in future improvements, as well as increased spillway capacity to 214,000 cfs (U.S. Bureau of Reclamation 1987).

The lower Salt then flows to its termination at a small impoundment (Maxwell Reservoir) behind Granite Reef Diversion Dam. The riverbed is dry through Phoenix, except during heavy rainstorms and flood conditions. Perennial flow in the Salt River, west of Phoenix to its confluence with the Gila River, is a result of urban effluent discharges.

D2.7.2 Verde River

Two water storage and flood control dams have been constructed on the Verde River north of Phoenix. The Verde flows freely from the north, although much of the water is diverted as it passes through inhabited areas on its way to Horseshoe Reservoir, created by Horseshoe Dam at Km 73.4. Constructed by Phelps Dodge Corporation in 1949 as part of a water exchange agreement, Horseshoe Dam is an earthfill and rockfill dam, with a structural height of 194 ft, hydraulic height of 142 ft, top width of 39 ft,

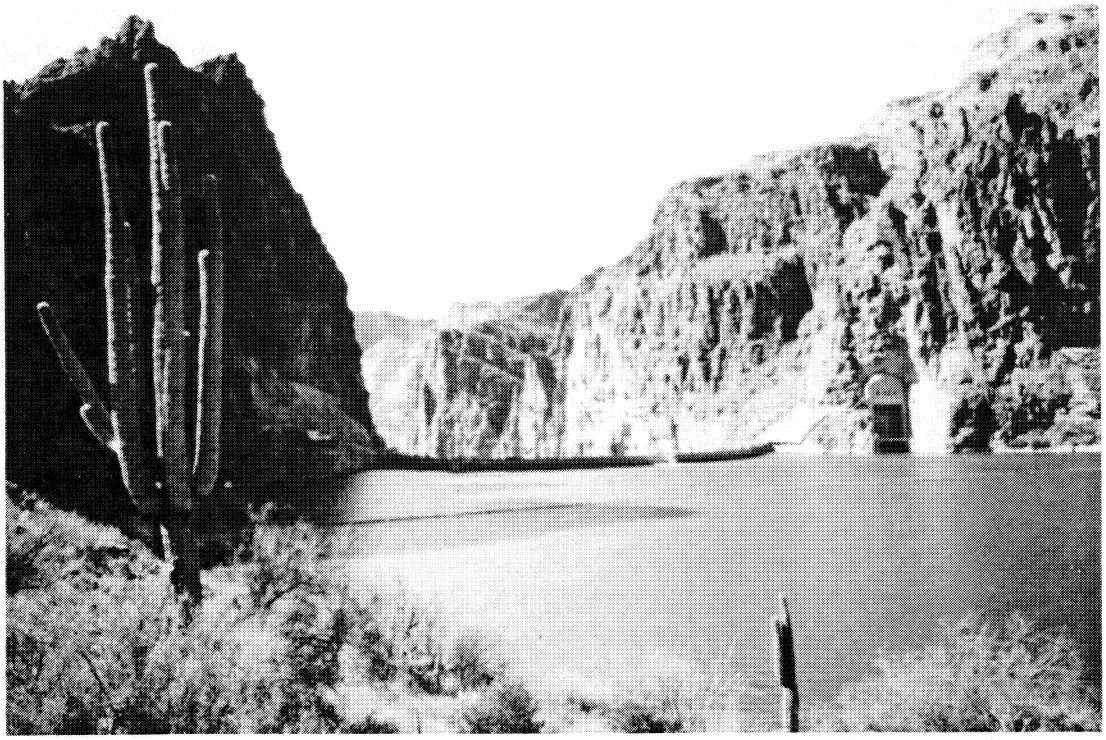

Plate D6. Apache Reservoir at the crest of Horse Mesa dam. The dam has pumpback storage capabilities, where by reversing the hydroelectric turbines, water is pumped from Canyon Reservoir (below the dam) back up into Apache Reservoir. Note the concrete gate on the right abutment that releases water into the spillway tunnel (photo by D. Driscoll, February 1986).

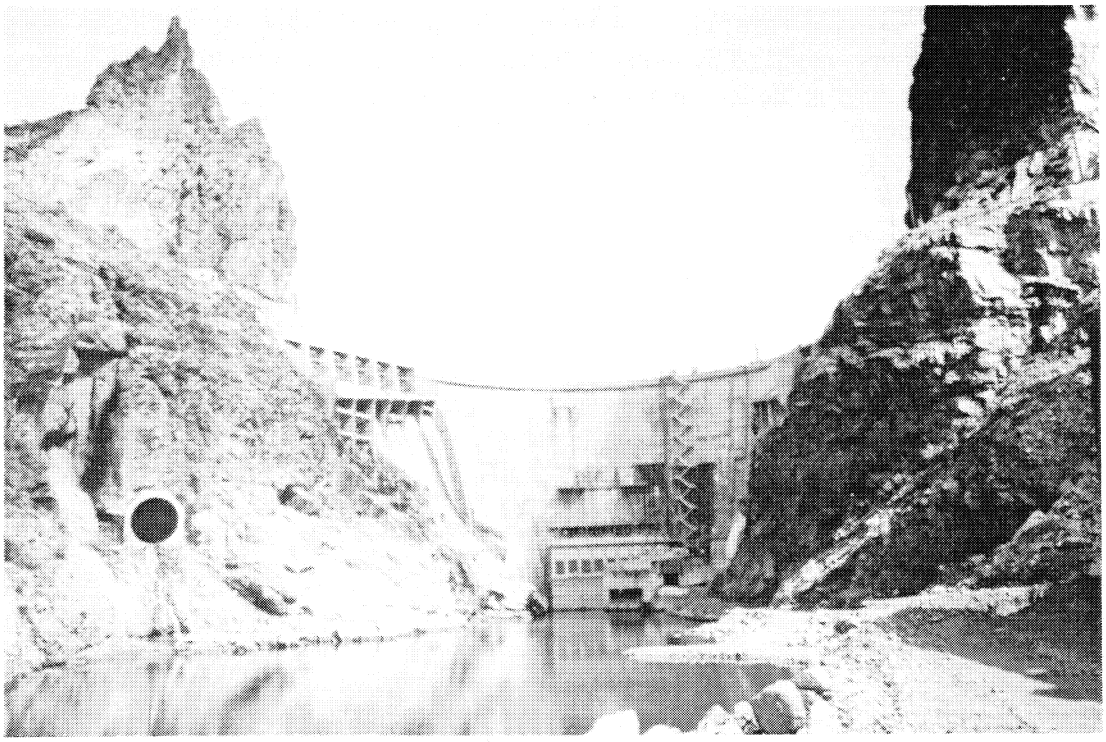

Plate D7. Horse Mesa dam, constructed during 1924-1927. Note the spillway tunnel on the left (photo by D. Driscoll, February 1986.

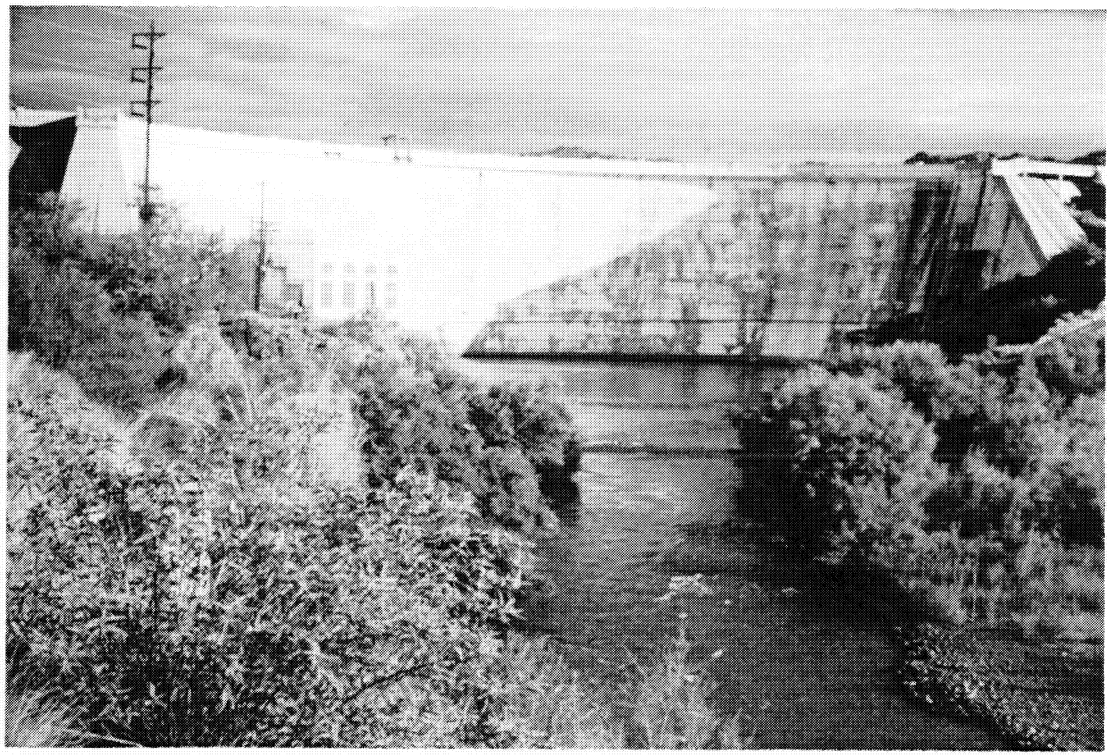

Plate D8. Stewart Mountain Dam, constructed during 1928-1930, is the fourth and final hydroelectric dam on the Salt River. The regulated Salt River flows from the dam to the Verde River confluence, then on to Granite Reef Diversion Dam where the river is diverted into canals (photo by D. Driscoll, September 1986).

Plate D9. Location of Orme Dam, proposed in the 1970s but never built, at the Salt and Verde River confluence (photo by D. Driscoll, September 1987).

Plate D10. Horseshoe Dam releasing water into the regulated Verde River. The two dams on the Verde River are for water storage and flood control, and do not produce hydroelectric power (photo by D. Driscoll, June 1986).

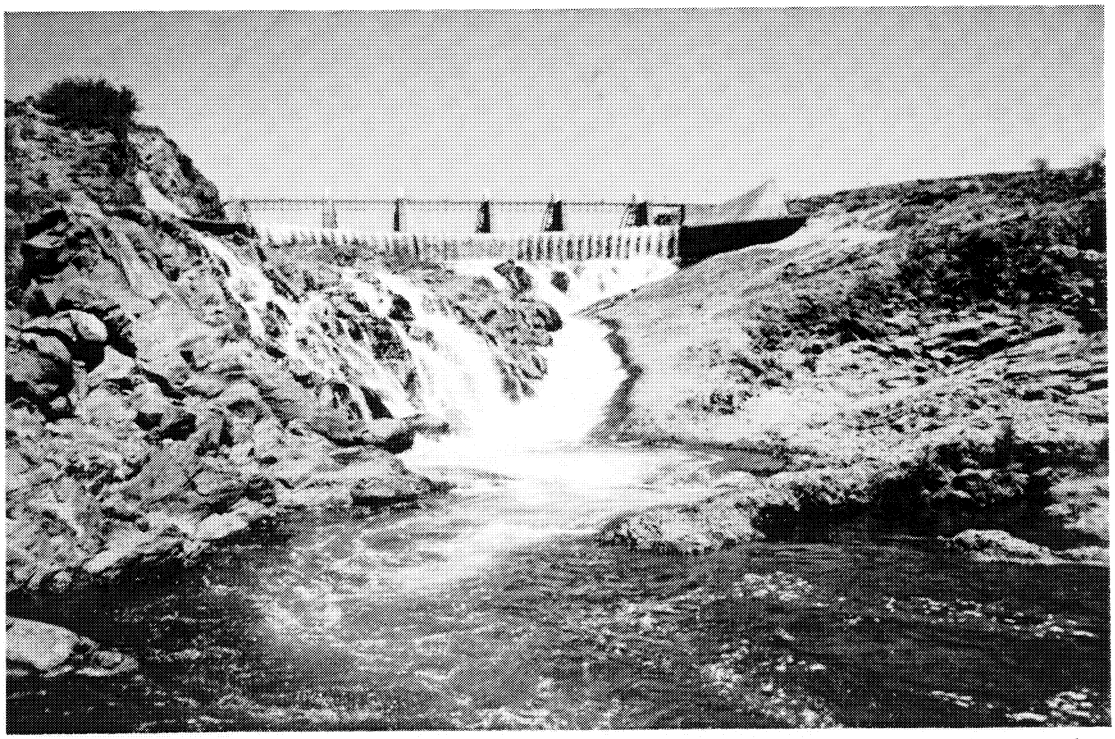

Plate D11. Horseshoe Dam is smaller than other impoundment dams on the Salt and Verde rivers, and creates a shallow reservoir (Horseshoe) without a hypolimnion layer, thus water releases are warmer than those from other dams (photo by D. Driscoll, June 1986).

earthfill and rockfill dam, with a structural height of 194 ft, hydraulic height of 142 ft, top width of 39 ft, maximum base width of 619 ft, crest length of 1140 ft, and crest elevation of 2044.0 feet. The spillway is a concrete-lined channel at the right abutment, with a gate elevation of 2026.0 ft, a crest elevation of 2000.0 ft, and a capacity of 250,000 cfs. River flow is regulated by a circular outlet tower 126 ft high behind the left abutment, which has a capacity of 2200 cfs. The reservoir has an average annual inflow of 342,000 acre-ft, a total capacity of 139,238 acre-ft, and a surface area of 2,720 acres (Salt River Project 1983).

The river is regulated as it flows south to Bartlett Reservoir, backed up by Bartlett Dam at Km 39.3. Built by the U.S. Bureau of Reclamation during 1936–1939, Bartlett Dam is a concrete multiple arch dam, with a structural height of 287 ft, hydraulic height of 188 ft, top width of 4 ft, maximum base width of 390 ft, crest length of 800 ft, and crest elevation of 1799.5 feet. The spillway is a concrete-lined channel at the right abutment, with a gate elevation of 1798.0 ft, a crest elevation of 1748.0 ft, and a capacity of 175,000 cfs. River flow is regulated by five steel pipes through the dam near the left abutment, which have a capacity of 4000 cfs. The reservoir has an average annual inflow of 346,043 acre-ft, a total capacity of 178,490 acre-ft, and a surface area of 2775 acres (Salt River Project 1983).

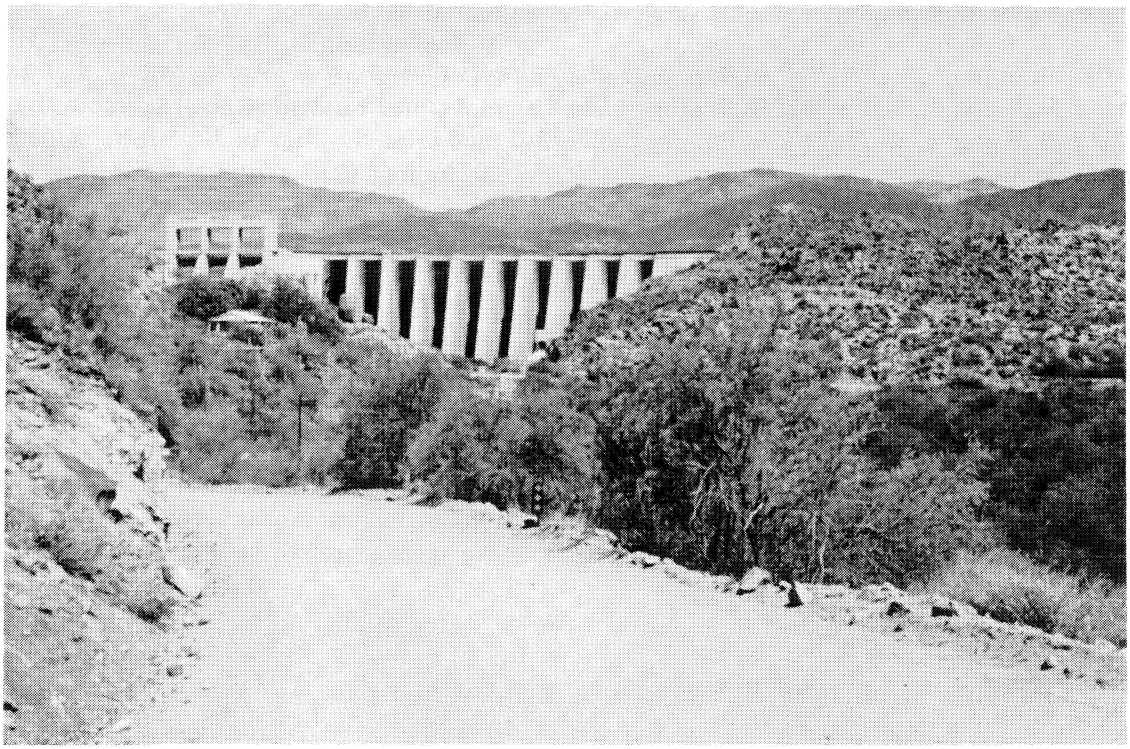

Plate D12. Bartlett Dam, constructed during 1936-1939, releases cool water from the reservoirs hypolimnion layer into the regulated Verde River (photo by D. Driscoll, August 1991).

Below Bartlett Dam, the Verde flows through the Fort McDowell and Salt River Indian Reservations, where portions are diverted for agriculture. The Verde River then empties into the Salt River at Km 5.5, just above Granite Reef Diversion Dam.

Two dams were proposed for the Salt and Verde rivers but never built. Orme Dam, proposed in the 1970s, would have been located on the Salt River, just below the confluence of the Verde River. Cliff dam was proposed in the 1980s, for construction between the existing Horseshoe and Bartlett dams on the Verde River.

D2.7.3 Other Drainages

In addition to the Salt and Verde rivers, reservoir impoundment dams were also constructed on the Gila, Agua Fria, and Bill Williams rivers. The three dams were built principally for flood control, irrigation, and water storage; however, Coolidge Dam on the Gila River produces hydroelectric power.

Coolidge Dam, which stores water in San Carlos Reservoir, was constructed on the Gila River by the U.S. Bureau of Indian Affairs and completed in 1931. The dam, a National Historic Monument, is a multiple dome reinforced concrete structure, with a spillway crest elevation of 2511 ft, conservation pool of 2523 ft, and a reservoir capacity of 912,000 acre-feet. Coolidge Dam is in need of modifications under Safety of Dams requirements sometime in the future, which will include spillway and power alterations. San Carlos Reservoir currently has a surface area of 17,212 acres; however, when spillway gates are repaired, the surface area will increase to 19,579 acres (T. Gatz, pers. comm.). Currently, the dam has two hydroelectric power turbine units with a combined capacity of 4000 cfs; however, they are now capable of delivering only 1500 cfs safely (U.S. Bureau of Reclamation 1984).

Alamo dam was built by the U.S. Army Corps of Engineers during 1963–1968 at Km 43.8 on the Bill Williams River, and creates Alamo Reservoir. The dam is a zoned earthfill structure, with a structural height of 283 ft, top width of 30 ft, crest length of 975 ft, and crest elevation of 1265 feet. A detached, broadcrested spillway at the right abutment, with a crest elevation of 1235 ft, and an unlined trapezoidal channel 110 ft wide by about 500 ft long, cuts through a rock saddle with a concrete sill, 3 ft wide by 116 ft long. The reservoir has a total capacity of 1,046,200 acre-ft, and a surface area of 13,300 acres (U.S. Army Corps of Engineers 1989).

On the Agua Fria River, Pleasant Reservoir has a surface area of 3966 acres (T. Gatz, pers. comm.) and is backed up by Waddell Dam, built in 1928 by the U.S. Bureau of Reclamation at Km 57.0. Waddell Dam, a multiple arch concrete dam, will be replaced by New Waddell Dam, an earthfill dam, currently under construction approximately 0.5 mi downstream. New Waddell Dam will have a structural height of 440 ft, crest length of 4900 ft, and crest elevation of 1730 feet. The spillway, at the right abutment, will have a crest elevation of 1706 ft, crest length of 1000 ft, and a capacity of 312,000 cfs. The reservoir will have a total capacity of 894,000 acre-ft, and a surface area of 10,238 acres (U.S. Bureau of Reclamation 1985).

D2.8 DRAINAGES SUPPORTING BREEDING BALD EAGLES

Bald eagles in Arizona currently nest in the central portion of the state, in an area roughly bounded by Perkinsville to the north, the town of White River to the east, the Gila River to the south, and Alamo Reservoir to the west. Bald eagle breeding areas in the state occur on five major drainages, the Salt, Verde, Agua Fria, Gila, and Bill Williams rivers (Figure D2.8-1).

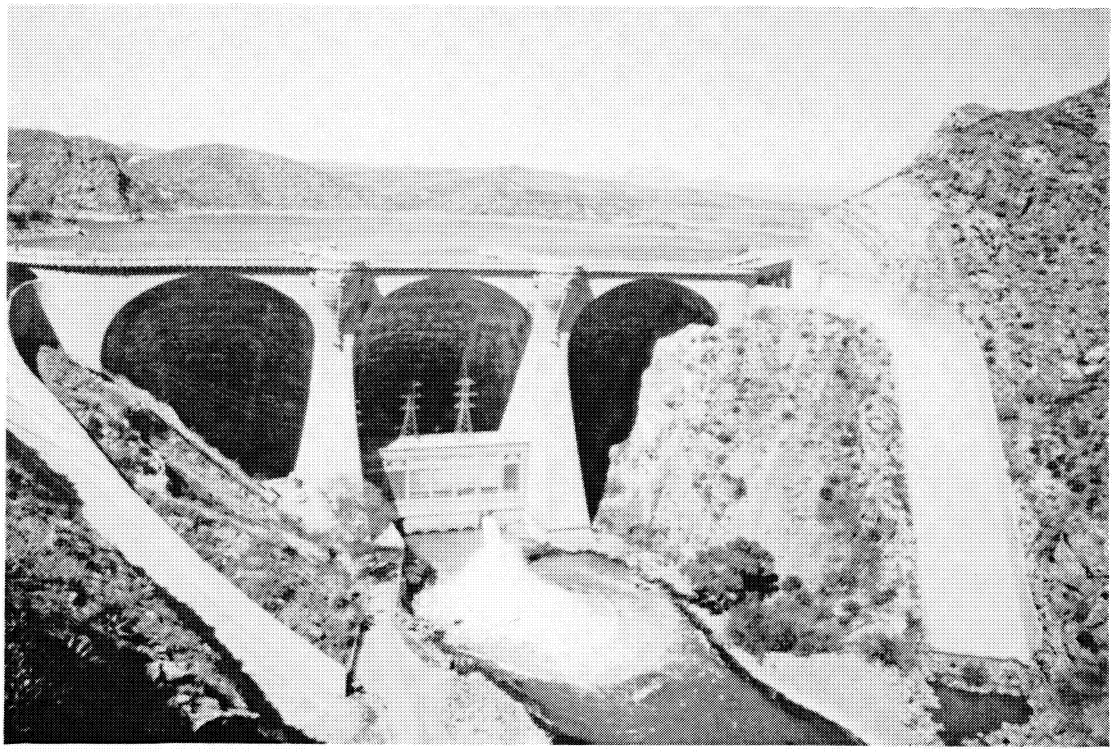

Plate D13. Coolidge Dam, a National Historic Monument, was completed in 1931. The dam stores water from the Gila River in San Carlos Reservoir (photo by D. Driscoll, April 1987).

Plate D14. Coolidge Dam, showing artwork on crest and face (eagle) (photo by D. Driscoll, April 1987).

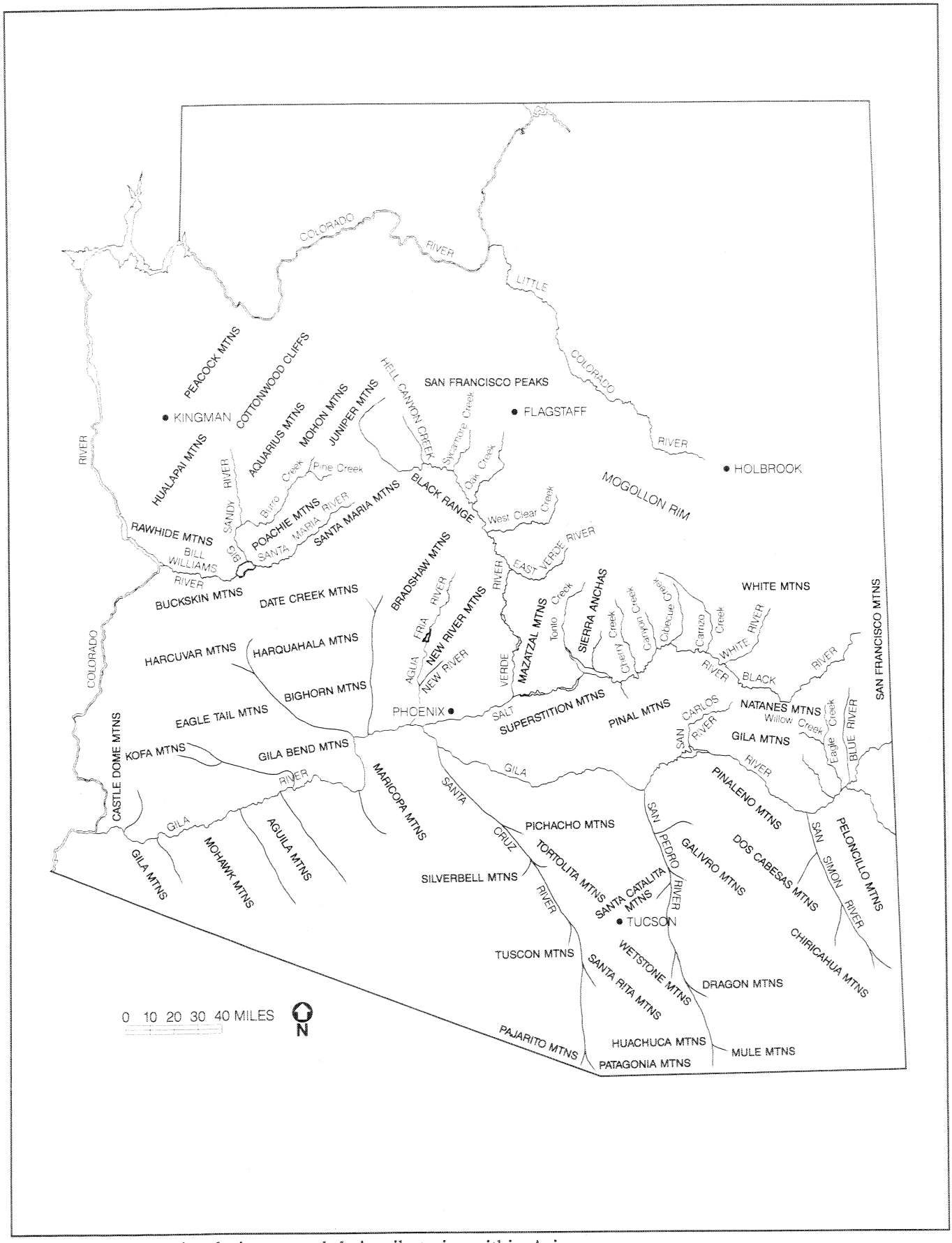

Figure D2.8-1. Major drainages and their tributaries within Arizona.

D2.8.1 Bill Williams Drainage

The Bill Williams Drainage is located in west-central Arizona, southeast of Kingman. The drainage is composed of the Big Sandy and Santa Maria rivers, which form the Bill Williams River and Alamo Reservoir at their confluence (see Figure D2.8-1). Vegetation surrounding the drainage is of the Semidesert Grassland Biome on the upper Big Sandy River, quickly flowing into the Sonoran Desertscrub Biome, Arizona Upland Subdivision, near the confluence of Trout Creek. As the Big Sandy flows south to the Bill Williams and Santa Maria, associated Mohave Desertscrub Biome, Joshua Tree Series species become apparent (Brown 1982).

The Big Sandy River flows south, collecting run-off from the Peacock Mountains and Cottonwood Cliffs to the north, the Hualapi Mountains to the west, and the Aquarius Mountains to the east. Willow, Trout, and Burro Creeks, fueled by run-off from the Mohon and Juniper Mountains, enter the Big Sandy from the east. The Big Sandy River, formed by the confluence of Trout and Knight Creeks, drains an area of about 2840 square miles and flows southward about 49 mi on an average stream gradient of 38 ft per mile (U.S. Army Corps of Engineers 1989). Portions of the Big Sandy River remain dry during part of the year.

The Santa Maria River flows southwest, draining the Santa Maria Mountains to the east, the Poachie Mountains to the north, and the Date Creek Mountains to the south. Date Creek flows into the Santa Maria from the south. The Santa Maria River, formed by the confluence of Kirkland and Sycamore Creeks, drains an area of about 1550 square miles and flows southwest about 51 mi on an average stream gradient of 30 ft per mile (U.S. Army Corps of Engineers 1989). Portions of the Santa Maria River remain dry during part of the year.

The Bill Williams River, formed by the confluence of the Big Sandy and Santa Maria rivers, flows southwest at a stream gradient of about 18 ft per mile (U.S. Army Corps of Engineers 1989) 12.5 river kilometers (Km) to Alamo Dam. Alamo Dam, at Km 43.8 on the Bill Williams River, creates Alamo Reservoir. The reservoir, at high levels, can reach beyond the Big Sandy and Santa Maria River confluence. The drainage area of Alamo Reservoir contains about 4770 square miles (U.S. Army Corps of Engineers 1989). Below Alamo Dam the Bill Williams River, collecting run-off from the Rawhide Mountains to the north and the Buckskin Mountains to the south, continues west 43.8 Km to the Colorado River.

D2.8.2 Agua Fria Drainage

The Agua Fria Drainage is located in central Arizona, northwest of Phoenix. The drainage is composed of the Agua Fria and New rivers. The New River enters the Agua Fria below Pleasant Reservoir, then the Agua Fria continues south into the Gila River west of Phoenix (see Figure D2.8-1). Vegetation surrounding the drainage is of the Sonoran Desertscrub Biome, Arizona Upland Subdivision above Pleasant Reservoir, and the Lower Colorado River Subdivision below the reservoir (Brown 1982).

The Agua Fria River flows south, collecting run-off from the Black Range to the north, the Bradshaw Mountains to the west, and the New River Mountains to the east. Waddell Dam, at Km 57.0 on the Agua Fria River, creates Pleasant Reservoir. The drainage area of Pleasant Reservoir contains about 1460 square miles (U.S. Bureau of Reclamation 1989). New Waddell Dam is currently under construction approximately 0.5 mi below Waddell Dam (U.S. Bureau of Reclamation 1985). The New River flows southwest from the New River Mountains and enters the Agua Fria below Pleasant Reservoir.

The Agua Fria River continues south, entering the Gila River west of Phoenix. Portions of the river remain dry during part of the year.

D2.8.3 Gila River Drainage

The Gila River Drainage is located south of Phoenix and flows west from its origin on the west slope of the American Continental Divide in New Mexico, across Arizona, and into the Colorado River (see Figure D2.8-1). As the Gila enters Arizona, vegetation surrounding the drainage is of the Madrean Evergreen Woodland Biome, flowing into the Chihuahuan Desertscrub Biome from just after the border until Clifton. From Clifton to Florence, vegetation is of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, changing to the Lower Colorado River Subdivision from Florence to the Colorado River (Brown 1982).

Upon entering Arizona, the Gila River is joined by the San Francisco and Blue rivers, draining the San Francisco Mountains to the north. Willow, Eagle, and Bonita Creeks, collecting run-off from the Natanes and Gila Mountains, also feed the Gila from the north. The San Simon River flows out of the Chiricahua Mountains to greet the Gila from the south. Continuing west, the Gila is joined by many small intermittent streams until it reaches San Carlos Reservoir. The San Carlos River flows into San Carlos Reservoir from the north, 15.2 Km above Coolidge Dam. From its origin, the Gila flows about 250 mi, dropping 6600 ft, at an average stream gradient of 26.7 ft per mile. The Gila River has a drainage area of about 12,020 square miles near Old San Carlos, which was west of the San Carlos River confluence, but is now inundated by Coolidge Dam (Olmstead 1919).

Below Coolidge Dam, the Gila River continues west, although water diversions for irrigation leave portions of the river dry during part of the year. The San Pedro River flows north out of the Huachuca Mountains, collecting run-off from several other mountain ranges in route to the Gila near Winkleman. The Santa Cruz River drains the Patagonia Mountains near the Mexico border and flows north to its confluence with the Gila southwest of Phoenix. West of Phoenix, the Salt River from the east, and the Agua Fria and Hassayampa rivers from the north join the Gila River prior to Gila Bend. Many small intermittent streams, converge with the Gila as it flows from Gila Bend southwest to the Colorado River.

D2.8.4 Verde River Drainage

The Verde River Drainage is located in central Arizona, flowing from the Flagstaff and Williams area, south to Phoenix. The drainage is composed of the Verde and East Verde rivers, as well as Sycamore, Oak, and West Clear Creeks. Horseshoe and Bartlett reservoirs also occur on the drainage (see Figure D2.8-1). Descriptions of vegetation biomes follow Brown (1982).

D2.8.4.1 Verde River. The Verde River, at its origin on the west slope of San Francisco Peaks, flows southwest through surrounding vegetation of the Great Basin Conifer Woodland Biome. The river turns southeast as it enters Sullivan Lake (now usually dry) near Highway 89, about 318 Km from the Verde River and Salt River confluence east of Phoenix. The Verde River enters a narrow canyon around Km 293. Hell Canyon Creek joins the Verde at Km 282.8 and the Verde opens up again around Km 279. The Verde River remains fairly open through lines of cottonwoods near Perkinsville, then enters a narrow canyon around Km 270. At this point surrounding vegetation changes into the Semidesert Grassland Biome, on mesas above the river canyon. Sycamore Creek, which drains the San Francisco Peaks from the south, enters the Verde through a steep canyon lined with Arizona sycamores at Km 252.0. At this point the Verde River takes a more southern direction, which it maintains to its confluence with the Salt. The Verde opens up again around Km 234, near Clarkdale and Pecks Reservoir

(a small mining operation impoundment). At this point the Verde Valley begins and the river remains open past Camp Verde to Km 168.

Through the Verde Valley the river is dredged, bulldozed, diverted, and basically manipulated to fit human needs. Along this section of river lie the communities of Clarkdale, Centerville, Cottonwood, Bridgeport, Middle Verde, and Camp Verde, as well as horse and cattle ranches and agricultural fields. Oak Creek, which drains the Flagstaff area of the Mogollon Rim, enters the Verde at Km 208.3. Run-off from the Black Range to the west, converges with the Verde as it flows through the Verde Valley, lined with a single row of cottonwoods and sycamores. Mean monthly flows of the Verde River at the Camp Verde USGS gaging station from November 1986 to June 1989 ranged from 23–1,144 cfs. Here vegetation of the Sonoran Desertscrub Biome, Arizona Upland Subdivision enters the valley from the north east. Below Camp Verde, West Clear Creek brings Mogollon Rim water to the Verde River at Km 175.3. The Verde enters a narrow canyon at Km 168, and is joined by Chasm Creek from the west at Km 162.8 and Sycamore Creek from the east at Km 162. In this area, the Verde is again surrounded by vegetation of the Semidesert Grassland Biome. From the east, Bull Run Creek enters the Verde at Km 158.5 and Towel Creek at Km 156.2, while Cold Water Creek joins the Verde from the west at Km 150.3. Flowing past the Verde Hot Springs at Km 143.5 and the Childs Powerplant at Km 142.2, the Verde is bounded by vegetation of the Great Basin Conifer Woodland and the Interior Chaparral Biomes. From the east, Fossil Creek converges with the Verde River at Km 136.3 and the East Verde River brings Mogollon Rim water into the Verde at Km 130.7. At the confluence of the East Verde River vegetation is diverse, with representation of the Great Basin Conifer Woodland, Interior Chaparral, and Semidesert Grassland Biomes.

D2.8.4.2 East Verde River. The East Verde River drains 320 square miles of the Mogollon Rim region of central Arizona and flows through surrounding vegetation of the Interior Chaparral and Great Basin Conifer Woodland Biomes on its way to the Verde. From its head at 7,300 ft, the East Verde flows 43 mi to its confluence with the Verde River at 2,500 ft (Carson 1986). The East Verde flows through rugged terrain, entering narrow canyons at some points, although open areas (such as LF Ranch) also exist.

The East Verde River receives water imports from Blue Ridge Reservoir on East Clear Creek. Intermittent streamflow imports began in October, 1965, by Phelps Dodge Corporation in exchange for using water in their copper mining operations in the upper Gila River drainage. Average daily imports from 1968–1984 ranged from a minimum of 4.5 cfs in January to a maximum of 21.1 cfs in June. East Verde River mean monthly flows in this same period ranged from a low of 26.5 cfs in July to a high of 208.3 cfs in February (Carson 1986). Mean monthly flows from November, 1986, to June, 1989, were similar to those of 1968–1984, ranging from 13–175 cfs. Carson (1986) states that all imported water added at the head of the river is considered to be available at the mouth, with evapotranspiration losses in the summer of less than 1 cfs.

D2.8.4.3 Verde River. Below the confluence of the East Verde River, Houston Creek joins the Verde from the northwest at Km 128.8. The terrain surrounding the Verde River opens up somewhat at Km 120, near Petes Cabin Mesa, sporting scattered willow and cottonwood trees, then quickly closes in at Mule Shoe Bend (Km 114). The Verde River opens up again at Km 110; however, promontory cliffs usually bound the east or west bank. Red Creek enters the Verde at Km 104.9 and Tangle Creek at Km 90.4, both from the west. In this area, vegetation surrounding the remainder of the Verde River changes to the Sonoran Desertscrub Biome, Arizona Upland Subdivision. Mean monthly flows of the

Verde River at the Tangle Creek USGS gaging station from November, 1986, to June, 1989, ranged from 114–2177 cfs. Sycamore Creek flows into the Verde from the east at Km 89.5, just above Sheep Bridge. The Verde River enters Horseshoe Reservoir at Km 85 when the reservoir, created by Horseshoe Dam at Km 73.4, is full. Water levels fluctuate tremendously, and the open, saucer-shaped reservoir is often reduced to a river in the summer months. Large willow trees once grew along the upper reservoir, near the promontory cliff of Chalk Mountain, although most have died and fallen due to inundation. Mullen Wash and Deadman Creek enter the reservoir from the east, and Lime Creek from the west, at Km 75–78.

Horseshoe Dam regulates the Verde River as it continues south. Mean monthly flows at the USGS gaging station below Horseshoe Dam ranged from 61 to 1,185 cfs between November, 1986, and June, 1989. Cottonwoods and mesquite bosques, in various stages of decay, are scattered along the regulated river, although there is some sparse regeneration. Davenport Wash enters the Verde at Km 67.7 and Sheep Creek at Km 59.0, both from the east. The Verde River enters Bartlett Reservoir at Km 58 when the reservoir, created by Bartlett Dam at Km 39.3, is full. Steep desert slopes bound the reservoir on the east, with gradual slopes on the west. Some promontory cliffs exist on the upper portion of the reservoir. Alder Creek enters the reservoir from the east at Km 47.0. The drainage area of the Verde River at Bartlett Dam is 6,160 square miles (Salt River Project 1983).

Below Bartlett Dam, mean monthly flows in the regulated Verde River ranged from 84-1022 cfs between November 1986 and June 1989. Camp Creek joins the Verde from the west at Km 29.1, near Needle Rock. At Km 21.5, the Verde enters the Fort McDowell Indian Reservation. In this section, the river is dredged for gravel operations, bulldozed to modify flow, and diverted for irrigation. Cottonwood trees and scattered mesquite bosques, in various stages of decay and thinning, line the lower Verde as it flows to its confluence with the Salt River. Sycamore Creek enters the Verde from the east at Km 10.4, and the river crosses into the Salt River Indian Reservation at Km 2.9. The Verde River flows into the Salt River near Arizona Dam Butte and Phon D Sutton Recreation Area (Km 5.5 on the Salt River).

D2.8.5 Salt River Drainage

The Salt River Drainage is located in central Arizona, flowing from the White Mountain area, west through Phoenix to its confluence with the Gila River. The drainage is composed of the White, Black, and Salt rivers, as well as Carrizo, Cibecue, Canyon, Ash, Cherry, Pinal, Pinto, Salome, and Tonto Creeks. Roosevelt, Apache, Canyon, and Saguaro reservoirs also occur on the drainage (see Figure D2.8-1). Descriptions of vegetation biomes follow Brown (1982).

D2.8.5.1 Salt River. The White River flows out of the White Mountains in east central Arizona, while the Black River drains the west side of the San Francisco Mountains and the Natanes Mountains, both emerging from the Petran Montane Conifer Forest Biome. The two rivers flow through the Plains and Great Basin Grassland Biome and converge east of Forks Butte to form the Salt River. The rivers delineate the boundaries of the Fort Apache Indian Reservation, north of the Black and Salt rivers, and the San Carlos Indian Reservation to the south. The Salt then flows 247 Km west to Granite Reef Diversion Dam, where it is diverted into canals for irrigation and the Phoenix Metropolitan Area. The Salt River is dry through Phoenix, except during heavy rainstorms and flood conditions. Perennial flow in the Salt River, west of Phoenix to its confluence with the Gila River, is a result of urban effluent discharges.

From the Black and White River confluence, the Salt River flows through a narrow canyon (Salt River Canyon) in rugged terrain, surrounded by vegetation of the Great Basin Conifer Woodland and the

Interior Chaparral Biomes. From the south, Cave Creek, a small intermittent stream, enters the Salt at Km 245.1, followed by Little Trough Creek at Km 231.0. Continuing west, Carrizo Creek, which drains the Mogollon Rim and numerous side canyons, carries warm water (due to geothermal activity) into the Salt from the north at Km 230.1. The Salt River Canyon is joined by Walnut Canyon and Flying V Canyon from the north, and Sawmill Canyon from the south, at Km 200–203. At Km 194.5, the Salt flows under the Highway 60 bridge and into Mule Hoof Bend, where Cienega Creek, Mule Hoof Canyon, and Phillips Canyon enter from the south at Km 191.4, followed by Coyote Canyon from the north at Km 188.6. The south side of the Salt River becomes U.S. Forest Service land at Km 187.6, although the north side remains the Fort Apache Indian Reservation. The high slopes in this section of the Salt River Canyon display the tailings of abandoned mining operations, and the trails used by miners.

Cibecue Creek drains the Mogollon Rim, as well as numerous side canyons, and enters the Salt River from the north at Km 183.6. In this area, the river flows into the Sonoran Desertscrub Biome, Arizona Upland Subdivision; however, the drainage is surrounded by vegetation of the Interior Chaparral, Californian Chaparral, and Semidesert Grassland Biomes above the canyon. The Salt River Canyon is joined by Regal and Walnut Canyons from the south, and Rock Canyon from the north at Km 175–176. Canyon Creek enters the Salt River from the north at Km 168.7, while Ash Creek flows in from the south at Km 167.3. As the Salt River passes Canyon Creek Butte (Km 166.0) the canyon opens up into Gleason Flat, although the surrounding terrain remains rugged. Here the river slows down and cottonwoods are scattered along the banks. At Km 163.9, Butte Creek enters Gleason Flat from the south, followed by Medicine Creek from the north at Km 162.7. The Salt River enters a narrow canyon at Km 160.5, sporting numerous rapids, rocks, and haystacks of water as it winds along the White Ledges. In this section the Salt is joined from the south by Hess Canyon at Km 153.8 and Yankee Joe Canyon at Km 149.3, while Upper and Lower Corral Canyons enter from the north at Km 151.3 and Km 148.1, respectively. At Km 148.5, the Salt River crosses onto U.S. Forest Service land to the north, leaving the Fort Apache Indian Reservation.

The Salt River enters Jump-Off Canyon at Km 147, flows past McGee Mountain (to the north), then opens up at the Cherry Creek confluence (Km 137.9). Cherry Creek drains the Mogollon Rim and the Sierra Anchas, flowing into the Salt from the north. The river immediately enters another canyon, which opens up at Horseshoe Bend (Km 132–135). Horseshoe Bend supported a large mesquite bosque as late as 1985; however, the land has now been cleared for cattle grazing. The Salt River slows down after Horseshoe Bend, as the terrain opens up and the stream gradient becomes lower than in the upper canyons. The Salt flows passed Redmond Flat (Km 124–127), where Coon and Chalk Creeks enter from the north at Km 124. The Salt River closes in as it passes Redmond Mountain to the south, and Black Mesa to the north. Pinal Creek flows out of the Pinal Mountains and enters the Salt at Km 112.7, although the water is tainted by tailings from copper mines in the Globe area. The river opens up into Tonto Basin as it passes the Salt River Mountains and Klondike Mountain to the south. At this point, surrounding vegetation of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, dominates the adjacent slopes. The Salt River flows under the State Road 288 bridge at Km 112.2, over the Roosevelt Diversion Dam at Km 110.8, and into the Meddler Point area, lush with cottonwood groves. The Salt River enters Roosevelt Reservoir around Cougar Point (Km 101) when the reservoir, created by Theodore Roosevelt Dam at Km 79.1, is full. Mean monthly flows in the Salt River at the 288 bridge USGS gaging station ranged from 114–2685 cfs between November, 1986, and June, 1989.

The drainage area of the Salt River at Theodore Roosevelt Dam is 5824 square miles (Salt River Project 1983). Roosevelt Reservoir backs up into the Salt River to the east (Salt Arm) and Tonto Creek to the north (Tonto Arm). On the Salt Arm, Pinto Creek flows into the reservoir from the south at Campaign

Bay (Km 100). Draining the Sierra Anchas to the north, Armer Gulch enters the reservoir at Km 89.9, and Salome Creek flows into Salome Bay at Km 87.5, north of Windy Hill. Some cottonwood trees exist in Salome Bay and near Grapevine Point, although most of the shoreline is composed of desert vegetation and cockleburs. Promontory cliffs bound the water in some areas and grasses grow on the occasionally inundated flats. Cottonwood Creek enters the Salt Arm from the south at Km 82.5 near Rock Island. After Rock Island, the Tonto Arm and Salt Arm converge as they approach Theodore Roosevelt Dam. The Tonto Creek channel intersects the Salt River channel at Km 79.9 on the Salt River.

D2.8.5.2 Tonto Creek. Tonto Creek drains the Mogollon Rim, flowing south from Promontory Butte, through the Interior Chaparral and Semidesert Grassland Biomes. Haigler Creek enters Tonto Creek from the east, south of Oxbow Mountain. Also from the east, Spring Creek joins Tonto Creek south of Diamond Butte. Soldier Camp Creek enters Tonto Creek from the east at Km 67.9, while Houston Creek joins from the west at Km 65.0. At this point, just north of Gisela, Tonto Creek opens up. The creek enters a narrow canyon "The Box" at Km 58, then opens up again. Rye Creek enters Tonto Creek from the west at Km 52.1, near the "76" Ranch. The creek enters another canyon at Km 49, joined by Gold Creek (from the west) at Km 44.5, and Gun Creek (from the east) at Km 44.0. Here the creek opens up into Tonto Basin, bounded by the Mazatzal Mountains on the west and the Sierra Anchas on the east. Cottonwoods, in various stages of decomposition, are lightly scattered along the banks, and surrounding vegetation is of the Sonoran Desertscrub Biome, Arizona Upland Subdivision.

As Tonto Creek enters Tonto Basin, it is joined by Cottonwood Creek at Km 42.5 and State Creek at Km 38, both from the west. Passing Kayler Butte, Buena Vista Creek (from the west) and Packard Wash (from the east) enter Tonto Creek at Km 32.1, while Reno Creek (from the west) and Lambing Creek (from the east) join at Km 28, below Punkin Center. Oak Creek (from the east) and Sycamore Creek (from the west) enter Tonto Creek at Km 21.5–22.5, while Greenback Creek (from the east) and Ash Creek join at Km 17.5–18.5. Tonto Creek then winds through a broad cottonwood and willow complex and enters Roosevelt Reservoir at Km 16 when the reservoir is full. Mean monthly flows in Tonto Creek at the USGS gaging station (near the Roosevelt Reservoir confluence) ranged from 3–567 cfs between November, 1986, and June, 1989. From the west, Bumblebee Creek enters the Tonto Arm of Roosevelt Reservoir at Km 13.0, followed by Rock Creek at Km 7.5, while Mills, Vineyard, and Chuckwalla Canyons join from Km 1.5–4.5.

D2.8.5.3 Salt River. Below Theodore Roosevelt Dam, the regulated Salt River flows through a narrow canyon, bounded by the Mazatzal Mountains to the north and Two Bar Ridge to the south, then quickly enters Apache Reservoir, created by Horse Mesa Dam at Km 52.3. Vegetation surrounding the remainder of the Salt River is of the Sonoran Desertscrub Biome, Arizona Upland Subdivision. Apache Reservoir is characterized by large promontory cliffs and steep slopes. From the south, Burnt Corral Creek joins the reservoir at Km 71.4, followed by Pine Creek at Km 68.6, and Davis Wash at Km 67.2, while Bronco Creek enters from the north at Km 69.7. Crabtree Wash drains the east side of Horse Mesa and joins Apache Reservoir from the south at Km 62.5. Ash Creek flows out of the Mazatzal Mountains and enters the reservoir from the north, between Goat Mountain and Painted Cliffs, at Km 58.6, followed by Alder Creek at Km 55.0 and Long Canyon at Km 54.0. In this section, Painted Cliffs (to the north) and Horse Mesa (to the south) begin converging to Horse Mesa Dam.

Below Horse Mesa Dam, the regulated Salt River flows through a narrow canyon and quickly enters Canyon Reservoir, created by Mormon Flat Dam at Km 36.6. Canyon Reservoir is characterized by large promontory cliffs, and reservoir levels can fluctuate up to five ft within a couple hours due to power generation and pump back capacities at each dam. From the south, Fish Creek emerges from a canyon

Plate D15. Tonto Creek flowing through the "76" bald eagle breeding area, 8 September 1986 (photo by D. Driscoll).

to enter the reservoir at Km 49.7, while Tortilla Creek flows out of the flats and into Canyon Reservoir at Km 38. La Barge (Km 38) and First Water Creeks (Km 37.9) enter the reservoir from the south.

A short distance below Mormon Flat Dam, the regulated Salt River enters Saguaro Reservoir, created by Stewart Mountain Dam at Km 21.8. Saguaro Reservoir is bounded by a multitude of promontory cliffs, although shallow water areas occur in coves. Willow Creek drains the Goldfield Mountains to the south, joining the reservoir at Km 35.3, while Cottonwood Creek enters from the north at Km 35.6. Willow Springs Canyon intersects Saguaro Reservoir at Km 25.5, emerging from the Goldfield Mountains to the south.

The regulated Salt River below Stewart Mountain Dam contains highly variable flows, with monthly means ranging from 0–2,124 cfs between November, 1986, and June, 1989. The river remained completely dry (0 cfs) from 22 January to 5 March 1989, and again in the winter and spring of 1990. When flowing, the river passes Bulldog Cliffs at Km 20.7, runs under the Bush Highway bridge at Km 15.8, along the Blue Point Cliffs at Km 15.5 and by Coon Bluff at Km 6.5. Cottonwoods and mesquite bosques in various stages of decay are scattered along the river, although there is some sparse regeneration. The entire cottonwood grove at Km 9–10 burned in November 1987. The Verde River enters the Salt River at Km 5.5, then the Salt continues to Granite Reef Dam, where it is diverted into canals.

D3 BREEDING AREA HISTORY

Documented observations of bald eagles in Arizona appear as early as 1866 (Coues 1866) in the vicinity of Fort Whipple (Prescott), and 1875 (Henshaw 1875) south of Fort Apache. However, bald eagle bones dated between 700 and 1300 A.D. found in the Wupatki Pueblo (Wupatki National Monument) along the Little Colorado River near Grand Falls (Hargrave 1939) suggest bald eagles may have roamed the skies of Arizona prior to Columbus' arrival in America, although it is also possible that these bones were the product of Indian trading with other regions.

The first bald eagle breeding information was recorded by Edgar A. Mearns (1890) who wrote that, "A pair of these birds has bred for many years past in a pine-tree near Stoneman's Lake." By 1937, at least five additional nests had been documented. Bent (1937) reported breeding at Fort Whipple (Prescott) and the Salt River Bird Reservation, which was inundated by the completion of Theodore Roosevelt Dam in 1911 (Salt River Project Archives) creating Roosevelt Reservoir (possibly in the vicinity of the current Pinto breeding area); Bent also discussed bald eagle occurrence as far south as Central Mexico. Jenks and Stevenson (1937) wrote "The species is a permanent resident of central-eastern Arizona, principally in the Transition and high Upper Sonoran zones. Many sight records have been made for every month of the year, and several nests have been discovered in trees along rivers within the White Mountains" (possibly in the vicinity of the Lone Pine breeding area).

Phillips *et al.* (1964) described the bald eagle in Arizona as a "Not uncommon resident about the lakes and streams of the White Mountain region, rarer west down to Salt River and to Flagstaff region. Transient in northern mountains and Kaibab Plateau." Phillips also noted that the bald eagle was "... rare in the southeast ..." with "... winter records mainly from the Flagstaff and Colorado River Regions." In contrast to Jenks and Stevenson (1937), Hargrave, in Phillips *et al.* (1964), reported the eagles "... leave after nesting, at least on the Salt River," and Phillips noted "... nests in Arizona are always on the tops of buttes or chimneys of rock."

In addition to the six bald eagle nests discussed above, early records at eight known breeding areas include the following:

Fort McDowell:	Eagles breeding prior to arrival of white man (prior to 1900) (Hood, pers. comm.).
East Verde:	Possible nest at Eagle Nest Corral, named prior to mapping of area (1918) (Forbis, pers. comm.).
Mule Hoof:	Active in 1935: "This nest said by Indians to have been used for many years; birds seen again there in 1944 and 1949." (Housholder, in Phillips *et al.* 1964).
Blue Point:	Nesting 1930–1936 (Lane, in Phillips *et al.* 1964).
Bartlett:	Occupied since the early 1940s (Werner, in Phillips *et al.* 1964., and Ohmart and Sell 1980).
Horse Mesa:	Fledged young in 1950s (Gibbons, pers. comm.).

Perkinsville: Nest in area in 1960s (Rubink and Podborny 1976).

Ladders: Active every year since 1962 (Thompson, in Forbis 1979).

Information gathered on five historical nest sites, Box Bar, Grand Falls, Needle Rock, Rock Creek, and Tower, brings the pre-1970 total to 19 breeding areas. However, historical records and interviews leading to knowledge on some of these nest sites only recently surfaced, and were unknown during previous studies in Arizona.

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). 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.

Upon completion of the USFWS status report in 1976, a research project was conducted, under a multi-agency agreement, by Robert Ohmart (ASU), from 1977–1982. Ohmart's studies produced six documents and two Masters Theses, Hildebrandt and Ohmart (1978), Hildebrandt (1981), Sell (1982), Ohmart and Sell (1980), and Haywood and Ohmart (1980, 1981, 1982, and 1983). During this same period, a report on Arizona bald eagles was written by Stumph and Creighton (1977) of Reclamation.

The USFWS formulated a Southwestern Bald Eagle Recovery Plan in 1982 (U.S. Fish and Wildlife Service 1982), and a research project was conducted, under a multi-agency agreement, by Teryl Grubb (USFS), from 1983–1985. The Forest Service's studies produced three documents, Grubb *et al.* (1983), Grubb (1984), and Grubb (1986a).

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 1978–1985, 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, while collecting scientific data on nesting bald eagles, and providing valuable experience to young biologists. This program has produced a wealth of information on bald eagle breeding areas in Arizona. Details and pertinent data from ABENWP reports have been compiled and are presented under each appropriate breeding area in Section D4.

Although research for this document produced information on 19 breeding areas prior to 1970, management agencies knew of only two bald eagle breeding areas on a single river system in 1970. Subsequent nest searches and Occupancy and Reproduction Assessment (ORA) flights resulted in the location of eight breeding areas by 1974, 12 by 1979, and 18 by 1984 (Rubink and Podborny 1976, Haywood and Ohmart 1983, Grubb 1986a). By 1989, 28 breeding areas had been located, most containing cliff and tree nests, encompassing five river systems (Salt, Verde, Gila, Bill Williams, and Agua Fria), three perennial streams (Tonto, Burro, and Canyon creeks), and one intermittent stream (Ash Creek) (Figure D3.0-1). See Section D2 for a detailed description of Arizona drainages supporting breeding bald eagles, and the habitat along these streams.

The first consistent documentation of Arizona bald eagle breeding areas began in 1972, when Duane Rubink (USFWS) began monitoring the population (Rubink and Podborny 1976). Through aerial surveys he documented 36 nests along the Salt, Black, Verde, Gila, and Colorado rivers (Figure D3.0-2). Some of these original 36 nest sites have been placed in historical status, while others are still occupied,

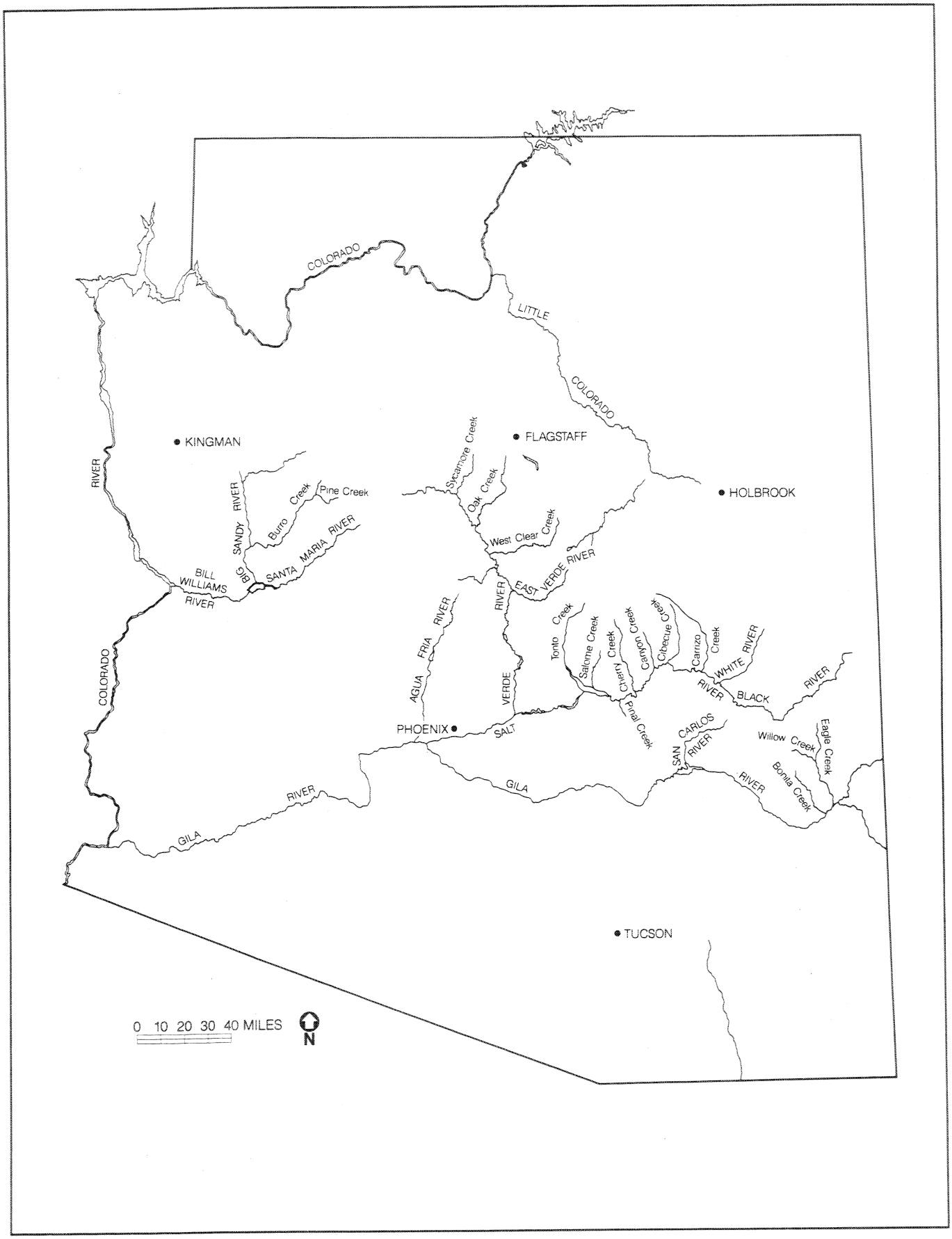

Figure D3.0-1. Major river systems in central Arizona.

often with several nests as alternates for the same breeding area (Table D3.0-1). It is likely that more breeding areas existed in the 1960s and 1970s than were known about, and that those in remote areas, as well as some close to Phoenix, remained undiscovered for many years.

The paucity of data on bald eagle breeding areas in Arizona prior to the first survey flights in 1972 is not surprising. The rugged terrain of Arizona no doubt kept many nest sites secluded in inaccessible canyons for many years. Based on our current knowledge of Arizona bald eagles, it is likely that many breeding areas have been around for a long time. This point was made by Floyd Thompson, a retired U.S. Fish and Wildlife Service agent, *in* Forbis (1979); "Mr. Thompson concluded that he thought that bald eagles have been around for a long time. He recalled conversations with Avertt Mercer, a Predator and Rodent Control Agent in Phoenix, about bald eagles back in 1935."

Table D3.0-1. Current breeding areas containing the original 36 nest sites found by Duane Rubink, U.S. Fish and Wildlife Service, during the first Arizona bald eagle surveys, from 1972–1974.

Nest Number*	Current Breeding Area	Breeding Area Status
1	Willow	Historical
2	Eagle	Historical
3	Natanes	Historical
4	Bronco	Historical
5	Sawtooth	Historical
6,7	Cedar Basin	Occupied
8,9	Mule Hoof	Occupied
10	Cibecue	Occupied
11,12	Redmond	Occupied
13,14	Blue Point	Occupied
15,16,17	Fort McDowell	Occupied
18,19,20	Bartlett	Occupied
21,22	Horseshoe	Occupied
23,24,25	East Verde	Occupied
26,27,28,29,30	Ladders	Occupied
31	Perkinsville	Occupied
32,33,34	Hell Point	Historical
35	Sullivan	Historical
36	Havasu	Historical

* Nest numbers from Rubink and Podborny 1976.

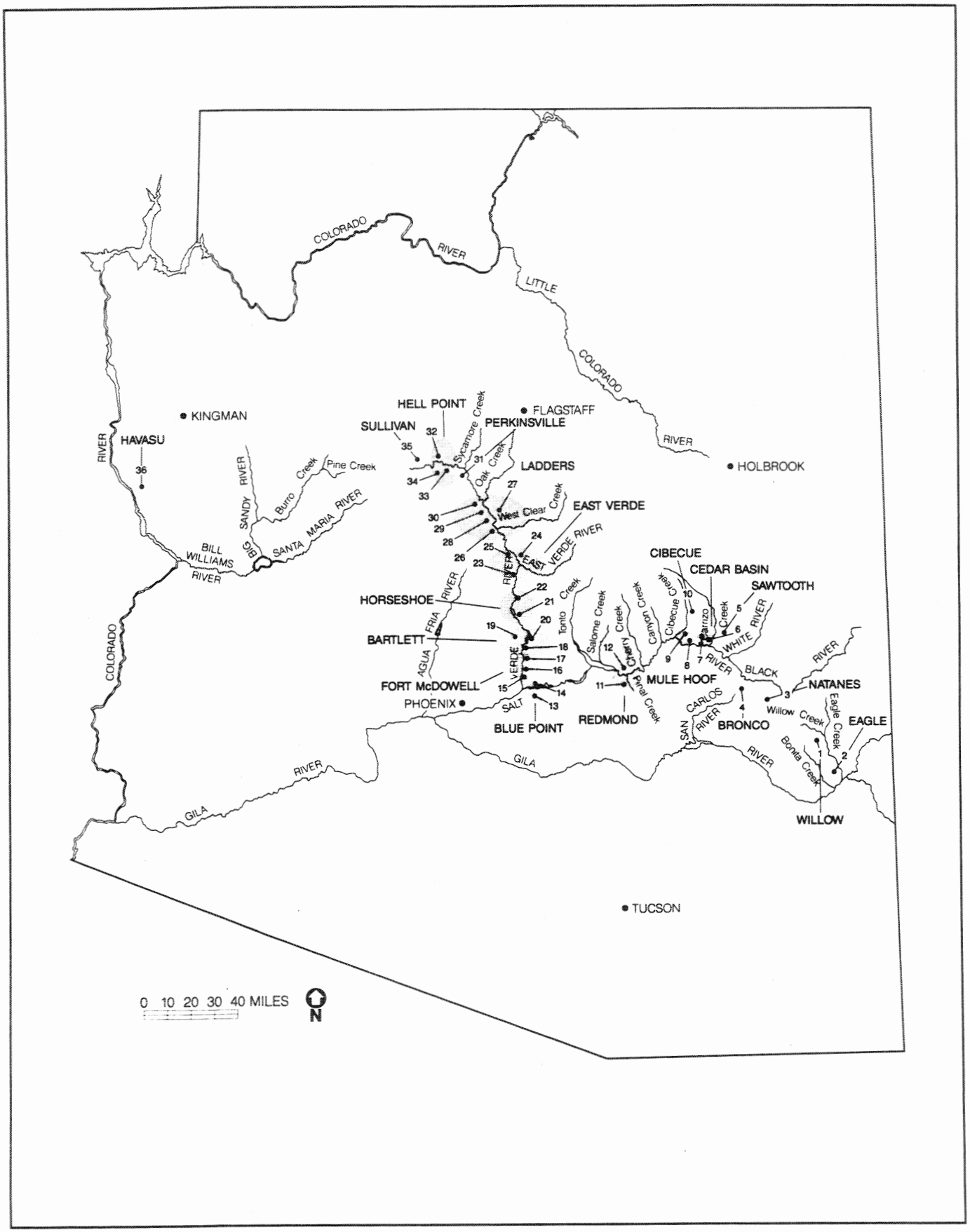

Figure D3.0-2. Current names and locations of the original 36 nest sites found by Duane Rubink, USFWS, during the first Arizona bald eagle surveys, from 1972–1974.

D4 KNOWN BREEDING AREAS

The Known Breeding Area section includes the history of those sites which in recent years have contained breeding pairs and are annually surveyed for productivity data. Although historical data is now available on many breeding areas prior to 1970, the only two breeding areas known to agency personnel in 1970 were Bartlett and Fort McDowell, on the lower Verde River, knowledge of their existence likely related to their close proximity to Phoenix (Table D4.0-1). Eight active nest sites were known by 1974, as nest search flights explored more inaccessible reaches of the Salt, Verde, and East Verde rivers and the tributary of Cibecue Creek. By 1979, 12 breeding areas had been located, including one on the Agua Fria river and one on Pinal Creek. Further examination of the Salt, Verde, and tributaries resulted in the location of 18 nest sites by 1984, with two on Tonto Creek, one on Ash Creek, and one on Cave Creek (Lone Pine). An increase in nest search intensity by AGF, USFWS, and Reclamation, and field personnel via the ABENWP, led to the knowledge of 28 breeding areas by 1989. These nest sites encompassed three new river systems, the Big Sandy, Bill Williams, and Gila, and the tributaries of Canyon Creek, and Burro Creek.

There are currently 28 known bald eagle breeding areas in Arizona (Figure D4.0-1). Four nesting territories are located in west-central Arizona: Chino on the Big Sandy River, Alamo and Ive's Wash on the Bill Williams River (Alamo Reservoir), and Devil's Post on Burro Creek. One nest site, Pleasant, occurs north of Phoenix on the Agua Fria River (Pleasant Reservoir). The Verde River sustains nine breeding areas; Orme at the confluence of the Salt and Verde rivers, then north up the Verde River are Fort McDowell, Bartlett (Bartlett Reservoir), Cliff, Horseshoe (Horseshoe Reservoir), Table Mountain, East Verde, Ladders, and Perkinsville (Table D4.0-2). The Salt River drainage supports thirteen pairs of breeding bald eagles, moving east of Phoenix (up the river) they are; Blue Point (Saguaro Reservoir), Horse Mesa (Canyon and Apache reservoirs), "76" and Sheep (on Tonto Creek), Pinto (Roosevelt Reservoir), Pinal, Redmond, Canyon (on Canyon Creek), Ash (on Ash Creek), Cibecue, Mule Hoof, Cedar Basin, and Lone Pine. One nesting territory, Coolidge, is on the Gila River (San Carlos Reservoir).

Each breeding area description will contain a narrative history, followed by a reproductive summary sheet. The following notations are presented to clarify terms used on summary sheets.

1. Unoccupied status indicates unoccupied at known nest locations. Some of these breeding areas may be active at unknown nest locations.

2. Elevation (above Mean Sea Level) was measured from the river, stream or reservoir to the highest nest. Sites with only tree nests may have one elevation reading instead of two.

3. Distances between breeding areas were measured from the nest nearest the adjacent breeding area. All distances are in River Kilometers (Km) unless otherwise indicated.

4. Distances from Phoenix to each breeding area were measured from South Mountain on aeronautical charts.

Table D4.0-1. Discovery of bald eagle breeding areas in Arizona.

Year*	Breeding Area	Drainage
1964	Bartlett	Verde River
1968	Fort McDowell	Verde River
1971	Blue Point	Salt River
1972	Ladders	Verde River
1973	Cibecue	Salt River
		Cibecue Creek
1973	East Verde	Verde River
		East Verde River
1974	Redmond	Salt River
1974	Mule Hoof	Salt River
1975	Horseshoe	Verde River
1978 (1973)**	Cedar Basin	Salt River
1978	Pinal	Salt River
		Pinal Creek
1979	Pleasant	Agua Fria River
1981	76	Tonto Creek
1982	Sheep	Tonto Creek
1982	Horse Mesa	Salt River
1984	Ash	Ash Creek
1984	Cliff	Verde River
1984	Lone Pine	Salt River
		Cave Creek
1985	Chino	Big Sandy River
1985	Coolidge	Gila River
1986	Alamo	Bill Williams
1986	Canyon	Canyon Creek
1986	Orme	Salt River
		Verde River
1987	Ive's Wash	Bill Williams
1987	Pinto	Salt River
1987	Table Mountain	Verde River
1988	Devil's Post	Burro Creek
1989 (1973)**	Perkinsville	Verde River

* Represents year nest was discovered. Many breeding areas were occupied prior to discovery.

** (1973) indicates nests were found in 1973, but not known occupied by eagles until preceding date. Perkinsville breeding area was previously occupied in the 1960s and early 1970s.

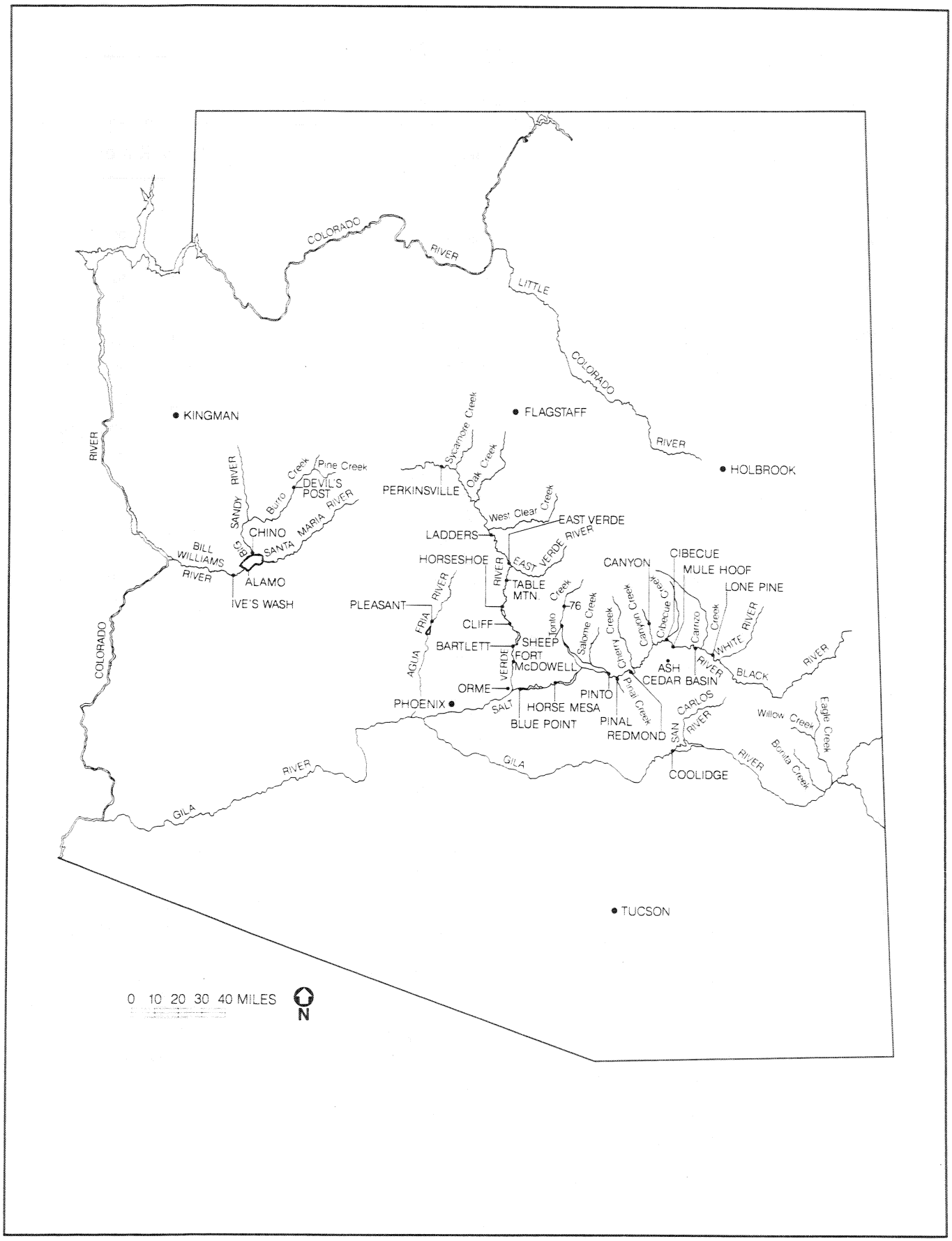

Figure D4.0-1. Known bald eagle breeding areas in Arizona, 1990.

Table D4.0-2. Distribution of bald eagle breeding areas in Arizona, 1990.

Breeding Area	Year*	Drainage	River Km of Nests†		
Breeding Areas of the Salt River Drainage					
Orme	1986	Salt River	2.5	to	5.5
		Verde River			0.9
Blue Point	1971	Salt River	9.9	to	25.5
Horse Mesa	1982	Salt River	52.3	to	52.9
Sheep	1982	Tonto Creek			33.7
76	1981	Tonto Creek	51.4	to	55.8
Pinto	1987	Salt River	101.5	to	101.8
Pinal	1978	Salt River			112.7
		Pinal Creek	0.4	to	3.5
Redmond	1974	Salt River	124.7	to	129.5
Canyon	1986	Canyon Creek	14.0	to	15.0
Ash	1984	Ash Creek			18.0
Cibecue	1973	Salt River	178.2	to	183.6
		Cibecue Creek			0.8
Mule Hoof	1974	Salt River	189.6	to	193.4
Cedar Basin	1978 (1973)**	Salt River	223.0	to	227.3
Lone Pine	1984	Salt River	241.3	to	245.0
		Cave Creek	0.0	to	1.5
Breeding Areas of the Verde River Drainage					
Orme	1986	Salt River	2.5	to	5.5
		Verde River			0.9
Fort McDowell	1968	Verde River	13.3	to	19.9
Bartlett	1964	Verde River	34.1	to	35.2
Cliff	1984	Verde River	65.4	to	69.4
Horseshoe	1975	Verde River	80.5	to	83.5
Table Mountain	1987	Verde River	110.1	to	119.4
East Verde	1973	Verde River	128.0	to	139.1
		East Verde River			6.4
Ladders	1972	Verde River	158.1	to	163.9
Perkinsville	1989 (1973)**	Verde River	271.1	to	271.2
Breeding Areas of Other Drainages					
Pleasant	1979	Agua Fria River	68.9	to	74.2
Coolidge	1985	Gila River	23.2	to	25.2
Chino	1985	Big Sandy River	4.9	to	5.0
Alamo	1986	Bill Williams	52.2	to	53.5
Ive's Wash	1987	Bill Williams	42.3	to	52.0
Devil's Post	1988	Burro Creek	60.0	to	61.0

* Represents year nest was discovered. Many breeding areas were occupied prior to discovery.

** (1973) indicates nests were found in 1973, but not known occupied by eagles until preceding date. Perkinsville breeding area was previously occupied in the 1960s and early 1970s.

† See Section E10—Central Arizona River Map Atlas for details on River Kilometers.

5. "Years," on the productivity sheet for each breeding area, indicates the number of occupied years with known productivity data.

6. Each nest is numbered chronologically based on its use by the eagles. Many smaller nests exist within bald eagle breeding areas, such as redtail hawks and ravens, which are not included in this report.

7. Species of nest trees are as follows:
   a. Cottonwood = Fremont Cottonwood (*Populus fremontii*);
   b. Willow = Goodding Willow (*Salix gooddingii*)
   c. Sycamore = Arizona Sycamore (*Platanus wrightii*)
   d. Ponderosa = Ponderosa Pine (*Pinus ponderosa*)
   e. Pinyon = Pinyon Pine (*Pinus cembroides*)
   f. Juniper = Juniper (*Juniperus* sp.)

8. Home Range data has been established through telemetry. Strong visual data exists at some sites, but has not been quantified by telemetry. Home range at these sites begins with "Unknown," and is followed by the visual data.

9. Eagles are identified by plumage in some cases, which correlates with age (McCollough and Krohn 1986).
   a. Adult—Eagle with full white head and tail, usually 5+ years of age.
   b. Near-adult—Eagle with brown mottling in predominately white head and tail, ca. four years old.
   c. Subadult—One to three-year-old eagle in various plumages of brown and white mottling. One-year-old bald eagles are typically dark, and two to three-year-old birds have white bellies with an inverted white triangle on their back. However, we observed a ten-month old telemetered nestling in the white belly phase, so variation does exist.
   d. Juvenile—A first year eagle, from fledging (when it leaves the nest) through migration.
   e. Nestling—A baby eagle, from hatching to fledging.

The number of bald eagle breeding areas in Arizona is expected to increase as nest search efforts continue. Although some new breeding areas are thought to be pioneer efforts by an expanding population, many contain multiple nests, indicating they were occupied prior to our knowledge of their existence (see Section C2). Most breeding areas have several alternate nests which the eagles choose between from one season to the next. An exception, the Sheep breeding area, contains only one nest, in a dilapidated tree, and appears to lack suitable nesting structure for the future. Alternate nests 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 nest 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 (Stalmaster 1987), and pairs may build new nests or refurbish old ones, and subsequently utilize another existing nest. In some cases, new nests have been completed within four days (Stalmaster *op. cit.*).

As of 1990, we have records of 111 nests documented through aerial surveys and interviews with the personnel from USFS, USFWS, and others. Details on each nest are given in the breeding area histories which follow, and the exact locations of these nests are plotted on maps in our Arizona Bald Eagle Nest Map Atlas (Part F) provided to the appropriate agencies by the Bureau of Reclamation. Of the 111 known nests, 48 percent were on cliffs (n = 36) or pinnacles (n = 17), 51 percent in trees (n = 46) or snags (n = 11), and one (1%) was on an artificial nesting structure (tower). Six 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, and Sheep) have only tree nests available. Eagles in the "76" territory nested on a cliff prior to 1974; however, only tree nests are currently available. Both tree and cliff nests exist at the remaining 14 breeding areas.

D4.1 ALAMO BREEDING AREA

The Alamo breeding area is located 166 km northwest of Phoenix, along the Bill Williams River, on Alamo Reservoir. The area surrounding the reservoir is fairly open, although the Bill Williams River has cut a steep canyon below Alamo Dam. At 1080 ft, Alamo is the lowest elevation bald eagle breeding area known in Arizona.

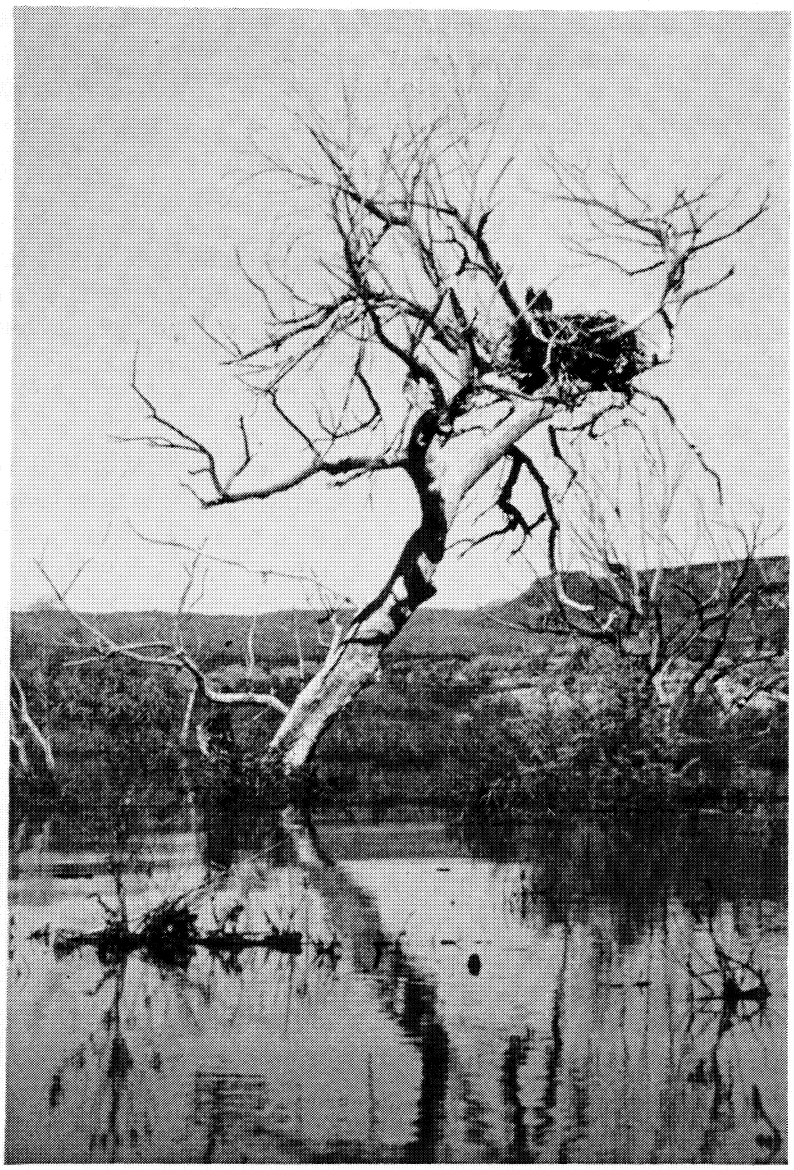

Plate D16. Alamo cottonwood snag nest (2) containing two 7.5-week-old eaglets, April 1991 (photo by D. Driscoll).

D4.1.1 Habitat

The biotic community in the Alamo area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desert Scrub Biome, Arizona Upland Subdivision, with associated Mojave Desert Scrub Biome species. The riparian habitat, restricted to the upper portion of Alamo Reservoir and the Bill Williams, Big Sandy, and Santa Maria rivers to the north, is a mixture of the Sonoran Riparian Deciduous Forest and Woodlands Biome and the Sonoran Riparian Scrubland Biome (see Section D2).

Habitat immediately surrounding the Alamo nests is a salt cedar jungle. Cattle grazing is no longer permitted in the upper portion of Alamo Reservoir, although trespass cattle are a common sight, and there is still very little regeneration of cottonwoods and willows. The cottonwood snags which supply nest and perch sites are deteriorating, and no large live trees exist in this area. Since the grazing moratorium went into effect, some small willows and cottonwoods are beginning to work their way above the salt cedar. It will be many years, however, until these trees are large enough to supply nesting and perching habitat for eagles.

Due to the shallow water in the upper (northern) portion of the reservoir, small bays harbor various species of emergent vegetation and support a large population of waterfowl and shorebirds through the bald eagle breeding season. The reservoir also contains a healthy population of channel catfish, carp, tilapia, and largemouth bass, the latter drawing many fishermen to the nest area.

D4.1.2 Reproductive History

The Alamo breeding area was founded in December 1986. To discuss its origin, we must look at the history of the Chino nesting territory. When the Chino breeding area was discovered in 1985 the adult female carried a backpack transmitter, and a USFWS band on her right tarsus. Assuming an Arizona origin, she would be a 1979 nestling from either the Bartlett or Fort McDowell nest sites (see Section D4.7). 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. comm.). 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 in a cottonwood snag just upstream of the existing nest. Thus, with Chino active, the new nest at Alamo Reservoir was named the Alamo breeding area. 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, hypothesis 1 or 3 is more likely, given current knowledge of bald eagle mate fidelity. Although male bald eagles have been known to breed with two females in the same season (Section D4.23), switching mates (hypothesis 2) has not been documented in the literature. 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 hypothesis.

Eagles at Alamo have been early nesters since 1987, building nests in November and December, laying eggs from 31 December to 13 January, and hatching young from 3 to 17 February which fledged between 3 and 16 May (Table D4.1-1). The Alamo pair did not lay eggs in 1987, but, of the five eggs laid from 1988–1990, four young hatched and fledged. In 1989, we also collected a whole egg (containing a 12-day-old embryo) that did not hatch. Three nests, all in cottonwood snags, have been built on the upper end of Alamo Reservoir. The eagles sat in nest 1 in 1987, but did not lay eggs. The birds used nest 2 from 1988 to 1990, even though nest 3 was built in December 1989. All three nests are still in existence.

Table D4.1-1. Nesting chronology of the Alamo breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1987	—	-	-
1988	31 December	3 February*	3 May*
1989	8 January	17 February*	5 May*
1990	13 January	17 February*	16 May*

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

A noteworthy incident occurred at the Alamo nest in 1988. The eaglet fell from the nest on 20 April and could not yet fly or reach a safe perch. We entered the area on 23 April and found the nestling on the ground with a fishing lure lodged in its tongue. A white-faced ibis, brought by the adults as prey, hung from the opposite end of the lure. After removing the lure, the eaglet and its meal were returned to the nest.

D4.1.3 Mortalities

The Alamo breeding area appears to have a serious problem with adult mortality. In the four years of its existence, two females and one male have been replaced. In 1987, the first year the territory was occupied, the adult female carried a USFWS band on her right tarsus. She was replaced by an unbanded female in 1988, which was again replaced by a female banded on her right tarsus in 1989. Replacement within an adult pair is difficult to detect, unless the new bird is a near-adult or is banded. No apparent changes in the Alamo male occurred until 1990, when the male 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 dogs retrieval. This is a serious concern, since steel shot is not mandatory until the 1990–1991 season. Not only is there a possibility of lead poisoning, but it seems possible that an angry hunter might shoot the eagle for stealing a downed duck.

D4.1.4 Known Foraging Areas and Food Habits

The Alamo eagles are known to forage from Km 50.5 on Alamo Reservoir to Km 56.3 at the confluence of the Big Sandy and Santa Maria rivers. Most foraging, however, apparently occurs in the upper portion of Alamo Reservoir (Newbold and Newbold 1988, Moller *et al.* 1989, Bock and McLuckie 1990).

Prey items described by Newbold and Newbold (1988), Moller *et al.* (1989), and Bock and McLuckie (1990) are presented in Table D4.1-2, along with prey items collected at the nest during 1986 through 1989. See Section B5.1.1 for a detailed analysis of prey remains collected from 1986 through 1989.

Table D4.1-2. Prey species observed taken by bald eagles or collected from the nest at the Alamo breeding area.

Fish		**Mammals**
Carp	Grebes	Cottontail rabbit
Channel catfish	Western grebe	Blacktail jackrabbit
Bullhead (catfish)	Eared grebe	Muskrat
Tilapia	Shorebirds	Striped skunk
Largemouth bass	Black-bellied plover	Neotoma
Black bass	Dowitcher	Rock squirrel
Bluegill	Wading Birds	Unidentified rodent
Golden shiner	American coot	
Sucker	Great blue heron	**Herptiles**
Unidentified fish	Unidentified Ardeidae	Western diamondback rattlesnake
	White-faced ibis	Chuckwalla
Birds	Raptors	
Waterfowl	Western screech owl	
Green-winged teal	Passerines	
Pintail	Western meadowlark	
Mallard	Unidentified passerine	
Ruddy Duck		
Anas sp.		
Unidentified Anatidae		
Unidentified waterfowl		

Kleptoparasitism is commonly observed among bald eagles in Arizona and other populations. An Alamo adult was observed attempting to steal a ruddy duck from a peregrine falcon in 1988 (see Section D4.1.6). In 1989 one of the adults successfully pirated a green-winged teal from a peregrine falcon (Moller *et al.* 1989).

D4.1.5 Human Impacts

Human disturbance is a serious problem at the Alamo nest site. Fishermen, hunters, shooters, boaters, and off-road vehicles pass immediately below the nest (depending on reservoir levels) for their recreational activities. Military aircraft on low level flight training, as well as subsequent sonic booms, are also a daily occurrence (Weiss 1987, Weiss and Brashear 1987, Newbold and Newbold 1988, Moller *et al.* 1989, and Bock and McLuckie 1990).

Waterfowl hunting in the immediate nest vicinity may pose a serious threat to this breeding area. The Alamo pair lay their eggs in December each year. The period just prior to and during incubation is a critical time as far as nest success is concerned. During this period, the birds may abandon their nest, or simply not lay eggs, if they are disturbed. The Alamo eagles have also developed the behavior of stealing ducks from hunters, taking the duck off the surface before the dog is able to retrieve it, and, as mentioned above, the possibilities of lead poisoning or shooting are imminent.

Fishermen also threaten the success of this breeding area. Adults were flushed repeatedly off the nest by boats approaching too close to the nest tree. Another matter of environmental importance is waste monofilament (see above). Monofilament is present in an abundance on Alamo Reservoir. Each cottonwood snag, including the nest trees, have a preponderance of monofilament, hooks, and lures in them. Monofilament can kill adult bald eagles and other wildlife species (see Section C3.3). Eaglets have also died from becoming entangled in monofilament at the nest (Section D4.22.3).

Weiss (1987) stated, "I feel that human disturbance is the main problem with this nest site ..." and "... the best solution for eagle management is to restrict the immediate access to the area and to stop the military jet traffic." Weiss and Brashear (1987) also stressed this point, "I feel the site was unsuccessful due to an overabundance of recreational users and the many aerial intrusions." Newbold and Newbold (1988), Moller *et al.* (1989), and Bock and McLuckie (1990) voiced similar opinions based on their observations. See U.S. Fish and Wildlife Service (1989) and (1990) for detailed accounts of disturbance at Alamo in 1988 and 1989.

D4.1.6 Wildlife Interactions

In 1988, 230 interactions were recorded at the Alamo nest site, and several are noteworthy. Due to the close proximity of the Ive's Wash breeding area (1 km by air), intraspecific interactions are common. In one instance, the two males locked talons in flight, and on another occasion actually plummeted from a perch into Alamo Reservoir, still locked together as they hit the water. In an interspecific interaction, the Alamo adults dove on a coyote eight times, striking it twice, and driving it from the nest area (Newbold and Newbold 1988).

On 23 April 1988, as we approached the nest to return a fallen eaglet, a peregrine falcon flushed a flock of ruddy ducks out of a bay near nest 2. The falcon struck a duck, then circled and caught it in mid-air and flew to the west. The adult male bald eagle dove at the falcon which dropped its prey and perched in a nearby willow. The falcon remained on its perch as we proceeded to the nest. Other observations of peregrines have been made in this vicinity, and it is possible that an eyrie exists in the area.

Observed interactions in 1989 totalled 89, about half of which involved the Ive's Wash and other bald eagles (Moller *et al.* 1989). In 1990, Bock and McLuckie estimated 116 intraspecific interactions between the Ive's Wash and Alamo eagles, which nested within 1 km of each other. Many of these interactions simply involved perching at territory boundaries and vocalizing. In addition, 117 interspecific interactions were recorded in 1990. On one occasion, the adult locked talons with an osprey and actually forced the intruder into the reservoir, making several stoops on the floating bird. A bobcat climbed the nest tree on 31 March 1990, although it retreated upon reaching the nest (Bock and McLuckie 1990). Interactions with peregrine falcons were again observed in 1989 (see Section D4.1.4) and 1990.

D4.1.7 Wildlife Sightings

The Alamo breeding area supports a variety of wildlife species, due to the combination of desert, riparian, and reservoir habitats. Observations of particular interest, due to their isolation, or the species involved, are presented here.

American white pelicans are common winter visitors to Alamo Reservoir. In 1990, adult and immature brown pelicans were also present (Bock and McLuckie 1990). Two great blue heron rookeries are located in the Alamo area, one on the upper end of Alamo Reservoir, south of Brown's Crossing, and one upstream of the Santa Maria River confluence on the Big Sandy River. Double-crested cormorants also nest in these rookeries. Other species of interest include merlins, black-shouldered kites, black-crowned night herons, loons, horned grebes, red-breasted mergansers, hooded mergansers, northern shrikes, and American avocets (Newbold and Newbold 1988, Moller *et al.* 1989, Bock and McLuckie 1990). As discussed in Section D4.1.6, peregrine falcons are regularly sighted on Alamo Reservoir.

D4.1.8 Management Recommendations

1. A closure should be enacted for the upper portion of Alamo Reservoir, which would include the Alamo and Ive's Wash nest sites, from 1 December through 30 June. Closure boundaries should include a minimum 200-m buffer on the southern border, from the nest site into Alamo Reservoir, and be marked with floating buoys. The northern boundary should be closed south of Brown's Crossing, and the road into Woody's Cove closed on the eastern border. All borders should be clearly posted. This closure is of crucial importance to the existence of the Alamo and Ive's Wash nest sites (see Sections D4.1.5 and D4.16.5).

2. Since a moratorium on grazing already exists for the upper portion of Alamo Reservoir, all trespass cattle should be removed immediately and kept out of the riparian areas. This would give young willows and cottonwoods a chance to grow above the salt cedar jungle. The planting of cottonwood poles may also be necessary to provide future nest trees and perches, since no large live trees exist in the area and the snags are falling apart (see Section D4.1.1). In addition, a program of salt cedar eradication may be necessary.

3. Reservoir levels necessary to sustain the three bald eagle breeding areas (Alamo, Chino, and Ive's Wash) associated with Alamo Reservoir should be established.

ALAMO BREEDING AREA

Date Discovered: 1 December 1986
Drainage: Bill Williams River / Alamo Lake (Reservoir)
Elevation (MSL): 1080 ft
County: La Paz
Latitude–Longitude Ten Minute Block: 341-1133
Land Management: U.S. Bureau of Land Management, Kingman District
U.S. Army Corps of Engineers
Arizona Game and Fish Department
Distance From Phoenix: Air - 166.0 km Northwest
Distance To Nearest Breeding Area Upstream: Chino - 8.0 Km
Air - 7.5 km
Distance To Nearest Breeding Area Downstream: Ive's Wash - 0.2 Km
Air - 1.0 km
Distance From Big Sandy / Santa Maria River Confluence: 2.8 Km
Distance From Colorado River Confluence: 52.2 Km
Distance From Alamo Dam: 9.0 Km
Air - 7.3 km
Home Range: Unknown. Known to utilize Km 50.5 on Alamo Reservoir to Km 56.3 at the confluence of the Big Sandy and Santa Maria rivers.

Quadrangles: Artillery Peak - 15 Minute
Alamo Dam - 15 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Snag	1987	Existing - Built December 1986.
2	Cottonwood	Snag	1988-1990	Existing - Built November 1987.
3	Cottonwood	Snag		Existing - Built December 1989.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1987	Occupied	0	0	0	Adult female banded on right tarsus—possibly 1986 Chino pair.
1988	Successful	1+	1	1	New adult female (not banded). Young fell from nest 20 April, returned nestling 23 April, and removed fishing lure from its tongue.

ALAMO BREEDING AREA (Continued)

Productivity (cont'd.)

Year	Status	Eggs	Young	Fledged	Comments
1989	Successful	2+	1	1	New female-banded on right tarsus; one egg collected.
1990	Successful	2+	2	2	New male banded on right tarsus.
Total		5	4	4	
Years		4	4	4	
Mean		1.2	1.0	1.0	

D4.2 ASH BREEDING AREA

The Ash breeding area is located 142 km east of Phoenix, in the mountainous country along Ash Creek, a tributary of the Salt River. Ash Creek is a free-flowing intermittent stream which remains dry most of the year. The surrounding area is fairly open and rolling, intersected by Highway 60, although the

Plate D17. Ash ponderosa pine nest (2) containing two eaglets, May 1985 (photo by D. Driscoll).

land to the north falls steeply into the Salt River Canyon. Ash Creek enters the Salt River just above Gleason Flat. At 5640 ft, Ash is the highest elevation bald eagle breeding area in Arizona.

D4.2.1 Habitat

The biotic community in the Ash area is of the Upper Sonoran Life Zone. The mountainous country is characteristic of the Great Basin Conifer Woodland Biome (see Section D2), with large ponderosa pines in the bottoms and rocky slopes containing grasses, agave, cactus, live oaks, and junipers. Timber and firewood cutting has created grassy clearings in the uplands. Ash Creek remains dry most of the year and is devoid of riparian vegetation, with pines growing up to the narrow rocky streambed. The grassy clearings and live oaks create good habitat for turkeys, which have been reintroduced by AGF. Acorn woodpeckers are also common.

D4.2.2 Reproductive History

The two Ash nests were reported in 1982 (B. Jackson, pers. comm.), although the breeding area was not found by agency personnel until 2 May 1984. Data on the Ash pair is limited, since the nest was only active for two years (1984-1985) at known nest locations. Even then, data collection was limited to scattered sporadic nest checks in 1985 (Driscoll 1985b). The Ash nests are usually covered with snow during annual ORA flights in early February; however, eaglets 3-4 weeks old were in the nest on 3 April 1985 (Driscoll 1985b). Back-dating results in an egg laying period of 30 January to 6 February, with hatching from 6–13 March. Fledging occurred around 4 June in 1984 (Grubb 1984), and from 9–11 June in 1985 (Driscoll 1985b) (Table D4.2-1). Of four eggs laid in nest 2 in the two known active years, the Ash eagles fledged one young in 1984 (Grubb 1984), and two in 1985 (Driscoll 1985b). The two known nests, in live ponderosa pine trees, are still in existence.

Table D4.2-1. Nesting chronology of the Ash breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1984	—	—	4 June
1985	30 Jan–6 Feb	6–13 March	9, 11 June*
1986	—	—	—
1987	—	—	—
1988	—	—	—
1989	—	—	—
1990	—	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

The Ash breeding area has remained unoccupied at known nest locations 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 near nest 2 in late May

1986 (Hughes, pers. comm.), strongly suggest the breeding area continues to be active at a new nest location.

D4.2.3 Mortalities

No incidents of mortality have been recorded at the Ash breeding area; however, this is likely due to the limited amount of data on the site.

D4.2.4 Known Foraging Areas and Food Habits

Virtually nothing is known about the foraging behavior of the Ash pair. Driscoll (1985b) observed carp and suckers brought to the nest as prey when the creek was dry. Carp could exist in stock tanks (ponds) near the Ash nest, or in Seneca Lake (a pond) approximately 5 mi north of the nest, although no data are known to us on the fish inhabiting these waters. Suckers, however, would most likely be found in the Salt River, or lower Ash Creek near the river. Thus, it seems likely that the eagles travel to the Salt River for at least some of their foraging activities. Driscoll (1985b) also notes frequent flights and soaring over clearings, which likely contain rabbits and small mammals. Prey items described by Driscoll (1985b) are presented in Table D4.2-2, along with prey remains collected at the nest in 1984 (Grubb 1984).

Table D4.2-2. Prey species observed taken by bald eagles or collected from the nest at the Ash breeding area.

Fish	Birds	Mammals	Herptiles
Carp	Turkey	Lagomorph	None found
Sucker	Mourning dove	Rock squirrel	
Catfish		Unidentified rodent	

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). This may seem a considerable distance; however, Arizona bald eagles have been known to travel 22 Km up tributaries to forage (see Section D4.12). Thus, the Ash pair can easily access either section of the river, and likely avoid the Cibecue and Canyon pairs which nest in between. The Mule Hoof breeding area is also nearby (Km 191 on the Salt River), although the current status of this site remains a mystery (see Section D4.19).

D4.2.5 Human Impacts

The close proximity of Timber Camp provides strong possibilities for human intrusion in the nest vicinity, and a jeep trail leads from the camp to Ash Creek, just above the nest area. Gun shots and jet traffic were reported by Driscoll (1985b).

The area surrounding the Ash territory is popular for hunting, and although no known mortalities have occurred at the Ash nest, an adult (AM07) was found dead near Hess Canyon in April 1989 (see Section C3.7). It is possible that indiscriminate shooting may pose a threat to the Ash eagles.

D4.2.6 Wildlife Interactions

The only known interactions of the Ash eagles with other wildlife were aggressive chases after common ravens reported by Driscoll (1985b).

D4.2.7 Wildlife Sightings

The Ash breeding area supports a variety of wildlife due to the vegetation form and plant species composition. Merriam's turkeys can be heard gobbling on spring mornings, and acorn woodpeckers are abundant. Golden eagles are common in the area, and Driscoll observed mountain lion tracks along the creek.

D4.2.8 Management Recommendations

1. The Ash eagles have not occupied the two known nests in recent years, although if the birds do return, the road leading from Timber Camp to Ash Creek should be blocked. A locked gate currently exists on a west fork of the jeep trail which crosses Ash Creek. Moving this gate to a point prior to the fork would continue to stop vehicle traffic, and possibly reduce the risk of hikers walking under the nest (Driscoll 1985b).

2. Adult eagles have been sighted at the Highway Tanks east of Highway 60, and these may be the Ash birds. One of the eagles could be captured and radio-tagged in order to locate their new nesting location. Also, the foraging behavior of the Ash eagles could be determined in this manner. Foraging data on the Ash pair could be beneficial in the future management of the forest surrounding the nest, and of the Gleason Flat and Mule Hoof Bend areas of the Salt River.

ASH BREEDING AREA

Date Discovered: 2 May 1984. First Reports 1982.
Drainage: Ash Creek (Free-flowing - Intermittent)
Elevation (MSL): 5640 ft
County: Gila
Latitude-Longitude Ten Minute Block: 334-1103
Land Management: U.S. Forest Service, Tonto National Forest, Globe Ranger District
Distance From Phoenix: Air - 142.5 km East
Distance To Nearest Breeding Area Upstream: Mule Hoof Air - 11.5 km
Distance To Nearest Breeding Area Downstream: Cibecue Air - 14.5 km
Distance From Salt River Confluence: 18.0 Km Air - 13.0 km
Home Range: Unknown (Most likely travel to Salt River or lower Ash Creek - suckers brought to nest in 1985).
Quadrangles: Chrysotile 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Ponderosa	Live	Unknown	Existing - Found 2 May 1984.
2	Ponderosa	Live	1984-1985	Existing - Found 2 May 1984.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1982	Occupied	?	?	?	Adults and nest reported.
1983	Occupied	?	?	?	
1984	Successful	2+	1	1	One egg collected.
1985	Successful	2+	2	2	
1986	Unoccupied*				Two young near nest 2 in May.
1987	Unoccupied*				
1988	Unoccupied*				
1989	Unoccupied				
1990	Unoccupied				
Total		4+	3	3	
Years		2	2	2	
Mean		2.0	1.5	1.5	

* Adults sighted at Highway Tanks (East of Highway 60) in 1986, 1987, and 1988. Two juveniles sighted near nest 2 in May 1986.

D4.3 BARTLETT BREEDING AREA

The Bartlett breeding area is located 54 km northeast of Phoenix, along the regulated Verde River below Bartlett Dam. The surrounding area is characterized by steep slopes and promontory cliffs, although the land opens up downstream near Needle Rock. Due to high levels of recreation pressure, a closure was enacted at the Bartlett breeding area on 9 July 1979. 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.

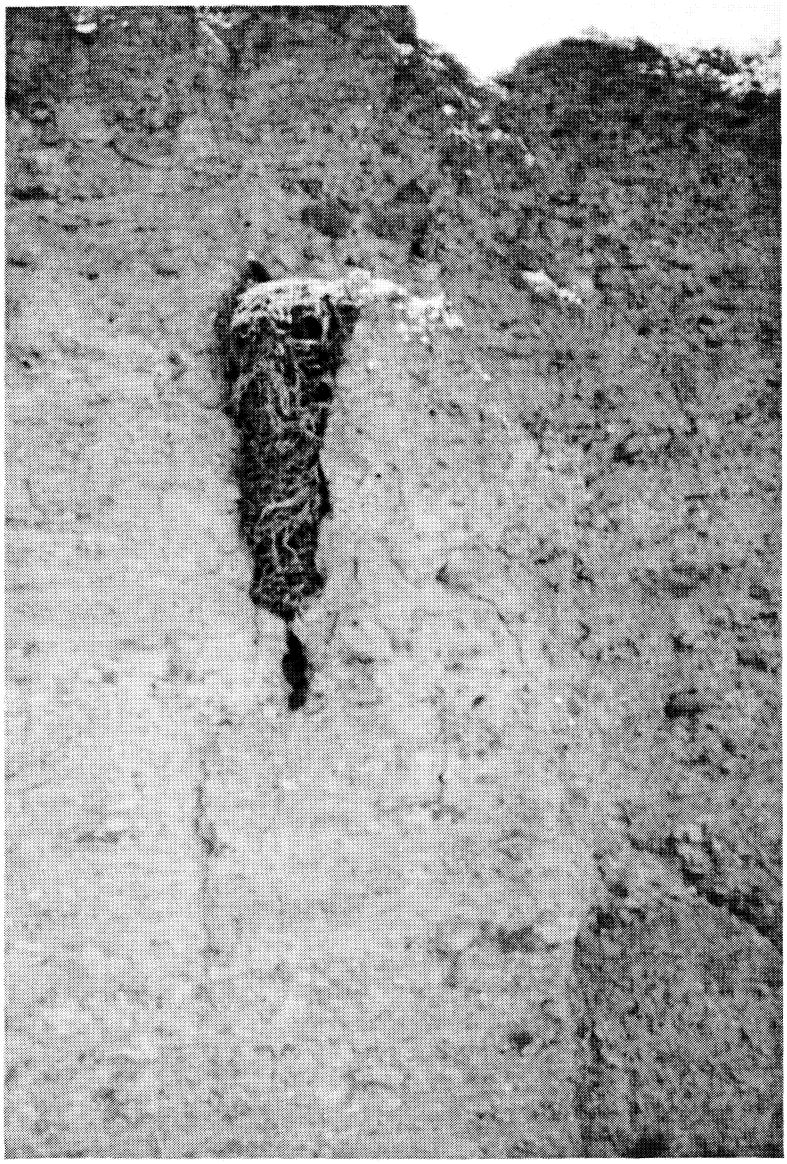

Plate D18. Bartlett cliff nest (1) with adult perched on top, June 1988. This nest has been present since at least the 1940s, and was nearly 5 m tall in 1990 (photo by D. Driscoll).

D4.3.1 Habitat

The biotic community in the Bartlett area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desert Scrub 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).

The upper portion of Bartlett Reservoir contains some large 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. 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. Along this reach, the river supports some emergent vegetation along scattered cutbanks and larger cliffs.

D4.3.2 Reproductive History

Eagles at the Bartlett breeding area have been very dependable nesters, having laid eggs in each of the 24 years data has been collected. The Bartlett eagles have laid eggs from 5 January to 10 February, excluding a second clutch laid on 14 March in 1990. Hatching ranges from 17 February to 16 March, with young fledging from 4 May to 5 June (Table D4.3-1).

The Bartlett breeding area was first known to be occupied in the 1940s (Phillips *et al.* 1964), but productivity data were not recorded until 1964. The Bartlett eagles have built a (1) cliff nest, (2) a pinnacle nest, and (3) a tree nest on the regulated river reach below Bartlett dam. Nest 1 was built during or prior to the 1940s (Phillips *et al.* 1964), and was used by the eagles regularly until 1982 (Rubink and Podborny 1976, Haywood and Ohmart 1983). The nest, used again from 1984-1985 (Aitkenhead and Aitkenhead 1984, Senger and Senger 1985) and also in 1990, is 4.8 m (15.8 ft) deep (measured in 1990). Nest 2 was built in 1953, then blown down in a storm and was rebuilt later in the 1960s (Rubink and Podborny 1976). Nest 2 was used in 1983 (Grubb, pers. comm.) as well as 1986-1990. Nest 3 was found in 1973 (Rubink and Podborny 1976), but not used until 1977 (Hildebrandt 1981), although the nest may have been utilized prior to its discovery. 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. Nests 1 and 2 are still in existence.

Although early records are limited to sporadic nest visits, they at least provide an outline of breeding area occupancy. Bartlett was occupied in the 1940s (Phillips *et al.* 1964), and again in 1953 (Rubink and Podborny 1976). Two young hatched in 1964, but one died in the nest after the shooting of one adult and possible abandonment by the other. The second eaglet was recovered by Chuck Binder, a local falconer, but it also died at a later date. The nest was not checked in 1965, 1968, or 1969; however, 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 40 eggs, failing seven years and fledging 19 young in the other 14 years (Rubink and Podborny 1976, Hildebrandt 1981, Sell 1982, Ohmart and Sell 1980, Haywood and Ohmart 1981, Haywood and Ohmart 1982, Grubb 1986a, and Section C2).

The current Bartlett male first occupied the breeding area in 1988, as a near-adult. We captured the male on 28 March 1988, for banding and telemetry purposes, and found he carried a USFWS band (629-14559) on his right tarsus. The eagle had been banded as a nestling in 1984 at the Blue Point breeding area (Grubb 1984).

Table D4.3-1. Nesting chronology of the Bartlett breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1975	< 25 February	< 21 March	> 2 June
1976	—	—	—
1977	5 February	2 March*	25 May*
1978	10 February	16 March	5 June*
1979	26 January	2 March	14 May*
1980	29 January	3 March	7 May*
1981	—	17 February	—
1982	—	—	—
1983	5 January	—	—
1984	6 January	—	—
1985	20 January	24 February	27 May*
1986	18 January	22 February	4 May
1987	< 2 February	—	—
1988	24 January	27, 29 February*	13, 15 May*
1989	18–20 January	22, 24 February*	10, 11 May*
1990	< 5 February	—	—
	14 March**	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
** Indicates second clutch laid on known date.
< Indicates "prior to"
> Indicates "later than"

In 1990, the Bartlett eagles laid at least one egg in nest 2 prior to 5 February. The nesting attempt failed on 12 February and the adults immediately began refurbishing nest 1. On 14 March, the pair laid a second clutch of at least two eggs in nest 1. The second nesting attempt subsequently failed on 22 March (Kime and Upton 1990). This represents the third documented incidence of double-clutching in Arizona bald eagles.

When the two 1989 Bartlett juveniles fledged, they went to the ground where we picked them up for banding and radio-tagging. One eaglet had flown into a teddybear cholla cactus; we spent 10 minutes pulling cholla spines out of the bird's face, feet, and body. In the process, we collected a tick from underside of the bird's wing. Parasitologist J. Phillips identified the tick as *Argas cooleyi*, the first record of the species in Arizona and the first tick documented on a bald eagle.

D4.3.3 Mortalities

There have been seven documented juvenile bald eagle deaths at the Bartlett breeding area. Of these, two young died in the nest, two fell from the nest, two died after fledging, and one died in captivity. 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. As

mentioned, one young died in the nest and the other in captivity in 1964, after one adult was shot and the other abandoned the nest (Rubink and Podborny 1976). In 1978, one eaglet fell from the nest and the other died after fledging and was eaten by a mammalian predator (Hildebrandt 1981). Another juvenile died of unknown causes after fledging in 1981 (Haywood and Ohmart 1982), and an eaglet fell from the nest in 1985 (Senger and Senger 1985). In 1989, one eaglet died in the nest at 11 weeks of age, one day before its two siblings fledged. Possible factors contributing to nestling mortality (monofilament line, nest parasites, and heat stress) are detailed in Section C3.

The Bartlett breeding area has experienced high rates of adult mortality. Three males and an adult of unknown sex have been replaced at the Bartlett territory. A Bartlett adult was shot in 1964 and replaced in 1965 (Rubink and Podborny 1976), the male was replaced in 1978 by a near-adult (Hildebrandt 1981), the male was shot in September 1986, replaced in 1987, and replaced again in 1988 by a near-adult. It is important to note that these data represent a *minimum* mortality figure because it is difficult to determine if an adult has been replaced, unless the new adult is a near-adult or subadult eagle, or has been banded. Also, actually witnessing a mortality or finding a carcass (before other predators) in the vast expanse of the desert is rare. In addition, breeding pairs were not checked each year for replacement of individuals until 1987.

The large amount of recreational shooting (including handguns, shotguns, rifles, and automatic weapons) in Arizona puts bald eagles at a disadvantage, since they are conspicuous and their size makes them an easy target. Although adults are usually wary of humans, young eagles just out of the nest can be very naive to the ways of man. Hildebrandt (1981) witnessed people shooting at fledgling eagles at Bartlett, and there are numerous reports of gunfire near the Bartlett nest (Hildebrandt and Ohmart 1978, Grubb *et al.* 1983, Senger and Senger 1985, Fettig and Bock 1988, Adams and Linskens 1989). As noted above, there are two known cases of adult eagles being shot at Bartlett.

D4.3.4 Known Foraging Areas and Food Habits

The Bartlett breeding area is unique in that water temperatures in the regulated Verde River remain suitable for sucker spawning over a prolonged period during the bald eagle nesting season. Two riffles ideal for sucker spawning occur below the nest cliff, at Km 34.5 and 34.0, and were used extensively for foraging in 1988 and 1989 (see Section B4.1). The male was noted to discard uneaten day-old fish from the nest, and replace them with fresh suckers. With most foraging below the nest cliff, life for the Bartlett eagles seemed fairly easy; however, as shown by radio telemetry during the 1988 and 1989 nesting seasons, the adult male routinely ventured down to the Needle Rock area, and up to Bartlett Reservoir where he often foraged during late spring. The Bartlett adult male was telemetered by BioSystems on 28 March 1988 and provided detailed information on foraging and movements during the 1988 and 1989 nesting seasons. The home range of the Bartlett pair extends from Km 25.0 on the Verde River, to Km 53.0 on Bartlett Reservoir, totaling 28 Km.

Prior to the male's capture and radio-tagging in 1988, foraging information was limited to areas observed by ABENWP and other research personnel watching the nest, resulting in a bias toward the river section below the nest. This same bias also resulted in small home ranges, restricted to river sections and areas visible from nest observation points (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). However, the "best estimate" of home range, based on observed flights of adults by Sell (1982) is close to the actual home range recorded with telemetry data during 1988–1989 (see Section B4.1).

Prey items described by Rubink and Podborny (1976), Hildebrandt (1981), Haywood and Ohmart (1983), and Grubb (1986a), are presented in Table D4.3-2, along with prey items delivered to the nest during

1988 and 1989 and identified by BioSystems. See Sections B4.1 and B5.1.2 for detailed analysis of prey species utilized by the Bartlett eagles. In addition, the eagles were observed attempting to capture common mergansers and cinnamon teal (Aitkenhead and Aitkenhead 1984, Senger and Senger 1985).

Table D4.3-2. Prey species observed taken by bald eagles or collected from the nest at the Bartlett breeding area.

Fish	Birds	Mammals
Carp	Unidentified waterfowl	Cottontail rabbit
Channel catfish	American coot	Blacktail jackrabbit
Flathead catfish	Great blue heron	Neotoma
Bullhead (catfish)	Gila woodpecker	Rock squirrel
Largemouth bass	Mourning dove	Ground squirrel
Smallmouth bass	Unidentified bird	Unidentified rodent
Black bass		Unidentified mammal
Bluegill		
Green sunfish		
Black crappie		**Herptiles**
Desert sucker		Spiny softshell turtle
Sonora sucker		Unidentified snake
Unidentified fish		

Kleptoparasitism is commonly observed among bald eagles in Arizona, and elsewhere. The Bartlett adults were observed stealing prey from great blue herons and ospreys (Fettig and Bock 1988; Section B4.1).

In an interesting observation, one of the 1989 fledglings captured an apparently live fish on 8 June, by hopping off a boulder into a shallow pool. Both 1989 juveniles made several attempts to capture live fish, and each found and fed on carrion fish.

D4.3.5 Human Impacts

Human disturbance is a serious problem at the Bartlett breeding area. Fishermen, shooters, campers, and off-road vehicles enter the closure area and disturb the eagles during each breeding season (Haywood and Ohmart 1981, Aitkenhead and Aitkenhead 1984, Senger and Senger 1985, Fettig and Bock 1988, Adams and Linskens 1989, Kime and Upton 1990). Shooting is a problem of special concern, since two of Bartlett's male eagles have been shot and the rate of adult turnover is relatively high (see Section C3.7). Further details on human disturbance at the Bartlett breeding area during 1988–1989 are provided in Sections B4.1 and C4.7.

According to most reports, trespassers confronted in the closure area said they did not see a closure sign, while others read the signs and entered anyway. A lack of proper road blocks near Needle Rock allows access to the nest area from the southern boundary. Also, river traffic entering from the northern boundary frequently stopped for prolonged periods near the nest cliff, which in some cases noticeably altered the eagles behavior (Aitkenhead and Aitkenhead 1984, Senger and Senger 1985, Fettig and Bock 1988, Adams and Linskens 1989, Kime and Upton 1990).

Disturbance probably caused the pair to fail in 1990. Two clutches of eggs were laid that year. During an ORA flight on 5 February, USFWS, Reclamation, and AGF biologists observed incubation in nest 2. BioSystems accompanied ABENWP biologists to the nest area 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. Upon notifying USFS personnel of the situation, we were informed that they knew the gate was broken, and it had been broken for some time. 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 (2+) in nest 1 on 14 March. The second nest attempt failed on 22 March, when the adults stopped incubating (Kime and Upton 1990).

A video camera was installed at nest 1 in 1985, to obtain food habits data, by Teryl Grubb, USFS. The adults and eaglets reacted adversely to the camera, resulting in its removal eight hours later. The eaglets reacted to the camera's movement, especially panning, and the adults did not return to the nest until after the camera was removed (Senger and Senger 1985). Although the camera has been removed, two large wooden spools of video cable were left along the dirt road west of (behind) the nest cliff. By following the two lines of cable down the road, any passerby is led directly to the cliff, 7 m above nest 1.

Discussing human impacts at the Bartlett breeding area, Aitkenhead and Aitkenhead (1984) stated that the "... main problem was trespassing in the closure." Senger and Senger (1985), Fettig and Bock (1988), Adams and Linskens (1989), and Kime and Upton (1990) voiced similar opinions based on their observations, and all expressed the need for more closure signs and enforcement of closure laws. See U.S. Fish and Wildlife Service (1989) and (1990) for further accounts of disturbance at Bartlett in 1988 and 1989.

D4.3.6 Wildlife Interactions

Interactions with other bald eagles (intraspecific) and with other species (interspecific) are common among bald eagles. These interactions can be aggressive, as in territorial defense and attempts to pirate prey, but occasionally are not, such as soaring with other raptors. At the Bartlett nest site, interspecific interactions with common ravens have been the most numerous, followed by turkey vultures, and red-tailed hawks. Other species interacting with the eagles include Harris' hawks, osprey, golden eagles, prairie falcons, peregrine falcons, American kestrels, Cooper's hawks, sharp-shinned hawks, great blue herons, double-crested cormorants and coyotes (Haywood and Ohmart 1982, Aitkenhead and Aitkenhead 1984, Senger and Senger 1985, Fettig and Bock 1988, Adams and Linskens 1989, Kime and Upton 1990).

Intraspecific interactions usually involve pursuit, escorting the eagle out of the territory, or aggressive altercations. On 17 March 1989, both adults pursued three subadult bald eagles. The female locked talons with one and they fell about 30 m before separating (Adams and Linskens 1989). Interactions between other bald eagles were also described by Senger and Senger (1985), and Fettig and Bock (1988), and BioSystems researchers 1988–1989.

D4.3.7 Wildlife Sightings

The Bartlett breeding area supports a variety of wildlife species, due to the combination of desert, river, and reservoir habitats. Observations that seemed most interesting to us are presented here.

Bartlett is an area known by ABENWP and BioSystems personnel mostly for its density of western diamondback rattlesnakes. Other herptiles of interest are desert tortoises, gila monsters, Arizona coral snakes, and spiny softshell turtles. American white pelicans have been sighted, as well as snowy egrets, black-crowned night herons, and white-faced ibis. Waterfowl are common, especially on the reservoir,

and hooded mergansers have been seen in the nest area. Along with the usual desert raptors, golden eagles, peregrine falcons, and prairie falcons have been sighted occasionally (Fettig and Bock 1988, Adams and Linskens 1989, BioSystems researchers 1988-1989). A zone-tailed hawk was also sighted at Bartlett on 9 May 1989 by BioSystems personnel.

While attempting to radio-tag the Bartlett male, we had an interesting encounter with a large predator. Just before midnight on 21 January 1988 we forded the Verde River, between the nest pinnacle and the USGS gaging station, after examining potential capture sites downstream. We stopped on the north bank to put our boots on and had been talking for about five minutes. When we started hiking back to camp, we spotted a mountain lion about 20 m away, watching us from a small boulder. A stare-down ensued for about 15 seconds, then the lion sprang up the slope without making a sound. The cat stopped twice to look back at us, then vanished into the night.

D4.3.8 Management Recommendations

These recommendations, most of which are aimed at lowering the impact of public users, augment those given in Section B4.1.6.

1. The current closure area seems to be of sufficient size for protecting the Bartlett nest; however, the closure is not functional due to a lack of enforcement, proper posting, and road blocks (Aitkenhead and Aitkenhead 1984, Senger and Senger 1985, Fettig and Bock 1988, Adams and Linskens 1989, Kime and Upton 1990, and Section B4.1). Each of the above sources noted that many trespassers said they did not see a closure sign, while others read the signs and went in anyway. The authors also report that a lack of proper road blocks upstream of Needle Rock allow access to the nest area from the southern boundary, and river traffic often stopped for prolonged periods near the nest cliff.

   For river traffic, closure signs stating "No stopping until Needle Rock, Bald Eagle Nesting Area" need to be placed along the river (facing upstream) at the northern boundary and at the boulders below the nest cliff. At the northern boundary and near the southern boundary, say one river kilometer upstream of Needle Rock, closure signs stating "No Entry, Bald Eagle Nesting Area" need to be placed along the river for hikers, fishermen, off-road vehicles, and other public users. At the boulders below the nest cliff, a sign informing public users that they are within a bald eagle nesting closure and warning them of possible fines is needed. The sign could also state that ABENWP personnel are on duty, and are likely on their way to inform the trespassers of their error. If the river is properly posted, no one can say they did not see a sign.

   The closure gate on the road at the northern boundary effectively prevents vehicle entry to the nest area (when the gate is functional). However, a similar gate is needed to block roads entering the closure on the southern boundary, just upstream of Needle Rock. One way to avoid closure gates being broken by trucks and fences cut by trespassers is to place large boulders across strategic access bottlenecks. This program has been adopted by Pacific Gas and Electric Company and by the USFS (Lassen National Forest, Hat Creek Ranger District) to protect bald eagle breeding areas in northern California and has proved very effective.

2. To prevent disturbance to incubating adults, all closure signs, gates, fences, and other barriers should be in functional condition by November or December of each year. This task could promote eagle productivity, simply by reducing egg mortality due to disturbance during incubation.

3. It is apparent that lack of enforcement is reducing the effectiveness of the closure. A U.S. Forest Service, U.S. Fish and Wildlife Service, or Arizona Game and Fish Department representative with the authority to write citations should be present at Bartlett on weekends to enforce closure laws.

4. Due to the high level of recreational pressure at the Bartlett breeding area, ABENWP personnel should begin coverage in January, instead of the normal February start date. This would provide protection prior to egg laying, and during early incubation, when the nest is most susceptible to failure.

5. The two spools of video cable described in Section D4.3.5, as well as cable strung along the road to the nest cliff, need to be removed from the area. This should be done during the non-breeding season (August–September).

BARTLETT BREEDING AREA

Date Discovered: 1964. Earliest records 1940s.
Drainage: Verde River (Regulated)
Elevation (MSL): 1600 - 1700 ft
County: Maricopa
Latitude-Longitude Ten Minute Block: 334-1114
Land Management: U.S. Forest Service, Tonto National Forest, Cave Creek Ranger District
Closure: Tonto National Forest Closure
Order No. 12-29
Enacted 9 July 1979
Closed To All Entry 1 November - 30 June
Closed to all vehicles 1 January - 31 December
Revised 1987 - Closed to all entry 1 December - 30 June
Distance From Phoenix: Air - 54.5 km Northeast
Distance To Nearest Breeding Area Upstream: Cliff - 35.5 Km
Air - 15.5 km
Distance To Nearest Breeding Area Downstream: Fort McDowell - 14.2 Km
Air - 11.3 km
Distance From Salt River Confluence: 34.1 Km

Distance To Bartlett Reservoir: 4.3 Km
Air - 3.4 km
Home Range: Km 25.0 on Verde River to Km 53.0 on Bartlett Reservoir (Total = 28 Km)
Quadrangles: Bartlett Dam 7.5 Minute
Maverick Mountain 7.5 Minute
Lion Mountain 7.5 Minute
Horseshoe Dam 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	1940s	Existing - Built in or prior to 1940s.
			1964	
			1966-1967	Rubink No. 19.
			1970-1976	Nest depth - 4.8 m (15.8 ft).
			1978-1979	
			1981-1982	
			1984-1985	
			1990	Adults moved here from nest 2 and laid a second clutch of eggs on 14 March 1990.*

BARTLETT BREEDING AREA (continued)

Nest Sites (continued)

No.	Species	Type	Utilized	Status
2		Pinnacle	1953 1983 1986-1990	Existing - Built 1953. Blown down after 1960. Rebuilt after 1960 - Rubink No. 20. Adults incubating prior to 5 February 1990, but failed on 12 February and moved to nest 1.
3	Cottonwood	Live	1977 1980	Nest found 1973 - Rubink No. 18. Limb broke and nest fell, 1978. Artificial nest constructed in same tree by Teryl Grubb, USFS, October 1978. Artificial nest used in 1980. Limb broke and nest fell 1985.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1940s	Occupied	?	?	?	
1953	Occupied	?	?	?	
1964	Failed	2+	2	0	One adult shot, other adult abandoned nest. 1 eaglet died in nest. 1 young recovered by Chuck Binder (a local falconer), but later died.
1965	Unknown	?	?	?	New adult.
1966	Successful	1+	1	1	
1967	Active	1+	?	?	
1968	Unknown	?	?	?	
1969	Unknown	?	?	?	
1970	Successful	3	1	1	
1971	Successful	3	1	1	
1972	Failed	1+	?	0	
1973	Successful	2+	2	2	
1974	Failed	1+	?	0	
1975	Successful	1+	1	1	
1976	Failed	1+	0	0	
1977	Successful	2+	2	2	
1978	Successful	2+	2	1	New male, near-adult (ca. 4 years old). One eaglet fell from nest. One young died post-fledging and was eaten by a mammal.

BARTLETT BREEDING AREA (continued)

Productivity (cont'd.)

Year	Status	Eggs	Young	Fledged	Comments
1979	Successful	1+	1	1	
1980	Successful	1+	1	1	
1981	Successful	2+	2	2	One young died post-fledging.
1982	Successful	2	1	1	Eaglet jumped during banding attempt, but was returned to nest safely. One egg collected.
1983	Failed	3	0	0	Two eggs collected.
1984	Failed	3	0	0	Three eggs collected.
1985	Successful	2	2	1	One young fell from nest.
1986	Successful	1	1	1	Adult male shot in September.
1987	Failed	1+	0	0	New male. Failed 19 February.
1988	Successful	2	2	2	New male (4-year-old), banded on right tarsus as nestling in 1984 at Blue Point breeding area by Teryl Grubb, USFS. Black VID band placed on left tarsus.
1989	Successful	3	3	2	One young died in nest 9 May.
1990	Failed	3+	0	0	Adults laid 1+ eggs in nest 2, but failed 12 Feb. On 14 March 1990, the pair laid a second clutch (2+ eggs) in nest 1 and incubated until 22 March.* Disturbance from vehicles likely contributed to failures. Closure gate was broken and fence cut during Jan. and Feb.
Total		44+	25	20	
Years		24	21	22	
Mean		1.8	1.2	0.9	

* Third documented incidence of double-clutching in Arizona bald eagles.

D4.4 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. The surrounding area is characterized by steep slopes and promontory cliffs, although the land opens up downstream. Due to high levels of recreational pressure, 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 glass containers.

D4.4.1 Habitat

The biotic community in the Blue Point area is of the Lower Sonoran Life Zone. 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).

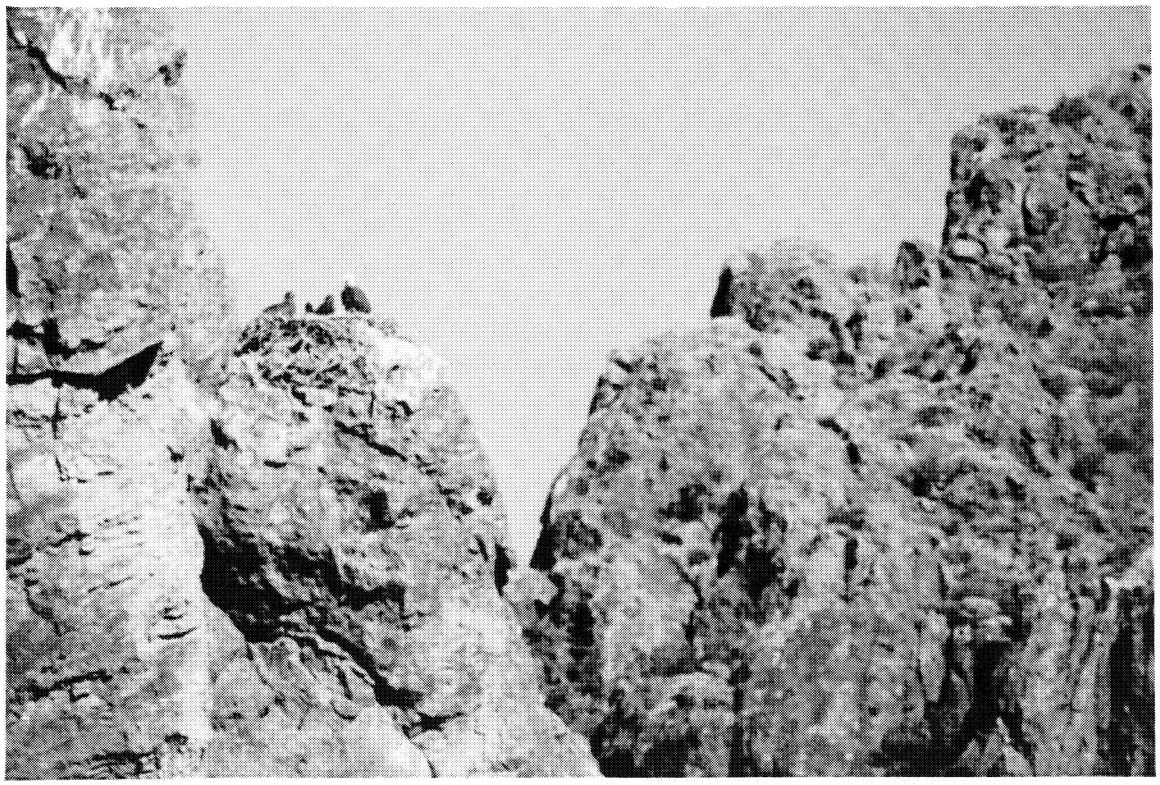

Plate D19. Blue Point pinnacle nest (6) containing three nine-week-old eaglets and the adult female, May 1988 (photo by D. Driscoll).

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 four km above the dam.

The regulated Salt River below Stewart Mountain Dam contains highly variable flows. Portions of the river are dry part of the year, with isolated pools in the riverbed from the dam to the Verde River confluence. For example, the river remained completely dry (0 cfs) from 22 January to 5 March 1989, and again in the winter and spring of 1990. Cottonwoods and mesquite bosques in various stages of decay are scattered along the river. The entire cottonwood grove near the Blue Point Ranger Station burned in November 1987. Large promontory cliffs (Bulldog Cliffs) exist near the dam, followed by the smaller Blue Point Cliffs, and a small set of cliffs near Blue Point Ranger Station. After the Verde River confluence the Salt continues to Granite Reef Dam, where it is diverted into canals for irrigation and the Phoenix Metropolitan Area.

D4.4.2 Reproductive History

The Blue Point breeding area, discovered in 1930 (Phillips *et al.* 1964), has had a sporadic history of activity, remaining unoccupied at known nest sites for up to six consecutive years. However, current knowledge of the eagles and nest sites create questions as to whether the pair may have been nesting at unknown locations. When the known nest sites have been active, the breeding area has been very productive, fledging three young per year on five occasions. The Blue Point eagles have laid eggs from 19 January to 6 February, hatching young from 23 February to 13 March, and fledging eaglets from 13 May to 7 June (Table D4.4-1).

The Blue Point eagles have built a pinnacle nest (1), a cliff nest (5), and three nests in live cottonwood trees (2, 3, 4) on the regulated Salt River below Stewart Mountain Dam, and a pinnacle nest (6) in a side canyon off Willow Springs Cove on Saguaro Reservoir. Nest 1 was built in or prior to 1930 and used until 1936, after which the nest was blown down and then rebuilt later (Phillips *et al.* 1964, Rubink and Podborny 1976, Rubink, pers. comm.). Nest 1 was utilized by the eagles again during 1981-1984 (Haywood and Ohmart 1983, Sherman 1983, Canestorp *et al.* 1984) and in 1989. Nest 2 was found in 1971, used by the eagles, then fell later that year (Simpson, unpublished field notes, Rubink, pers. comm.). Nest 3 was built on top of an old Harris' hawk nest in November 1971 and used by the eagles in 1972 (Simpson, unpublished field notes), then the nest tree fell in August 1975 (Rubink and Podborny 1976).

Nest 4 was an artificial nest built in 1979 by Teryl Grubb, USFS (Grubb, pers. comm.); the eagles sat on this nest in 1979 and built it up 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 burnt trees are still standing. Nest 5 was built and used by the eagles in 1985. It is possible that nest 5 existed previously (Collie *et al.* 1985) and was rebuilt in 1985, although Rubink (pers. comm.) described nest 1 as the site existing as early as 1930. Nest 5 was refurbished in November 1987, but the eagles used nest 6 that season. Nest 6 was found 16 March 1987 in a side canyon off Willow Springs Canyon, about 1.6 km east of Saguaro Reservoir. This nest, containing weathered sticks and appearing to be an old nest, was used by the Blue Point pair during 1987–1988; however, it may have been used in previous years when the breeding area was considered unoccupied. Nests 1, 5 and 6 are still in existence.

Table D4.4-1. Nesting chronology of the Blue Point breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1975	—	—	—
1976	—	—	—
1977	—	—	—
1978	—	—	—
1979	—	—	—
1980	—	—	—
1981	—	—	—
1982	—	—	—
1983	25 January	1 March	16 May*
1984	19 January	23 February	13 May*
1985	6 February	13 March	7 June*
1986	—	—	—
1987	30 January	5 March	1 June*
1988	28 January	2 March	14, 16 May*
1989	1 February	8 March	—
1990	—	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

It is worth noting that the Orme breeding area was discovered at the confluence of the Salt and Verde rivers in 1987, and operators in a nearby water treatment plant affirmed that the nest site had fledged young at least since the early 1970s (see Section D4.20). The Blue Point tree nests (2, 3, and 4), located only 4.5 river Km from the Salt and Verde confluence, probably were nests of the Orme pair. However, for the purpose of convention, and the integrity of early records, we reported these nests as belonging to the Blue Point pair.

Early productivity data at Blue Point remains incomplete, although first occupancy records include the period from 1930 to 1936 (Phillips *et al.* 1964), during which one or two young fledged in 1932 and 1933 (Rubink and Podborny 1976). No further records are available until 1971, when two young fledged (Forbis 1986). Simpson (unpublished field notes) states that the eggs did not hatch in 1972, although he notes that another AGF biologist claims seeing chicks in the nest. Haywood and Ohmart (1983) write that young were reported to have fledged in 1972, although other sources list the nest as unsuccessful (Forbis 1986). The breeding area remained unoccupied at known nest sites during 1973–1978 (Rubink and Podborny 1976, Haywood and Ohmart 1983); 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 (Haywood and Ohmart 1983).

The Blue Point pair fledged 12 young during 1981-1985 (Haywood and Ohmart 1983, Grubb 1986a), but did not nest in any of the known nest locations in 1986. After rebuilding nest 5, both adults sat together in the nest as late as 15 January 1987, then disappeared. The eagles were found later with three young in nest 6. The pair again raised three eaglets in the Willow Springs Canyon nest in 1988. The possibility exists that the Blue Point pair may also have nested in this location in 1986, and during the 1970s. The eagles hatched two young in 1989, which died in the nest (Bond *et al.* 1989, Sections C2.5 and C3.2). The site was occupied in 1990, although apparently no eggs were laid. In summary, the Blue Point eagles have laid at least 27 eggs and fledged 22–24 young in the 15 years of known occupancy and productivity data.

An interesting series of events occurred at the Blue Point breeding area in 1983. The pair laid eggs around 25 January and normal incubation activities followed. On 13 February the adult male disappeared, and on 14 February a near-adult male appeared in the area. The adult female continued to incubate the eggs alone, and over the next seven days she did not feed, leaving the nest unattended for a total of only 25 minutes. The female vocalized at the new male and chased him off at first; however, display flights began on 16 February. The new male landed at the nest on 17 February, after which courtship flights began. The male delivered prey to the nest on 19 February and the pair copulated on 24 February. On 27 February the new male began sharing incubation duties with the female, and subsequently helped to raise three young that were not his own (Sherman 1983, Grubb 1988). Later that year, a silver USFWS band was observed on the new male's right tarsus (Grubb *et al.* 1983).

We captured the Blue Point male on 20 March 1987, for banding and telemetry purposes, and found he carried a USFWS band (629-04463) on his right tarsus. The eagle was banded as a nestling in 1979 at the Fort McDowell breeding area (Haywood and Ohmart 1983). This male would have been four years old (a near-adult) in 1983, and is very likely the male which took over that year.

D4.4.3 Mortalities

There have been eight documented juvenile bald eagle deaths at the Blue Point breeding area. Of these, three young died in the nest, and five died after fledging. 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. One young at Blue Point died after fledging in 1981 (Haywood and Ohmart 1982). In 1985, one young died in the nest on 7 April, following helicopter disturbances the previous day (Collie *et al.* 1985).

A juvenile bald eagle from the Blue Point breeding area (JD10) was found dead in the vicinity of Bulldog Cliffs on 19 June 1987. 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 determination of the cause of death.

Three juveniles at the Blue Point breeding area left the nest on 14 and 16 May 1988, 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 mortality of the three

eaglets (see Sections C3.2 and C3.5) as all seemed in great discomfort in the days prior to jumping from the nest, a period of record high temperatures.

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 without flow below Stewart Mountain Dam through the nesting season in 1989, with only isolated pools in the usually sucker-rich river. The dry riverbed allowed public users 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 disturbance near the nest, during a crucial period (just after hatching), and possibly a lack of foraging opportunities (reducing prey availability) in the dry riverbed, contributed to the demise of the two eaglets.

Possible factors contributing to nestling mortality, including monofilament fishing line, nest parasites, and heat stress are detailed in Section C3.

The Blue Point breeding area has experienced the most known adult mortalities in Arizona, seven since 1971. The site has lost two males, three females, and two adults of unknown sex. The Blue Point male and female were both near-adults in 1971, obviously a new pair, and the carcass of an adult was found near the nest tree in 1972 (Simpson, unpublished field notes). One of the adults was replaced by a near-adult in 1980 (Haywood and Ohmart 1981). In 1983, the adult male disappeared and was replaced by a near-adult (Sherman 1983). The adult female was replaced by a near-adult in 1988, and she by a subadult in 1990.

It is important to note that these data represent a minimum mortality figure. It is difficult to determine if an adult has been replaced, unless the new adult is a near-adult or subadult eagle, or has been banded. Also, actually witnessing a mortality or finding a carcass (before other predators) in the vast expanse of the desert is rare. In addition, breeding pairs were not checked each year for replacement of individuals until 1987.

D4.4.4 Known Foraging Areas and Food Habits

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 may have been from the Orme breeding area, located at the confluence of the Salt and Verde. Reports in 1984 and 1985 maintained that the eagles concentrated their foraging near the dam spillway after AGF stocked trout in the area, and utilized the reservoir more as river recreation (tubing) increased (Canestorp *et al.* 1984, Collie *et al.* 1985). The above sources also noted the eagles utilized the Blue Point Cliffs and the mud cliffs near the Blue Point Ranger Station for perching. Although ABENWP personnel noted the eagles flying to the reservoir, they usually lost sight of the birds, so most observed foraging was located on the river.

Prior to the male's capture and radio-tagging in 1987, foraging information was limited to areas observed by ABENWP and other research personnel watching the nest, resulting in a bias toward the river section

below the nest. This same bias also resulted in small home range estimates, restricted to river sections and areas visible from nest observation points (Haywood and Ohmart 1982, Haywood and Ohmart 1983, Grubb *et al.* 1983, Grubb 1984, Grubb 1986a).

The Blue Point male was captured and radio-tagged on 20 March 1987, and provided detailed information on foraging and movements throughout 1987 and 1988. Much more extensive use of the reservoir was documented by telemetry, as well as shifts between the river and reservoir corresponding to prey availability. The home range of the Blue Point pair during our study extended from Km 6 on the Salt River to Km 36 on Saguaro Reservoir, totaling 30 Km.

In a noteworthy incident, a BioSystems biologist rescued a cactus wren from the reservoir on 19 October 1987, while tracking the Blue Point male. The wren sat on the bow of the boat drying itself and resting for over 30 minutes. When the wren took flight, it proceeded out over the reservoir and again landed in the water. At this point, the Blue Point male came off his perch, and made five passes before plucking the wren out of the water.

Prey items described by Haywood and Ohmart (1982), Haywood and Ohmart (1983), Sherman (1983), Canestorp *et al.* (1984), Grubb (1984), Collie *et al.* (1985), and Grubb (1986a) are presented in Table D4.4-2, along with prey items taken by the eagles and prey remains collected at the nest from 1986–1989. See Sections B4.2 and B5.1.3 for detailed analysis of prey species utilized by the Blue Point eagles. In addition, the eagles were observed attempting to capture common mergansers (Collie *et al.* 1985).

Kleptoparasitism is common among bald eagles in Arizona, as well as other populations. The Blue Point adults were observed stealing prey from ospreys, great blue herons, turkey vultures, and common ravens (Sherman 1983, Canestorp *et al.* 1984, Collie *et al.* 1985, and Section B4.2).

D4.4.5 Human Impacts

Human disturbance is a serious problem at the Blue Point breeding area. Due to its close proximity to Phoenix, the lower Salt River and Saguaro Reservoir receive much recreation pressure. Tubing on the river extends from March to September each year, and on weekends in the summer as many as 40,000 people are on the river (Section B4.2). The tubing "start point" is located immediately across the river from nest 1, and less than 1 km from nest 5. This is also a popular fishing spot. A large paved parking lot was constructed at this site in 1988, to accommodate recreationists. Saguaro Reservoir is popular for jet-skiing, water skiing, speed boats, and fishing.

Tubers do not pose a physical threat to the eagles, but they may interrupt foraging. The eagles do switch to alternate foraging locations when tuber numbers increase in the summer and on weekends (Sherman 1983, Canestorp *et al.* 1984, Collie *et al.* 1985, and Section B4.2). In one instance, tubers attempted to capture an eaglet which could not yet fly (Collie *et al.* 1985).

Through telemetry, we found the Blue Point eagles foraged extensively in Willow Springs Cove and at the "drowned mesquites," both on Saguaro Reservoir. Willow Springs Cove became a popular spot for boaters as the weather warmed up. The eagles usually foraged in the cove early in the morning, thereby avoiding the recreation pressure. Although, once the eaglets fledged in 1987, the adults and eaglets spent more time in the cove, and were flushed by boats on many occasions. See Sections B4.2 and C4.7 for details on human disturbance during 1987–1989.

Table D4.4-2. Prey species observed taken by bald eagles or collected from the nest at the Blue Point breeding area.

Fish	Birds	Mammals
Carp	Waterfowl	Cottontail rabbit
Channel catfish	Mallard	Blacktail jackrabbit
Flathead catfish	Unidentified waterfowl	Neotoma
Bullhead (catfish)	Grebes	Ground squirrel
Yellow bass	Eared grebe	Rock squirrel
Largemouth bass	Pied-billed grebe	Unidentified rodent
Smallmouth bass	Wading Birds	
Black bass	American coot	**Herptiles**
Desert sucker	Great blue heron	Unidentified snake
Sonora sucker	Passerines	Unidentified lizard
Trout	Cactus wren	
Walleye pike	Great-tailed grackle	
Yellow perch	Other Birds	
Crappie	Common poorwill	
	Gambel's quail	
	Gila woodpecker	
	Mourning dove	

Even if nests 2, 3, and 4 still existed in the Blue Point cottonwood grove on the Salt River, it is doubtful that the eagles would nest there. The increasing amount of recreational disturbance on the lower Salt River has likely forced the eagles into less populated areas for nesting. Nest 6 is located 1.6 km inland from Saguaro Reservoir in remote, rugged terrain. Similarly, nests 1 and 3 at the Orme breeding area (at the Salt and Verde confluence) are located 1.5 to 2 km inland from the Salt River, in high remote areas. In both cases, the eagles have chosen to nest in areas more typical of golden eagle nesting sites, away from public users. In this manner, recreation would appear to be a negative impact on bald eagle nesting habitat, basically rendering nest sites along the river unsuitable for breeding.

Shooting does not appear to be a serious problem at Blue Point according to the reports (Sherman 1983, Canestorp *et al.* 1984, Collie *et al.* 1985), although there is a high rate of turnover in the Blue Point adult pair and a juvenile eagle may have been shot in 1987 (see Section D4.4.3).

Discussing human impacts at the Blue Point breeding area, Sherman (1983), Canestorp *et al.* (1984), and Collie *et al.* (1985) all stated that low level military, private, and TV news helicopter traffic was a problem in the nest area. Each source described instances of helicopters flushing the adults from the nest or perches, and the eagles subsequently leaving the nest area. In 1985, the death of one eaglet was attributed to helicopters preventing prey deliveries by the adults, after which the Blue Point adult male began attacking helicopters that approached the nest area (Collie *et al.* 1985). Collie also describes a

portion of the nest collapsing, and the remaining eaglet falling out, as a helicopter flew past the nest cliff. Incidents of adults attacking helicopters have also been observed by BioSystems biologists working on bald eagles in Alaska.

D4.4.6 Possible Effects of Flow Cessation

Much of the Salt River remains dry during part of the year, with isolated pools occurring from Stewart Mountain Dam to the Verde River confluence. The Arizona bald eagle breeding season, from nest building to the fledging of young, ranges from November to June at most sites. During the 1987, 1988, 1989, and 1990 breeding seasons, the flow of Salt River was stopped at the dam. The USGS gaging station below the dam recorded flows of less than 9 cfs from October 1986 to 1 January 1987, and less than 11 cfs from 23 February to 9 March 1987. In the 1988 season, flows of 9–13 cfs from 4 October 1987 to 21 February 1988 were recorded, excluding five days with flows of 14, 16, 17, 18, and 26 cfs. Once again, the river was shut-off during the 1989 bald eagle breeding season, with flows of: 4–7 cfs from 17 October to 2 November 1988, and again 9–22 November 1988; 3–5 cfs from 29 November 1988 to 3 January 1989; 6 cfs on 10 January; 4 cfs on 11 and 12 January; and 1–3 cfs from 13 to 21 January. These small flows are attributed to leaking at the dam; however, the dam was repaired in January 1989 and leakage ceased.

Through the 1989 season, with the Blue Point pair attempting to raise eaglets in nest 1 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 D4.4.3, the Blue Point eagles failed during this period. The Salt River, in the Blue Point nesting area also remained dry during the most of the 1990 bald eagle breeding season when no known nesting attempt was made.

The Salt River below Stewart Mountain Dam supports large sucker populations known to be important to the eagles; the effects of flow termination on the health of the fish populations is unknown. However, the flow cessation does cause considerable fish mortality. For example, in November 1986, during a period when less than 9 cfs leaked into the lower Salt, we (BioSystems) counted 3.67 dead suckers per meter of river (over one per foot) 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. Logically, with the complete shut-off of flows (0 cfs) in 1989 and 1990, fish populations in the river must have been devastated. See Section B4.2 for details on fish populations at Blue Point.

D4.4.7 Wildlife Interactions

Interactions with other bald eagles (intraspecific) and with other species (interspecific) are common among bald eagles. These interactions can be aggressive, as in territorial defense and attempts to pirate prey, but occasionally are not, such as soaring with other raptors. At Blue Point, interspecific interactions were numerous with red-tailed hawks and prairie falcons which nested nearby. The eagles also chased common ravens, Cooper's hawks, great blue herons, and golden eagles, and pirated food from turkey vultures, ravens, and ospreys (Sherman 1983, Canestorp *et al.* 1984, Collie *et al.* 1985, and Section B4.2). On one occasion, the Blue Point male locked talons with a golden eagle, and the two fell through the sky and out of view (Sherman 1983).

Intraspecific interactions usually involve pursuit, escorting the eagle out of the territory, or aggressive altercations. Many interactions with other bald eagles at Blue Point simply involved escorting the intruder out of the area (Sherman 1983, Canestorp *et al.* 1984, Collie *et al.* 1985). In 1989, however, a third adult was observed fighting with the resident male.

D4.4.8 Wildlife Sightings

Although Blue Point is an area known by ABENWP and BioSystems personnel mostly for its human "wild-life," there have been some other interesting animals noted in the area. Prairie falcons, red-tailed hawks, and Cooper's hawks nest along the river below the dam, and ospreys have been sighted in almost every month of the year. Along with the usual desert raptors, peregrine falcons, golden eagles, black-shouldered kites, northern harriers, sharp-shinned hawks, northern goshawks, Swainson's hawks, common black hawks, and zone-tailed hawks are sighted occasionally (Driscoll, unpublished field notes, Collie *et al.* 1985). Snowy egrets, common egrets, and greater and lesser yellowlegs occur with spotted sandpipers on the river. Two great blue heron rookeries are also located along the river. The reservoir supports large rafts of eared and western grebes in winter and spring, along with Forster's terns and gulls. Beaver occur near the Salt and Verde River confluence, while ringtails, bobcats, and coatis have been observed along the reservoir. Herptiles of interest include western diamondback rattlesnakes, black-tailed rattlesnakes, desert tortoises, and gila monsters.

D4.4.9 Management Recommendations

We offer these recommendations based primarily on the literature review and they augment those given in Section B4.2.6.

1. The current closure area is not functional due to a lack of enforcement, and proper posting. When the riverbed is dry, public users hike and climb near the nest cliffs. Sherman (1983), Canestorp *et al.* (1984), Collie *et al.* (1985), and Bond *et al.* (1989) all expressed the need to expand and enforce the existing closure.

2. Shooting does not appear to be a serious problem, due to the minimal occurrences reported (Sherman 1983, Canestorp *et al.* 1984, Collie *et al.* 1985), although there is a high rate of turnover in the Blue Point adult pair and a juvenile eagle may have been shot in 1987 (see Section D4.4.3). Each of the above authors stated that a gun restriction should be enforced on the lower Salt River.

3. Due to the high level of recreational pressure at the Blue Point breeding area, ABENWP personnel should begin coverage in January, instead of the normal February start date. This would provide protection prior to egg laying, and during early incubation, when the nest is most susceptible to failure.

4. A flow regime should be established for the regulated Salt River below Stewart Mountain Dam to maintain the integrity of the bald eagle breeding area year round, and to ensure the existence of foraging habitat below the nest cliff. Since eagles begin choosing nest sites and constructing nests as early as June to October, it is important that the breeding area be suitable year round. The effects on bald eagles and fish of flows cessation from Stewart Mountain Dam should be investigated.

5. Although large promontory cliffs exist on the reservoir and near the dam, perching substrate may be lacking on the lower river. The existing trees are decaying and falling apart, and many were burned in the November 1987 fire. Cottonwood poles could be planted on the lower Salt River to provide future perch sites and maintain the riparian vegetation on the river.

BLUE POINT BREEDING AREA

Date Discovered: 1971. Earliest Records 1930.
Drainage: Salt River / Saguaro Reservoir (Regulated/Reservoir)
Elevation (MSL): 1340 - 2000 ft
County: Maricopa
Latitude-Longitude Ten Minute Block: 333-1113
Land Management: U.S. Forest Service, Tonto National Forest, Mesa Ranger District
Closure: Tonto National Forest Closure
Order No. 12-40-3R
16 January 1984
Closed To All Entry 1 December - 30 June
Distance From Phoenix: Air - 51.5 km East
Distance To Nearest Breeding Area Upstream: Horse Mesa - 26.7 Km
Air - 18.5 km
Distance To Nearest Breeding Area Downstream: Orme - 5.5 Km
Air - 5.9 km
Distance From Granite Reef Dam: 9.9 Km
Home Range: Km 6 on Salt River to Km 36 on Saguaro Reservoir (Total = 30 Km)
Quadrangles: Granite Reef Dam 7.5 Minute
Stewart Mountain 7.5 Minute
Mormon Flat Dam 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Pinnacle		1930-1936 1981-1984 1989	Existing - Built 1930. Blown down after 1936. Rebuilt after 1936. Rubink No. 13.
2	Cottonwood	Live	1971	Nest found 1971. Nest fell after 1971.
3	Cottonwood	Live	1972	Nest built on top of Harris hawk nest, November 1971. Nest tree fell in 1975 Rubink No. 14.
4	Cottonwood	Live	1979-1980	Artificial nest constructed by Teryl Grubb, U.S. Forest Service, 1979. Adults sat on nest 1979. Adults built up nest 1980. Nest burned in fire November 1987, tree standing. Wire grid still in tree.
5	Cliff		1985	Existing - Built 1985.
6	Pinnacle		1987-1988 1986?	Existing - Nest found 16 March. 1987. Weathered sticks indicate nest existed prior to 1987. Possibly site of 1986 season.

BLUE POINT BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1930	Occupied	?	?	?	Unknown if young fledged.
1931	Occupied	?	?	?	Unknown if young fledged.
1932	Successful	1+	1+	1 or 2	
1933	Successful	1+	1+	1 or 2	
1934	Occupied	?	?	?	Unknown if young fledged.
1935	Occupied	?	?	?	Unknown if young fledged.
1936	Occupied	?	?	?	Unknown if young fledged.
1971	Successful	2+	2	2	New pair, both near-adults (ca. 4 years old).
1972	Failed	2+	2	0	Adult died - carcass found near nest.
1973	Unoccupied				
1974	Unoccupied				
1975	Unoccupied				
1976	Unoccupied				
1977	Unoccupied				
1978	Unoccupied				Adult in area.
1979	Occupied				
1980	Occupied				New adult, near-adult (ca. 4 years old).
1981	Successful	3	3	3	One young died post-fledging.
1982	Successful	3	3	3	
1983	Successful	3	3	3	Adult male disappeared 13 Feb. Near adult banded male (ca. 4 years old) entered area on 14 February and subsequently raised original male's young.
1984	Successful	2	2	2	
1985	Successful	2	2	1	One young died in nest. Helicopter disturbances may have contributed.
1986	Unoccupied				Possibly in nest 6.
1987	Successful	3	3	3	One young died post-fledging. Adult male banded on right tarsus as nestling in 1979 at Fort McDowell breeding area by Robert Ohmart, and entered pair in 1983 at age 4. Black VID band placed on left tarsus.

BLUE POINT BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1988	Successful	3	3	3	New female, near-adult (ca. 4 years old). Three young died post-fledging.
1989	Failed	2+	2	0	Two young died 16-19 March. Third adult fighting with resident male. Much disturbance due to dry riverbed.
1990	Occupied				New female, subadult (ca. 3 years old).
Total		27+	27	22-24	
Years		15	15	15	
Mean		1.8	1.8	1.5-1.6	

D4.5 CANYON BREEDING AREA

The Canyon breeding area is located 138 km east of Phoenix in the remote country along Canyon Creek, a tributary of the Salt River. Canyon Creek is a free-flowing perennial stream which meanders through a deep chasm bounded by large cliffs. The surrounding area is composed of rugged terrain filled with canyons, although some open grassy areas occur on the mesas. Canyon Creek enters the Salt River just above Gleason Flat.

D4.5.1 Habitat

The biotic community in the Canyon area is of the Upper Sonoran Life Zone. The upland habitat is characteristic of the Interior Chaparral Biome and the Great Basin Conifer Woodland Biome (see Section D2). The riparian habitat in the canyon bottom is of the Sonoran Riparian Deciduous Forest and Woodlands Biome. Portions of the creek are bounded by cliff walls, although more open areas support large cottonwoods and sycamores.

Plate D20. Canyon nest pinnacle (left) along Canyon Creek, July 1986. Note the rubble on the slope from the decomposition of cliff substrate (photo by D. Driscoll).

D4.5.2 Reproductive History

The Canyon breeding area was discovered on 1 May 1986; however, six nests have been found, indicating the territory has existed for many years. Due to its remote location in rugged terrain, data on the Canyon pair is limited to nest checks during ORA helicopter flights. In the five years we have known about the Canyon pair, they have laid eggs from 9–16 January to mid-February, hatched young from 13–20 February to mid-March, and fledged eaglets from 1–6 May to mid-June (Table D4.5-1).

Table D4.5-1. Nesting chronology of the Canyon breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1986	—	—	> 1 May
1987	< 2 February	—	< 6 May
1988	—	< 16 March	26 May
1989	9–16 January	13–20 February	—
1990	Mid-February	Mid-March	> 1 June

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

Six nests have been found in the Canyon breeding area, five on pinnacles near the canyon rim, and one in a live sycamore tree along the creek. Nests 1, 2 and 3 are pinnacle nests on the west rim of the canyon which have not been used since their discovery on 6 May 1987. Nest 1 is merely the remnants of an old nest, and is likely the oldest known nest in the territory. Nest 4, in a live sycamore tree along the creek, was found on 1 May 1986 and has not been used since its discovery. Nest 5, a pinnacle nest on the west rim of the canyon, was used by the eagles in 1986 and 1987. The cliff and other pinnacles above nest 5 are composed of very loose rock, making nest climbs to band young too dangerous for the climber and the eaglets. One large pinnacle above nest 5 is merely sitting on a flat ledge, and sways when touched. Nest 6 was built on a pinnacle on the east rim of the canyon in 1988, and used by the eagles from 1988–1990. All six nests are still in existence.

Eagles at the Canyon breeding area have been successful every year since we found the site in 1986. One eaglet fledged from nest 5 in 1986, and another in 1987. Four young have fledged out of nest 6 from 1988-1990.

D4.5.3 Mortalities

No incidents of mortality have been recorded at the Canyon breeding area; however, this is likely due to the limited amount of data on the site.

D4.5.4 Known Foraging Areas and Food Habits

Virtually nothing is known about the foraging behavior of the Canyon pair. Carp and sucker prey remains were collected from nest 5 in 1986, after the eaglet had fledged. The loose structure of the nest cliff and pinnacles has precluded further climbs to band young or collect prey remains. The Canyon nests are only 11 km (by air) from the Salt River, near Gleason Flat. This may seem like a considerable distance; however, Arizona bald eagles have been known to travel 22 Km up tributaries to forage (see Section D4.12).

An adult bald eagle was observed foraging at Gleason Flat in May 1985 (M. Cross, pers. comm.). This adult may have been associated with the Canyon or Ash (11.5 km away, see Section D4.2) breeding areas, or a yet undiscovered nesting territory, or may simply have been a non-breeding eagle. Prey remains collected at the nest in 1986 are presented in Table D4.5-2.

Table D4.5-2. Prey species observed taken by bald eagles or collected from the nest at the Canyon breeding area.

Fish	Birds	Mammals	Herptiles
Carp Sucker	None found	None found	None found

D4.5.5 Human Impacts

The remote location of the Canyon breeding area, in rugged terrain, likely precludes much human disturbance. However, if the eagles are foraging on the Salt River there is potential for human impact. Gleason Flat attracts fishermen and hunters, and is a common stopping point for rafters floating the river. A subadult bald eagle (SF01) was found at the Canyon Creek confluence on the Salt River on 21 June 1987, with a broken wing. In addition, a radio-tagged near-adult bald eagle (NF01) was likely shot near Gleason Flat in May 1988, and an adult (AM07) was found dead near Hess Canyon in April 1989 (see Section C3.7).

D4.5.6 Wildlife Interactions

Due to the limited amount of data on the Canyon breeding area, no wildlife interactions have been recorded at this site.

D4.5.7 Wildlife Sightings

The Canyon breeding area supports a variety of wildlife due to the vegetation form, plant species composition, and the lack of human activity. Common black hawks nest in a tree adjacent to the eagles nest along Canyon Creek. Black (cinnamon) bears also occur in the area. In one instance, USFWS and ABENWP biologists were held at bay upon some boulders, until nightfall, by a bear.

D4.5.8 Management Recommendations

The Canyon eagles seem to be doing well; however, some data on foraging and possible use of the Salt River could benefit future management of the Gleason Flat area.

CANYON BREEDING AREA

Date Discovered: 1 May 1986 (Existed prior to discovery)
Drainage: Canyon Creek (Free-flowing - Perennial)
Elevation (MSL): 3800 - 4200 ft
County: Gila
Latitude-Longitude Ten Minute Block: 335-1104
Land Management: U.S. Bureau of Indian Affairs
Fort Apache Indian Community
Distance From Phoenix: Air - 138.5 km East
Distance To Nearest Breeding Area Upstream: Cibecue - Air-13.5 km
Distance To Nearest Breeding Area Downstream: Redmond
Air - 32.5 km
Distance From Salt River Confluence: 14 Km
Air - 11 km
Home Range: Unknown
Quadrangles: Double Buttes 7.5 Minute
Picacho Colorado 7.5 Minute
Blue House Mountain 15 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Pinnacle	Unknown	Existing - Remnant. Found 6 May 1987.
2		Pinnacle	Unknown	Existing - Found 6 May 1987.
3		Pinnacle	Unknown	Existing - Found 6 May 1987.
4	Sycamore	Live	Unknown	Existing - Found 1 May 1986.
5		Pinnacle	1986-1987	Existing - Found 1 May 1986. Very loose rock.
6		Pinnacle	1988-1990	Existing - Built 1988.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1986	Successful	1+	1	1	
1987	Successful	1+	1	1	
1988	Successful	1+	1	1	
1989	Successful	1+	1	1	
1990	Successful	2+	2	2	
Total		6+	6	6	
Years		5	5	5	
Mean		1.2	1.2	1.2	

D4.6 CEDAR BASIN BREEDING AREA

The Cedar Basin breeding area is located 164 km east of Phoenix along the free-flowing Salt River in the remote country near Carrizo Creek. In this area the Salt River flows through a narrow canyon (Salt River Canyon) bounded by large promontory cliffs. The white-water in this section of river is treacherous, and thus rarely does anyone raft or kayak here. The surrounding area is composed of rugged terrain filled with canyons.

D4.6.1 Habitat

The biotic community in the Cedar Basin area is of the Upper Sonoran Life Zone. The upland habitat is characteristic of the Interior Chaparral Biome and the Great Basin Conifer Woodland Biome (see Section D2). Manzanita, prickly pear, and grasses grow amongst junipers and live oaks on the mesas, with ponderosa and pinyon pines in the higher areas. The riparian habitat in the canyon bottom is of the Sonoran Riparian Deciduous Forest and Woodlands Biome. Portions of the creek are bounded by cliff walls, although more open areas and side canyons support cottonwoods and sycamores, as do side canyons off the Salt River.

Plate D21. Cedar Basin sycamore tree nest (4) containing one egg, May 1988 (photo by D. Driscoll).

D4.6.2 Reproductive History

The Cedar Basin breeding area was discovered in 1973; however, the site was not known to be occupied by eagles until 1978. Due to its remote location in rugged terrain, data on the Cedar Basin territory is mainly limited to nest checks during ORA helicopter flights. Although the pair has laid at least 14 eggs in the 12 years of known occupancy, only two young have hatched and fledged. The Cedar Basin eagles have not laid eggs prior to the first ORA flights in early February; however, they are usually incubating by the second flight in mid-March. Eggs have been laid from mid-February to mid-March; however, no data exist on hatching or fledging dates (Table D4.6-1).

Table D4.6-1. Nesting chronology of the Cedar Basin breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1978	—	—	—
1979	—	—	—
1980	—	—	—
1981	—	—	—
1982	—	—	—
1983	—	—	—
1984	< 20 March	—	—
1985	< 26 March	—	—
1986	< 18 March	—	—
1987	< 17 March	—	—
1988	< 16 March	—	—
1989	—	—	—
1990	< 21 March	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

Four nests have been found in the Cedar Basin breeding area: (1) one on a pinnacle, (2, 3) two on cliffs, and (4) one in a live sycamore tree. Nests 1 and 2 were found in 1973, but have not been used since their discovery. Nest 1 is merely the remnants of an old nest and is likely the oldest known nest in the territory (Rubink and Podborny 1976). Nest 3, found in 1978, fledged two young that year (Ohmart and Sell 1980). The nest was used again in 1979; then the breeding area was apparently unoccupied in 1980. A pair was present in 1981 and 1982, although no known eggs were laid (Haywood and Ohmart 1983). Nest 3 was also used from 1983–1984 (W. Eakle, pers. comm.) and from 1989–1990. We observed an adult in incubation or brooding posture on 26 April 1990, indicating possible hatching, although the nest was empty on 1 June. Nest 4, in a live sycamore tree along the creek, was built in 1985 and used by the eagles during 1985–1988. All four nests are still in existence.

The Cedar Basin eagles appear to have a productivity problem; although the pair has laid at least 14 eggs in the 12 years of known occupancy, only two of these eggs have hatched. Possible reasons include: (1) The female is contaminated with pesticides, leading to thin eggshells, or dead or deformed embryos; (2) One of the adults is infertile, and a mate replacement has occurred 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 can not support the pair through incubation, and the adults must leave the nest 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 weight) or 2.3 ppm wet weight (see Section C5). 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, at 0.651 mm (Section E5). These data likely rule out the first 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 remaining 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 during periods when fish become unavailable (see Section B4), and non-fish prey have been found in the Cedar Basin nest (see Section D4.6.4). Carrizo Creek is located 7 km upstream from the Cedar Basin area, and attracts a congregation of eagles in February. Carrizo Creek carries warm water into the Salt River, due to geothermal activity, which could create early spawning runs in and around the mouth of the creek.

In summary, hypothesis 2, 3, or 4 could be acting to suppress reproduction at Cedar Basin. To accurately address the productivity problems, further data are needed on the ecology of the eagles and their prey base.

D4.6.3 Mortalities

No incidents of mortality have been recorded at the Cedar Basin breeding area; however, this is likely due to the limited amount of data on the site.

D4.6.4 Known Foraging Areas and Food Habits

Virtually nothing is known about the foraging behavior of the Cedar Basin pair. Channel catfish and great blue heron prey items were collected in 1980 (Haywood and Ohmart 1981), and are presented in Table D4.6-2, along with prey remains collected at the nest during 1986-1988. See Section B5.1.7 for a detailed analysis of prey remains collected during 1986-1988.

Table D4.6-2. Prey species observed taken by bald eagles or collected from the nest at the Cedar Basin breeding area.

Fish	Birds	Mammals	Herptiles
Channel catfish	Great blue heron	Cottontail rabbit	None found
Sucker			
Black bass			

D4.6.5 Human Impacts

The remote location of the Cedar Basin breeding area likely precludes much human disturbance. Due to the treacherous white-water, even rafters and kayakers rarely (if ever) float this section of the Salt River. It is possible to hike up the river to the nest in summers with low water flows, but the site is protected by higher flows and the rugged terrain during the breeding season.

D4.6.6 Wildlife Interactions

Due to the limited amount of data on the Cedar Basin breeding area, no wildlife interactions have been recorded at this site.

D4.6.7 Wildlife Sightings

The Cedar Basin breeding area supports a variety of wildlife due to the vegetation form, plant species composition, and the lack of human activity. Common black hawks are often sighted in the area, as are golden eagles. As stated previously, Carrizo Creek attracts a congregation of bald eagles in February. Black (cinnamon) bears and mountain lions also occur in the area, and we have observed their tracks along the river.

D4.6.8 Management Recommendations

1. More data are needed on the foraging ecology and nesting activities of the Cedar Basin eagles in order to determine why the eggs continually fail to hatch.

2. Scheduling ORA flights on a once per month basis from February through June could provide more data on egg or nestling mortality at Cedar Basin.

CEDAR BASIN BREEDING AREA

Date Discovered: 1973
Drainage: Salt River (Free-flowing)
Elevation (MSL): 4000 - 4400 ft
County: Gila
Latitude-Longitude Ten Minute Block: 334-1102
Land Management: U.S. Bureau of Indian Affairs
Fort Apache Indian Community (North of Salt River)
San Carlos Indian Community (South of Salt River)
Distance From Phoenix: Air - 164.5 km East
Distance To Nearest Breeding Area Upstream: Lone Pine - 14.1 Km
Air - 11.0 km
Distance To Nearest Breeding Area Downstream: Mule Hoof - 29.6 Km
Air - 14.0 km
Distance From Granite Reef Dam: 223.0 Km
Home Range: Unknown
Quadrangles: Beckers Butte 7.5 Minute
Carrizo S.E. 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Pinnacle	Unknown	Existing—Remnant. Found 1973. Rubink No. 7.
2		Cliff	Unknown	Existing—Found 1973. Rubink No. 6.
3		Cliff	1978-1979 1983-1984 1989-1990	Existing—Found 1978.
4	Sycamore	Live	1985-1988	Existing—Built 1985.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1973	Unknown	?	?	?	Nest 1 and 2 found.
1974	Unknown	?	?	?	
1975	Unknown	?	?	?	
1976	Unknown	?	?	?	
1977	Unknown	?	?	?	
1978	Successful	2+	2	2	
1979	Failed	1+	0	0	
1980	Unoccupied				
1981	Occupied				

CEDAR BASIN BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1982	Occupied				
1983	Failed	1+	0	0	
1984	Failed	1+	0	0	
1985	Failed	1+	0	0	
1986	Failed	1+	0	0	
1987	Failed	3	0	0	
1988	Failed	2	0	0	One egg collected.
1989	Failed	1+	0	0	
1990	Failed	1+	?	0	Adult incubating/brooding on 26 April. No young in nest on 1 June.
Total		14+	2	2	
Years		12	11	12	
Mean		1.2	0.2	0.2	

D4.7 CHINO BREEDING AREA

The Chino breeding area is located 167 km northwest of Phoenix, along the free-flowing Big Sandy River. Five river kilometers to the south the Big Sandy and Santa Maria rivers join to form the Bill Williams River, which flows another 5 km south into Alamo Reservoir. The surrounding area is fairly open, although salt cedar invasion chokes portions of the riparian corridor.

D4.7.1 Habitat

The biotic community in the Chino area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with associated Mohave Desertscrub Biome species. The riparian habitat, is a mixture of the Sonoran Riparian Deciduous Forest and Woodlands Biome and the Sonoran Riparian Scrubland Biome (see Section D2).

Habitat immediately surrounding the Chino nests is a corridor of scattered cottonwoods and willows, with mesquite and salt cedar proliferating in areas. Cattle grazing is no longer permitted in the upper portion of Alamo Reservoir and the Chino area, although trespass cattle are a common sight, and there is still very little regeneration of cottonwoods and willows. The cottonwood snags which supply nest and perch sites are deteriorating, and large live trees are sparse. Cattle grazing has suppressed the regeneration of

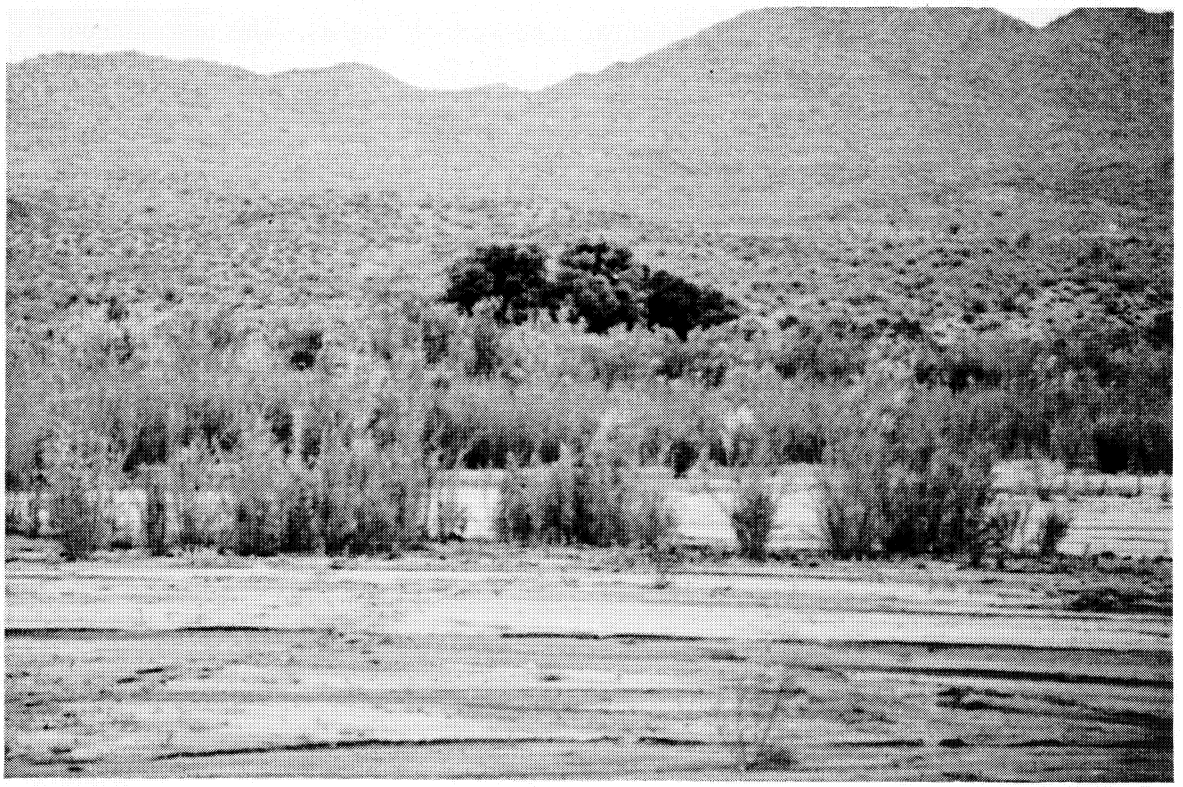

Plate D22. Chino nest trees along the dry Big Sandy riverbed, May 1987 (photo by D. Driscoll).

cottonwoods and willows, although since the grazing moratorium went into effect, trees have responded. In 1987, numerous cottonwood seedlings sprouted from the dry Big Sandy riverbed, and several intermediate stands of willows and cottonwoods have taken hold. These young trees represent a promising future; however, many trespass cattle still enter the area. It will be many years until these trees are large enough to supply nesting and perching habitat for eagles. In the interim, cattle grazing in the area may prevent the seedlings from reaching any advanced stage of development.

Due to the sandy substrate of the river bottom, pockets of quicksand occur along the river. A marshy area occurred at the confluence of the Big Sandy and Santa Maria rivers, with beaver ponds and emergent vegetation in 1985 and 1986. In May 1985, the reservoir extended past the Santa Maria River, and fishermen proceeded up the river in their boats (Hall, unpublished field notes). The reservoir has receded since 1985, and currently the upper (northern) portion of the reservoir is located south of Brown's Crossing, 5 km below the Big Sandy and Santa Maria confluence. In 1987, the area from Brown's Crossing to the reservoir was carpeted with lush green grass. Currently this area is a salt cedar jungle. The upper reservoir is shallow, with small bays harboring various species of emergent vegetation and supporting a large population of waterfowl and shorebirds through the bald eagle breeding season. The reservoir also contains a healthy population of channel catfish, carp, tilapia, and largemouth bass, the latter drawing many fishermen to the upper reservoir.

D4.7.2 Reproductive History

Reclamation and AGF biologists Tom Gatz, Richard Bauman, and Rich Glinski found the Chino breeding area on 25 April 1985 in the midst of a wildfire; with the help of a BLM fire crew, they extinguished the fire and saved the nest tree, which contained two nine-week-old eaglets. This nest (number 1), in a live cottonwood tree, fledged two young that year.

The eagles used this nest again in 1986, but the egg failed to hatch. During the same time frame (mid-March), the Horseshoe nest was being slowly inundated by the rising Horseshoe Reservoir, on the Verde River. On 17 March 1986, the two Horseshoe eaglets, which hatched 11-13 March, were taken from the nest to the Phoenix Zoo. On 21 March the two eaglets were flown to the Chino breeding area and placed in the nest. The addled egg, which should have hatched by 1 March and was still being incubated by the Chino adults, 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).

The 1987 breeding season brought about many changes at the Chino breeding area. When Chino was discovered in 1985 the adult female carried a backpack transmitter, and a USFWS band on her right tarsus. Assuming an Arizona origin, her background was easily traced; the only Arizona bald eagles radio-tagged prior to 1986 were six nestlings telemetered during 1977–1979 by Master's students under Robert Ohmart, ASU. Hildebrandt (1981) telemetered two nestlings in 1977, T02 (USFWS band 629-04452) from the Fort McDowell nest, and T04 (USFWS band 629-04454) from the Bartlett breeding area. T02 drowned after breaking its left humerus in an aggressive interaction with its sibling (Hildebrandt 1981). T04 survived until 1980, when it was shot in Calgary, Alberta, Canada (Ohmart 1985).

In 1978, two more nestlings were radio-tagged, one from the Bartlett breeding area (USFWS band 629-04460), and one from the Cibecue nest (USFWS band 629-04461). The Bartlett eaglet died after fledging and was eaten by a mammalian predator (Hildebrandt 1981). The Cibecue eaglet disappeared

after leaving the nest, but was banded on the left leg so is ruled out as a possible source for the Chino female. In 1979, two additional young were telemetered, one at the Bartlett nest (USFWS band 629-04462), and another at the Fort McDowell territory (USFWS band 629-04464). The 1979 Bartlett eaglet returned to Roosevelt Reservoir the next year, although its transmitter failed in July 1980. No data are available on the 1979 Fort McDowell eaglet (Sell 1982). Therefore, the 1985 Chino female, banded on her right tarsus, would have been six years old and from the 1979 Bartlett or Fort McDowell nest.

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. comm.). 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 (Number 2) would be an unlikely occurrence and has not been documented in the literature. 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 hypothesis. Also, in the period during 1985–1987, the reservoir receded from a northern boundary upstream of the Big Sandy and Santa Maria River confluence, 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).

In 1987, the new Chino eagles laid two eggs, which failed to hatch, in nest 2. The nest and supporting branch fell between 15 April and 15 May 1987. The Chino breeding area has remained unoccupied at the one known nest site from 1988–1990. Nest 1 is still in existence.

Data on the nesting chronology of the Chino eagles is limited. In 1985, the eaglets fledged on 15 and 16 May (Forbis 1985). Back-dating through 12 weeks in the nest, and the 35-day incubation period, results in an egg-laying date of around 16 January, and a hatch date of around 20 February. In addition, incubating adults were observed on 26 January in 1986 and 27 March in 1987. Thus, it appears that the Chino eagles lay eggs in mid-January, which hatch in late February, and young fledge in mid-May (Table D4.7-1).

Table D4.7-1. Nesting chronology of the Chino breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1985	16 January	20 February	15, 16 May*
1986	< 26 January	—	1, 3 June**
1987	< 27 March	—	—
1988	—	—	—
1989	—	—	—
1990	—	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
** Two young fostered from Horseshoe breeding area.
< Indicates "prior to"
> Indicates "later than"

D4.7.3 Mortalities

The Chino breeding area was only occupied (at known nest locations) from 1985–1987, and there is virtually no data on mortality. In December 1986, the Chino pair (or female) moved to Alamo Reservoir, and a new pair of eagles occupied the Chino breeding area. It is possible that the Chino male died in 1986, and the female found a new mate at Alamo. However, the Chino pair often foraged at Alamo Reservoir, and due to the receding reservoir, may have moved to Alamo to nest closer to their foraging areas. The new Chino adults have not been seen since 1987. Thus, there are no known mortalities at the Chino territory.

D4.7.4 Known Foraging Areas and Food Habits

The Chino eagles were known to forage from Km 62.0 (5.7 km above the Big Sandy and Santa Maria River confluence) on the Big Sandy River to Km 53.3 on Alamo Reservoir. In 1986, the Chino pair "... utilized the reservoir on all occasions that observations were made there." The pair also utilized some beaver ponds near the Big Sandy and Santa Maria River confluence (Sudar and Morgan 1986). Prey items described by Sudar and Morgan (1986) are presented in Table D4.7-2, along with prey remains collected from the nest in 1986 and 1987. See Section B5.1.1 for a detailed analysis of prey remains collected in 1986 and 1987.

D4.7.5 Human Impacts

Human disturbance was not a major problem at the Chino nest site in 1986. Sudar and Morgan (1986) described low flying helicopters, low level military jets, sonic booms, and ATCs as disturbances to the eagles. ATC riders close to the nest were particularly disruptive to the Chino pair.

Fishermen may threaten the success of this breeding area due to the amount of waste monofilament. Monofilament is present in an abundance on Alamo Reservoir. Each cottonwood snag, including the

Table D4.7-2. Prey species observed taken by bald eagles or collected from the nest at the Chino breeding area.

Fish	Birds	Mammals	Herptiles
Carp	Unidentified waterfowl	Blacktail jackrabbit	None found
Channel catfish		Neotoma	
Tilapia			
Largemouth bass			
Black bass			
Crappie			

Alamo nest trees, have a preponderance of monofilament, hooks, and lures in them. Monofilament not only kills bald eagles, but many other wildlife species as well (see Section C3.3). In 1986, monofilament, hooks, and bass lures were removed from the Chino nest. Similar problems occur at the nearby Alamo nest site. In 1988 the Alamo eaglet fell from the nest, and when found on the ground it had a fishing lure lodged in its tongue. A white-faced ibis, brought to the nestling by the adults, was hanging from the opposite end of the lure. Eaglets have also died from becoming entangled in monofilament at the nest (Section D4.22.3).

D4.7.6 Reservoir Elevations

Alamo Reservoir extended north passed the Big Sandy and Santa Maria River confluence in 1985 (Hall, unpublished field notes). Currently, the northern boundary of the reservoir is south of Brown's Crossing. This lowering of the reservoir is likely what prompted the Chino pair to move to Alamo in December 1986. The subsequent loss of aquatic (foraging) habitat likely contributed to the abandonment of the known nest sites since 1987.

D4.7.7 Wildlife Interactions

Due to the limited amount of data on the Chino breeding area, the only interspecific interactions recorded involve the chasing of great blue herons, turkey vultures, and hawks by the eagles. Northern orioles were also observed diving on eagles at the nest (Sudar and Morgan 1986). No intraspecific interactions have been recorded at Chino; however, other eagles (one a near-adult) were observed on the reservoir and flying toward Alamo Dam (Sudar and Morgan 1986). These eagles were likely the Ive's Wash pair, which were not discovered by agency personnel until May 1987.

D4.7.8 Wildlife Sightings

The Chino breeding area supported a variety of wildlife species, due to the combination of desert, riparian, and reservoir habitats existing in 1986. Mammals in the area include muskrats, beavers, raccoons, javelina, and feral burros. Herptiles include rosy boa snakes, western diamondback rattlesnakes, gila monsters, and spiny soft-shelled turtles. Sudar and Morgan (1986) observed golden eagles, Harris' hawks, common moorhens, green-backed herons, blue grosbeaks, and great egrets at the beaver ponds. A great blue heron rookery is located upstream of the Santa Maria confluence, on the Big Sandy River.

D4.7.9 Management Recommendations

1. Since a moratorium on grazing already exists for the upper portion of Alamo Reservoir and the Chino area, all trespass cattle should be removed immediately and kept out of the riparian areas. This would give young willows and cottonwoods a chance to grow. The planting of cottonwood poles may also be necessary to provide future nest trees and perches, if cattle cannot be kept out of the area.

2. Reservoir levels necessary to sustain the three bald eagle breeding areas (Alamo, Chino, and Ive's Wash) associated with Alamo Reservoir should be established. If the reservoir were to fill to 1985 and prior levels, it is possible that the Chino breeding area could become active again, due to the increase in aquatic habitat and foraging areas, although it is not known what impact higher reservoir levels would have on the Alamo and Ive's Wash eagles.

CHINO BREEDING AREA

Date Discovered: 25 April 1985
Drainage: Big Sandy River (Free-flowing - Intermittent)
Elevation (MSL): 1200 ft
County: Mohave
Latitude-Longitude Ten Minute Block: 342-1133
Land Management: U.S. Bureau of Land Management
Kingman District
Distance From Phoenix: Air - 167.0 km Northwest
Distance To Nearest Breeding Area Upstream: Devil's Post
Air - 48.5 km
Distance To Nearest Breeding Area Downstream: Alamo - 7.8 Km
Air - 7.5 km
Distance From Bill Williams River Confluence: 5.0 Km
Distance To Alamo Reservoir: 8.3 Km
Air - 7.8 km
Home Range: Unknown. Known to utilize Alamo Reservoir frequently, 1986.
Quadrangles: Artillery Peak 15 Minute
Palmerita Ranch 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Live	1985-1986	Existing - Saved from wildfire 25 April 1985 when found by Tom Gatz and Richard Bauman, U.S Bureau of Reclamation, and Rich Glinski, Arizona Game and Fish Department.
2	Cottonwood	Snag	1987	Built 1987 - Branch broke and nest fell April-May, 1987.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1985	Successful	2+	2	2	Adult female banded on right tarsus and telemetered as nestling in 1979 at Bartlett or Fort McDowell breeding area, by Robert Ohmart.

CHINO BREEDING AREA (continued)

Productivity (cont'd.)

Year	Status	Eggs	Young	Fledged	Comments
1986	Failed/Foster	1	0(2)	0(2)	One egg collected. Two young from Horseshoe breeding area fostered into nest and fledged.
1987	Failed	2+	0	0	New female or pair. Old pair (banded female) moved to Alamo breeding area.
1988	Unoccupied				
1989	Unoccupied				
1990	Unoccupied				Nest not occupied in December 1989. Nest not checked during remainder of season.
Total		5+	2	2	
Years		3	3	3	
Mean		1.7	0.7	0.7	

D4.8 CIBECUE BREEDING AREA

The Cibecue breeding area is located 146 km east of Phoenix, along the free-flowing Salt River, below the Highway 60 bridge, near Cibecue Creek. In this area, the Salt River flows through a narrow canyon (Salt River Canyon) bounded by large promontory cliffs. Cibecue Creek is a free-flowing perennial stream which meanders through a deep chasm bounded by large cliffs and enters the Salt River from the north. Cibecue Creek has three waterfalls on it; the first one, occurring 2-3 mi upstream of the Salt River, is 30-40 m high. The surrounding area is composed of rugged terrain filled with canyons. High above the river, steep slopes bear the remains of abandoned mines and mining trails.

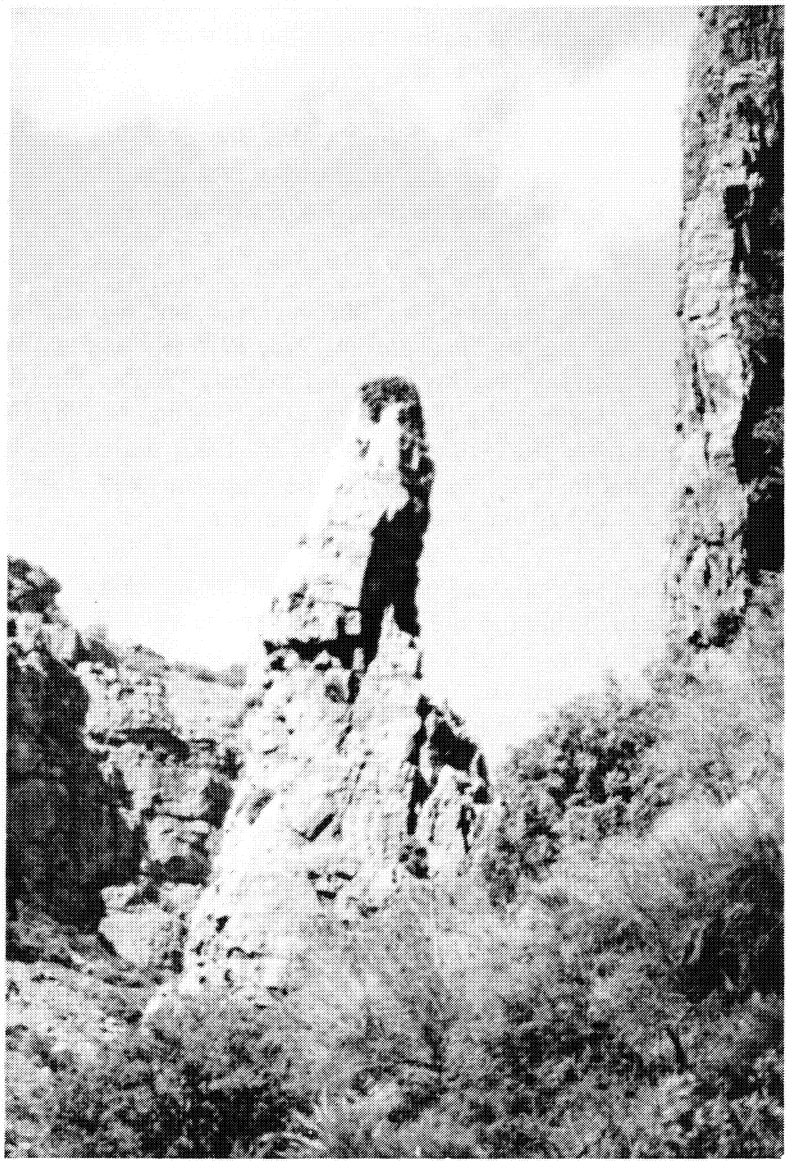

Plate D23. Cibecue pinnacle nest (1), May 1987 (photo by D. Driscoll).

D4.8.1 Habitat

The biotic community in the Cibecue area is of the Upper Sonoran Life Zone. The upland habitat is characteristic of the Interior Chaparral Biome and the Great Basin Conifer Woodland Biome (see Section D2). Manzanita, prickly pear, and grasses grow amongst junipers and live oaks on the mesas above the canyon. Riparian habitat along the creek and river in the canyon bottom is a mixture of the Sonoran Riparian Deciduous Forest and Woodlands Biome, the Sonoran Riparian Scrubland Biome, and the Sonoran Interior Strands Biome. Portions of the creek are bounded by cliff walls, although more open areas support large cottonwoods and sycamores.

The free-flowing Salt River contains variable flows, and due to the narrow canyon, heavy rains (especially during the spring snowmelt) can be transformed into a wall of destruction; during heavy rains in mid-March 1985, a 12-foot wall of water came through the Cibecue area.

D4.8.2 Reproductive History

The Cibecue breeding area, discovered in 1973 (Rubink and Podborny 1976), has had a sporadic history of occupancy, success, and failure. The Cibecue eagles have laid eggs from 27 January to 5 March, hatching young from 3 March to 8 April, and fledging eaglets from 13 May to between 5 and 12 June (Table D4.8-1).

The Cibecue eagles have built a pinnacle nest (1) on Cibecue Creek, and two cliff nests (2, 3) on the Salt River. Nest 1, found in 1973, was used by the eagles in 1973, 1975 (Rubink and Podborny 1976), 1977 (Hildebrandt and Ohmart 1978), and 1980 (Haywood and Ohmart 1981). Nest 2 was found 2 March 1977 (Rubink, unpublished field notes), and utilized from 1978-1979 and in 1982 (Haywood and Ohmart 1983). Nest 2 was used again from 1983–1984 (Grubb *et al.* 1983, Sudar and Morgan 1984), and in 1986 and 1990. Nest 3 was built in 1985, and used by the eagles in 1985, 1987, and 1989. In 1988, the adults rebuilt all three nests, and all three are still in existence.

Productivity at Cibecue has been sporadic and plagued by nestling mortality. One young fledged from the nest in 1973, and again in 1975, but the site was not checked in 1974 (Rubink and Podborny 1976). The territory was unoccupied at known nest locations in 1976, and hatched one young in 1977 which disappeared from the nest (Hildebrandt and Ohmart 1978). In 1978, the Cibecue pair hatched three young, although only two fledged (Hildebrandt 1981). The site failed in 1979, but hatched three young which died prior to fledging in 1980 (Haywood and Ohmart 1981). The territory was unoccupied at known nest locations in 1981, and fledged one young in 1982 (Haywood and Ohmart 1983). The Cibecue pair hatched seven eaglets, but only fledged four, from 1983-1985 (Grubb 1986a). The site was successful, but again lost one eaglet in 1986. The Cibecue nest failed in 1987, losing one eaglet, and was occupied in 1988, though apparently no eggs were laid. One young fledged and one died in 1989, and another died in 1990.

We rescued an adult male (AM07) on 21 November 1988 from the Salt River below nest 2, and transported him to the Liberty Wildlife Rehabilitation facility. The eagle had broken his right ulna (wing) in two places. Upon capture, we noticed the adult carried a USFWS band (629-04453) on his right tarsus. The eagle had been banded as a nestling in 1977 at the Bartlett breeding area (Hildebrandt 1981).

Table D4.8-1. Nesting chronology of the Cibecue breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1973	—	—	—
1974	—	—	—
1975	< 20 February	< 17 April	> 27 May
1976	—	—	—
1977	6 February	13 March	—
1978	5 February	12 March	5 June
1979	—	—	—
1980	1, 4, 5 March	4, 7, 8 April*	—
1981	—	—	—
1982	—	—	—
1983	27 January	1 March	—
1984	27 January	3 March*	13 May*, 1 June
1985	2 February	8–11 March	30–31 May*
1986	7 February	14 March	7 June
1987	9 February	14 March	—
1988	—	—	—
1989	6 February	13 March	5–12 June
1990	26 February	2–5 April	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

D4.8.3 Mortalities

The Cibecue breeding area has experienced the most known juvenile mortalities in Arizona, 13 since 1977. Of these, five young died in the nest, four disappeared from the nest, three fell from the nest, and one disappeared after fledging. 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. One young disappeared from the nest in 1977, and one fell from the nest in 1978. Another 1978 juvenile, which was radio-tagged, disappeared after fledging (Hildebrandt 1981). In 1980, all three young died, one disappeared 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 on 7 May (Haywood and Ohmart 1980). Two eaglets disappeared from the nest between 11 March and 13 April in 1983 (Grubb *et al.* 1983). One young died in the nest on 18 April 1985 (DeCandido 1985), and one eaglet fell from the nest on 17 May 1986 (Hein and Nahstoll 1986).

At the Cibicue territory in 1987, the eaglet died after being attacked by a near-adult bald eagle. ABENWP biologists P. Carroll and A. Housser last observed the adult female 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 during 5-8 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 (*Cimicidae*) (see Section C3.4).

In 1989, breeding activity remained unknown at the Cibecue breeding area until 5 June, when we observed an approximately 12 week old juvenile in the nest. A wildlife officer for the White Mountain–Fort Apache tribe 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 eaglets' death may have been linked to high temperatures (see Section C3.4), although the implication is circumstantial.

The 1990 Cibecue eaglet died on 14 April, at 1.5 weeks of age. The adult female was reported to carry a fuzzy object (likely the dead eaglet) away from the nest on that date (Kershaw and Mehling 1990). Two river rafting guides, who were also professional photographers, had photographed the nest and adults in early March. When the nest watchers arrived on 13 March, the photographers informed ABENWP personnel that the adults were circling the area and vocalizing during filming. On 5 April, on the nest watchers day off, the river rafting guides "blazed a trail" up the backside of the nest cliff, and once again photographed the adults and nest. The photographers later informed ABENWP personnel that one adult was circling and vocalizing, while the other remained on the nest. On 14 April, after the female apparently removed the dead eaglet, the nest watchers hiked up the very noticeable "blazed trail," and observed the nest was empty (Kershaw and Mehling 1990). It would appear that the photographer's disturbances at a crucial point in the nesting cycle (just after hatching) may have contributed to the eaglet's demise. Other possible factors contributing to nestling mortality, including monofilament fishing line, nest parasites, and heat stress are detailed in Section C3.

There have been three known adult mortalities at the Cibecue breeding area. In 1987, the female did not return after being chased out of the area by a near-adult male bald eagle on 18 April (Carroll and Housser 1987). It appears highly likely that the near-adult male killed the Cibecue female on that date. This near-adult later entered into aggressive altercations with the resident male and even attacked the eaglet in the nest. A new female occupied the Cibecue territory in 1988 but was replaced by a near-adult female in 1990.

We rescued an adult male (AM07) on 21 November 1988 from the Salt River below nest 2. The eagle's right wing had been broken in two places, with a section broken out of the ulna. Given the pattern of injury, it is possible that the wing had been broken in an aggressive altercation with another eagle or with a large falcon. Peregrines nest near Cibecue Creek, and have been known to attack bald eagles (see Sections D4.14 and D4.17).

We 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/Pinto nesting territory on 22 February. However, AM07 was found dead on 11 April 1989 near Hess Canyon, north of Globe, Arizona. The eagle's state of decomposition precluded determination of the cause of death, but poisoning seemed to us the most parsimonious explanation.

D4.8.4 Known Foraging Areas and Food Habits

The Cibecue eagles are known to forage from Km 177.0 to Km 186.6 on the Salt River, and Km 0.0 to Km 1.5 on Cibecue Creek, as well as in Salt River Draw. On 13 May 1987, we sighted an adult flying low over the water 2-3 km above the first waterfall on Cibecue Creek. Most known foraging has been documented in the river below the nests, although the eagles were observed flying to other areas and returning with prey (Hildebrandt 1981, Sudar and Morgan 1984, De Candido 1985, Hein and Nahstoll 1986, Carroll and Housser 1987, Kershaw and Mehling 1990). Foraging information was limited to areas observed by ABENWP and other research personnel watching the nest, resulting in a bias toward the river section below the nest. This same bias also resulted in small home ranges, restricted to river sections and areas visible from nest observation points (Hildebrandt 1981, Grubb 1986a). Haywood and Ohmart (1980, 1981) investigated foraging sites at Cibecue by conducting ground searches for white-wash and castings, but it should be remembered that herons and ravens also produce white-wash and that bald eagles may not cast unless feeding on mammals or birds. Finally, ringtails, raccoons, and other predators feeding on fish may leave remains indistinguishable from those of bald eagles.

Sucker spawning occurred in Cibecue Creek and Salt River Draw from 11-27 March 1984 (Sudar and Morgan 1984), 23 March to 21 April 1985 (De Candido 1985), and mid-March to early April 1987 (Carroll and Housser 1987). Each of the above sources noted prey deliveries to the nest from upriver during incubation and the early nestling period, then shifting to both upstream and downstream use later in the nestling period. The authors also noted more prey deliveries from the direction of Cibecue Creek during spawning. The shift to downstream foraging later in the season may be a response to increased river rafting and kayaking, which concentrates in the upstream areas during trip departures.

Prey items described by Rubink and Podborny (1976), Hildebrandt (1981), Haywood and Ohmart (1981), Haywood and Ohmart (1983), Grubb (1984), Sudar and Morgan (1984), De Candido (1985), Grubb (1986a), Hein and Nahstoll (1986), Carroll and Housser (1987), and Kershaw and Mehling (1990) are presented in Table D4.8-2, along with prey remains collected at the nest from 1986-1989. See Section B5.1.7 for a detailed analysis of prey species utilized by the Cibecue eagles. In addition, the eagles were observed attempting to capture common mergansers (Sudar and Morgan 1984).

The Cibecue adults were observed stealing prey from great blue herons, turkey vultures, common ravens, and red-tailed hawks (De Candido 1985, Carroll and Housser 1987). De Candido (1985) observed the adult male pirate a frog or toad from a raven, a small mammal from a red-tailed hawk, and a woodrat (*Neotoma*) from some turkey vultures. De Candido (1985) noted the eagle carried the pirated neotoma in its beak, which is unusual for raptors, as they normally carry prey in their feet.

D4.8.5 Human Impacts

Human disturbance is a problem at the Cibecue breeding area. This section of the Salt River, from Mule Hoof Bend to just above Cibecue Creek, is the launching spot for numerous rafters and kayakers that float the Salt River. De Candido (1985) reported that during high volumes of rafting and kayaking traffic, one group passed below the eagle nest at least every ten minutes. Rafters and kayakers were also recorded as disturbances by Sudar and Morgan (1984), and Carroll and Housser (1987). Other disturbances included a bulldozer repairing the road below nest 2 (Sudar and Morgan 1984), low level military jet and

Table D4.8-2. Prey species observed taken by bald eagles or collected from the nest at the Cibecue breeding area.

Fish	Birds	Mammals
Carp	Waterfowl	Cottontail rabbit
Channel catfish	Unidentified Anatidae	Blacktail jackrabbit
Flathead catfish	Unidentified waterfowl	Neotoma
Bass	Passerines	Rock squirrel
Desert sucker	Scrub jay	Unidentified Sciuridae
Sonora sucker	Other Birds	Unidentified small mammal
	Gambel's quail	
		Herptiles
		Unidentified snake
		Unidentified lizard
		Unidentified frog or toad

helicopter traffic, vehicles on the road below the nest, gunshots, and fishermen in or near foraging areas (Sudar and Morgan 1984, De Candido 1985, Hein and Nahstoll 1986, Carroll and Housser 1987, Kershaw and Mehling 1990). Dynamite blasts downstream of nest 2 were described as disruptive to the eagles in 1986 and 1990 (Hein and Nahstoll 1986, Kershaw and Mehling 1990). People camping, picnicking, and partying on the beach below nest 3, and below nest 2 were thought to be the greatest disturbance to the eagles (Sudar and Morgan 1984, De Candido 1985, Hein and Nahstoll 1986, Carroll and Housser 1987, Kershaw and Mehling 1990).

As described above, two river rafting guides, who are also professional photographers, photographed the nest and adults in early March 1990. 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). The Cibecue eaglet died on 14 April, at 1.5 weeks of age. Photographers have been associated with nest failures at two other breeding areas in Arizona (see Section 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.

Also in 1990, an army helicopter flew within 200 m of the nest twice on 24 March, and an air force jet screeched past 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 past the nest (Kershaw and Mehling 1990).

D4.8.6 Wildlife Interactions

At Cibecue, bald eagle interactions were observed with red-tailed hawks, peregrine falcons, American kestrels, common ravens, great blue herons, golden eagles, osprey, and turkey vultures. In addition, the

eagles pirated prey from turkey vultures, ravens, and red-tailed hawks (Sudar and Morgan 1984, De Candido 1985, Hein and Nahstoll 1986, Carroll and Housser 1987, Kershaw and Mehling 1990).

Many interactions with other bald eagles at Cibecue were aggressive (Sudar and Morgan 1984, Kershaw and Mehling 1990). As mentioned above, a near-adult bald eagle entered the territory on 18 April, and attacked the resident female, male, and eaglet over the rest of the nesting season (Carroll and Housser 1987). The adult female was last observed on 18 April, being chased downstream by the near-adult male. 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. On 15 May, the last day of observations, the near-adult was still fighting with the resident male (Carroll and Housser 1987).

D4.8.7 Wildlife Sightings

The Cibecue breeding area supports a variety of wildlife species, due to the wide range of elevation change, and associated habitats, over a small area. Peregrine falcons nest in the Cibecue area and are commonly sighted, occasionally interacting with the bald eagles. Other raptors observed include red-tailed hawks, Cooper's hawks, sharp-shinned hawks, ospreys, golden eagles, American kestrels, and zone-tailed hawks. Anna's, Costa's, and rufous hummingbirds have been sighted in the area, along with vermillion flycatchers, rose-breasted grosbeaks, blue grosbeaks, lazuli buntings, indigo buntings, purple finches, verdins, loggerhead shrikes, acorn and ladder-backed woodpeckers, Stellar's jays, common crows, hooded and Scott's orioles, and snowy egrets (De Candido 1985, Kershaw and Mehling 1990). Ringtails and raccoons are common mammals. Herptiles of interest include western diamondback rattlesnakes, gopher snakes, black-necked garter snakes, and Sonoran mud turtles (Kershaw and Mehling 1990).

D4.8.8 Management Recommendations

1. Various areas need to be closed, depending where the eagles nest. If the eagles are in nest 1, the hiking trail up Cibecue Creek should be closed. If the birds use nest 2, the area below the nest should be closed to *stopping* rafters, kayakers, and vehicles. In years when the eagles nest at site 3, the picnic ground across the river below the nest should be closed to all entry, including rafters and kayakers, and night parties (Sudar and Morgan 1984, De Candido 1985, Hein and Nahstoll 1986, Carroll and Housser 1987, Kershaw and Mehling 1990).

2. Due to the high level of juvenile mortality and the amount of recreation at the Cibecue breeding area, ABENWP personnel should begin coverage at the onset of incubation. This would provide protection during early incubation and when the young first hatch, two periods when the nest is very susceptible to failure. This schedule would also provide more data on juvenile mortality at Cibecue.

3. Commercial river rafting outfitters currently have to apply for permits to float the Salt and Verde rivers. Most outfitters know the locations of eagle nests and point them out to their parties while floating the river. This provides a valuable experience and educates the public user about bald eagles. However, one of the restrictions of the permit should be that commercial (and private) rafters and kayakers should not stop near eagle nests, or make camp within the view of the nest. These "No Stop" zones could be placed on river maps (commercially available) which are currently used by private and commercial outfits.

CIBECUE BREEDING AREA

Date Discovered: 1973
Drainage: Salt River / Cibecue Creek (Free-flowing / Perennial)
Elevation (MSL): 3120 - 3400 ft
County: Gila
Latitude-Longitude Ten Minute Block: 334-1103
Land Management: U.S. Bureau of Indian Affairs
Fort Apache Indian Community (North of Salt River)
U.S. Forest Service, Tonto National Forest,
Globe Ranger District (South of Salt River)
Distance From Phoenix: Air - 146.0 km East
Distance To Nearest Breeding Area Upstream: Mule Hoof - 6.9 Km
Air - 6.0 km
Distance To Nearest Breeding Area Downstream: Canyon
Air - 13.5 km
Distance From Granite Reef Dam: 178.2 Km
Home Range: Unknown. Known to utilize Salt River, and Cibecue Creek, from above first waterfall to confluence.
Quadrangles: Mule Hoof Bend 7.5 Minute
Blue House Mountain 15 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Pinnacle	1973 1975 1977 1980	Existing - Found 1973. Rubink No. 10.
2		Cliff	1978-1979 1982-1984 1986 1990	Existing - Found 2 March 1977.
3		Cliff	1985 1987 1989	Existing - Built 1985.
*			1988	Adults rebuilt nests 1, 2 and 3.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1973	Successful	1+	1	1	
1974	Unknown	?	?	?	Nest not checked.
1975	Successful	1+	1	1	
1976	Unoccupied				

CIBECUE BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1977	Failed	1+	1	0	Young disappeared from nest.
1978	Successful	3	3	2	One eaglet fell from nest. One young disappeared post-fledging (telemetered).
1979	Failed	1+	0	0	
1980	Failed	3	3	0	One eaglet disappeared from nest. One died in nest (intestinal ulcer and hemorrhage). One young fell during banding attempt.
1981	Unoccupied				
1982	Successful	1+	1	1	
1983	Failed	2+	2	0	Two young disappeared from nest.
1984	Successful	3	3	3	
1985	Successful	2+	2	1	One eaglet died in nest.
1986	Successful	2+	2	1	One young fell from nest on 17 May.
1987	Failed	1+	1	0	Adult female vanished 18 April after aggressive interaction with near-adult male bald eagle. Near-adult continued to attack resident male and eaglet. Nestling died 8–11 May. Severe Mexican chicken bug infestation in nest.
1988	Occupied				New female. Adults rebuilt nest 1, 2 and 3.
1989	Successful	2+	2	1	Adult male found below nest 2 on 21 November 1988 with broken (in 2 places) right ulna (wing), and taken to rehabilitation facility. Male banded on right tarsus as nestling in 1977 at Bartlett breeding area by Robert Ohmart. Injured male replaced at nest by new male Nov–Dec 1988. Rehabilitated male banded on left tarsus with black VID band and released 16 January 1989 at Tonto estuary on Roosevelt Reservoir. Rehabilitated male recap-tured 22 Feb 1989 on Roosevelt Reservoir, near School House Point, in excellent condition. Rehabilitated male found dead 11 April 1989 north of Globe near Hess Canyon. One young died in nest at 5 weeks of age.

CIBECUE BREEDING AREA (continued)

Productivity (cont'd.)

Year	Status	Eggs	Young	Fledged	Comments
1990	Failed	1+	1+	0	New female, near-adult (ca. 4–5 years old). One young died in nest 12–14 April. Adult female carried fuzzy object, apparently the dead eaglet, away from nest on 14 April. Photographer disturbances on 5 April may have contributed.
Total		24+	23	11	
Years		15	15	15	
Mean		1.6	1.5	0.7	

D4.9 CLIFF BREEDING AREA

The Cliff breeding area is located 65 km northeast of Phoenix, along the regulated Verde River below Horseshoe Dam. The surrounding area is fairly open, with abundant vehicle access points; however, some promontory cliffs do exist. The land closes in downstream as the river approaches Bartlett Reservoir. Due to high levels of recreation pressure, a closure was enacted 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.

D4.9.1 Habitat

The biotic community in the Cliff area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Paloverde-Cacti-Mixed Scrub Series and the Creosotebush-Crucifixion-thorn 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).

Plate D24. Cliff pinnacle nest (4), containing two 6.5 to 7-week-old eaglets, along the regulated Verde River, April 1988 (photo by D. Driscoll).

Below Horseshoe Reservoir, the Verde River supports a single line of cottonwoods and a vast mesquite bosque which is used as a campground. The river is braided in this section, with several shallow areas offering fording by vehicle. Access roads have been worn through the mesquite bosques, and recreation abounds until large promontory cliffs on the west bank, near the USGS gaging station, limit vehicle travel along the river. Some four-wheel drive vehicles ford the river at this point and travel down the east bank.

Trees are scarce downstream from the nest vicinity to Bartlett Reservoir, and cliffs become more numerous, although dry washes still provide vehicle access. In this section, the river supports some emergent vegetation along scattered cutbanks and small cliffs. The upper portion of the reservoir contains some large 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.

D4.9.2 Reproductive History

The Cliff breeding area appears to have productivity problems. In the seven years of its known existence, the Cliff territory has been successful two years, failed three years, and apparently did not lay eggs in two years. The eagles have laid eggs during 2–27 February, hatched eaglets from 9 March to 5 April, and fledged young from 27 May to 8 June (Table D4.9-1).

Table D4.9-1. Nesting chronology of the Cliff breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1984	26 February	1 April	—
1985	5 February*	12 March*	7, 8 June*
1986	2 February*	—	—
1987	—	—	—
1988	4 February	9 March	27 May*
1989	27 February*	5 April*	—
1990	—	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

The Cliff breeding area was discovered on 12 April 1984 (Dodds 1984), and has had four known nest sites, two on cliffs (1, 2), one in a live cottonwood tree (3), and one on a pinnacle (4). Nests 1, 2, and 4 occur in a cliff bowl downstream of the USGS gaging station, while nest 3 is located near KA Ranch. Nest 1 was built on top of the cliff (basically a ground nest) and was accessible to humans and predators. The eagles used nest 1 from 1984–1985, then the nest fell between July and November 1985 (Eakle, pers. comm.). Nest 2 is an artificial nest constructed by Teryl Grubb, USFS, in November 1984, and has not been used by the eagles (Grubb, pers. comm.). Nest 3 was built in December 1984 on top of a great blue heron rookery (Forbis, pers. comm.). Nest 3 was never used by the eagles, and fell along with the

supporting branches between June and December 1989. The Cliff pair built nest 4 in 1986, and have used the nest from 1986–1990. Nest 4 is located on top of a free-standing pinnacle, and is merely a ring created by a few sticks. Nests 2 and 4 are still in existence.

When the Cliff breeding area was found in 1984 two eaglets were in the nest; however, the young disappeared between 31 May and 5 June. One eaglet was later found dead below the nest cliff (Grubb 1984). In 1985, the pair fledged two eaglets (Grubb 1986a). The eggs failed to hatch in 1986, and the pair apparently did not lay eggs in 1987. Two young fledged from the Cliff nest in 1988, and one eaglet hatched in 1989, but died within a week. The eagles apparently did not lay eggs in 1990.

When the Cliff nest was entered to band the eaglets in 1988, one young (JI27) had an eye infection, with scabbing over the eye and nares. We took photographs and cleaned his eyes before leaving the nest. We captured the other young (JI26) for radio-tagging, after she had fledged. Although JI26 did not show signs of eye infection when banded in the nest, she had scabbing and foam around her eyes when captured. It was later determined that the eye infections were probably avian pox (USFWS 1987, K. Ingram, pers. comm., D. Garcelon, pers. comm.). We cleaned her eyes, and also removed a fishing hook from her toe. The hook had been broken off, and the entire upper portion was inside her toe. We collected some monofilament line, three fishing hooks, and some fishing weights from the nest when the chicks were banded.

Both of the Cliff adults have carried USFWS bands, the male on his right tarsus and the female on her left tarsus, at least since 1985 (Camara and Motzkin 1985). We captured the Cliff male on 8 June 1988, for banding and telemetry purposes, and read the USFWS band (629-04467) on his right tarsus. The eagle was banded as a nestling in 1979 at the Redmond breeding area (Haywood and Ohmart 1983), and would have been five years old in 1984.

D4.9.3 Mortalities

There have been three documented juvenile bald eagle deaths at the Cliff breeding area. Of these, two young disappeared from the nest (one later found below nest cliff), and one died in the nest. In 1984, the two eaglets survived to 8–9 weeks of age, then disappeared from the nest between 31 May and 5 June. A search of the area on 6 June found one eaglet dead below the nest cliff; however the other young was not located (Grubb 1984).

At the Cliff nest site in 1990, one eaglet hatched on 5 April, but died prior to 12 April. 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 may have been a victim of the above-average temperatures during this period (see Section C3.5). Possible factors contributing to nestling mortality, including monofilament line, nest parasites, and heat stress are detailed in Section C3.

The two banded Cliff adults have been at the breeding area since at least 1985, and no known adult mortalities have occurred.

Kuder and Sinor (1989) reported people shooting at the Cliff adults in January 1989. Such a disturbance (if not fatal) could result in the pair not nesting, or abandoning eggs that have been laid. There have been numerous reports of gunfire near or under the Cliff nest (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, and Section B4.7).

D4.9.4 Known Foraging Areas and Food Habits

Prior to BioSystems study, most foraging at Cliff has been documented 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 (Camara and Motzkin 1985, Mehling and Kershaw 1990).

Camara and Motzkin (1985) and Cooper (1985) observed a trend in the Cliff eagles' foraging behavior. The eagles captured prey below the nest cliff and also brought prey back from distant locations prior to hatching. From 12 March (hatch date) to 5 May 1985 the eagles foraged almost exclusively below the nest. During this same period, carp were observed spawning below the nest cliff. After 5 May, foraging was less localized, 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, as we have observed carp wallowing in the shallows with their backs out of the water from March to October at Km 65–66.

The Cliff adult male was captured and telemetered on 8 June 1988, and provided information on foraging and movements during the 1989 nesting season. Unfortunately the nest failed in 1989, foiling the opportunity to study foraging and habitat use associated with feeding eaglets at the nest. The home range of the Cliff pair extends from Km 50.0 on the Bartlett Reservoir, to Km 75.0 on Horseshoe Reservoir, totaling 25 Km. The Cliff eagles were observed interacting with both the Horseshoe and Bartlett eagles, which were also telemetered.

Prey items described by (Dodds 1984, Martin 1984, Grubb 1984, Camara and Motzkin 1985, Cooper 1985, Williams 1985, Grubb 1986a, Nahstoll and Prescott 1987, Dixon and Maack 1988, Kuder and Sinor 1989, Mehling and Kershaw 1990) are presented in Table D4.9-2, along with prey items observed taken by eagles and prey remains collected from the nest from 1986-1989. See Sections B4.7 and B5.1.4 for detailed analysis of prey species utilized by the Cliff eagles.

The Cliff adults were not observed stealing prey from other species; however, other birds did attempt to pirate prey from the eagles. Cooper (1985) noted a golden eagle unsuccessfully attempting to steal prey from the adult male. The golden stooped on the male, but did not acquire the prey, which fell to the ground. In a scenario likely only to be performed by a bird as clever as a Corvid, a raven (which nested within 200 m of the eagles) pirated prey directly out of the bald eagles nest, when they left to chase off a golden eagle. Dodds (1985) detailed the incident as follows, "... the golden eagle came up and both adult bald eagles were engaging it, one of the ravens went over and landed in the eagle nest and pecked at the chicks but it was fended off by the chicks so it pirated some food and left."

D4.9.5 Human Impacts

Human disturbance is a serious problem at the Cliff breeding area. Fishermen, shooters, campers, partiers, and off-road vehicles enter the closure area and disturb the eagles during each breeding season (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). Kuder and Sinor (1989) stated, "We had a constant barrage of people, jets, private aircraft, and boaters in or at the

Table D4.9-2. Prey species observed taken by bald eagles or collected from the nest at the Cliff breeding area.

Fish	Birds	Mammals
Carp	Unidentified waterfowl	Cottontail rabbit
Channel catfish	American coot	Blacktail jackrabbit
Flathead catfish	Unidentified passerine	Neotoma
Largemouth bass	Gambel's quail	Unidentified mammal
Black bass	White-winged dove	
Crappie		
Sucker		**Herptiles**
Shad		Unidentified snake
Unidentified fish		

closure boundary." The cable car at the USGS gaging station has become a joy ride for public users (Williams 1985, Nahstoll and Prescott 1987). Dodds (1984) described a hiker's dog attempting to get at the eagles in nest 1 (basically a ground nest). The level of recreational use in the nest area was quantified by Kuder and Sinor (1989) who camped at the closure boundary upstream of the nest on weekends from 10 March to 16 April 1989; they prevented 323 people from entering the closure. Dodds (1984), Camara and Motzkin (1985), and Cooper (1985) noted that heavy human use limited foraging at Cliff, and described changes in the eagles behavior on weekends verses week-days. This change was also observed by Martin (1984), who stated, "Foraging activity was often interrupted by the many disturbances, thereby making prey deliveries erratic, especially on weekends."

Although low level military jets, private airplanes, and helicopters were common in the area, they did not disturb the eagles in most cases (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). However, Williams (1985) observed an adult flushing during a low level aircraft disturbance, and stated the eagles were disturbed by sonic booms. In one instance, Dixon and Maack (1988) noted an incubating eagle huddled over the eggs when an air force jet screeched past within 150 m of the nest, and Kuder and Sinor (1989) observed the male flushed off the eggs once by a low level jet.

Shooting is a major problem at the Cliff breeding area. Kuder and Sinor (1989) reported people camped inside the closure, on the gravel bar across from the nest, and were shooting at the adults in January 1989. People were also observed shooting spawning carp in the river, and shooting swallows which nest near the gaging station (Williams 1985). Gunshots were recorded near or below the nest in all available sources (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).

The Cliff territory receives much pressure from recreation. Four-wheel-drive vehicles, fishermen, campers, and people shooting automatic, semi-automatic, and other types of firearms continually flow into the nest area. The Cliff nest site is within a legally designated Bald Eagle Breeding Area Closure,

although the closure has not been enforced. Trespassers in the closure area said they did not see a closure sign, while others read the signs and entered nonetheless. The latter was especially true of repeat offenders, who said they had always ignored the closure signs and had never been stopped (Kuder and Sinor 1989). A lack of proper road blocks and posting allows continual access to the nest area from the northern boundary. Mehling and Kershaw (1990 and pers. comm.) described numerous accounts of vehicles and gunshots within the closure in February 1990. It is possible that too much disturbance in January and February deterred the eagles from nesting in 1990. See U.S. Fish and Wildlife Service (1989) and (1990) for detailed accounts of disturbance at the Cliff breeding area in 1988 and 1989.

Fishermen also threaten the success of this breeding area by irresponsibly disposing of waste monofilament line. We collected monofilament, hooks, and weights from the nest in 1988, and removed a hook from one nestling's toe. Monofilament not only kills bald eagles, but many other wildlife species as well (see Section C3.3). Arizona bald eaglets have died from becoming entangled in monofilament at the nest (Section D4.22.3).

D4.9.6 Wildlife Interactions

At the Cliff nest site, interactions with common ravens are numerous, and occur daily because the ravens nest within 200 m of the eagle nest. Other species interacting with the eagles include red-tailed hawks, which also nest nearby, Harris' hawks, osprey, golden eagles, peregrine falcons, Cooper's hawks, Swainson's hawks, turkey vultures, great blue herons, and coyotes (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, kingbirds harassed the eagles at a perch tree, suspected to be the kingbirds nest tree (Williams 1985).

On 3 March 1988, at 0530 hours, coyotes calling near the nest elicited 90 seconds of vocalizations from the eagles. The next day, at 2145 hours, a pair of great horned owls calling near the nest caused the eagles to vocalize for five minutes (Dixon and Maack 1988). Great horned owls have been suspected of killing nestling and post-fledging eagles in Arizona (see Section D4.15 and D4.17).

On 10 February 1985, an immature bald eagle attempted to enter the Cliff nest. The incubating female spread her wings to protect the nest and vocalized. She then left the eggs to chase the intruder away (Camara and Motzkin 1985). Nahstoll and Prescott (1987) observed a subadult bald eagle in the nest area during 6–22 February 1987; the subadult entered the nest on several occasions and rearranged the nest material. Even though the adults were in the area, they did not react aggressively toward the young eagle. Other subadult and near-adult bald eagles were chased out of the area (Dixon and Maack 1988, Kuder and Sinor 1989, Mehling and Kershaw 1990).

D4.9.7 Wildlife Sightings

Herptiles in the area include western diamondback rattlesnakes, desert tortoises, gila monsters, spiny softshell turtles, and short-horned lizards. White-faced ibis have been sighted, as well as snowy egrets, double-crested cormorants, Canada geese, gadwalls, pintails, green-winged teal, cinnamon teal, redheads, and ring-necked ducks. Along with the usual desert raptors, golden eagles, peregrine falcons, prairie falcons, osprey, zone-tailed hawks, common black hawks, Cooper's hawks, barn owls, screech owls, and elf owls have been sighted. Other birds observed in the area include black-chinned, Costa's, Anna's, rufous, and broad-tailed hummingbirds, Inca doves, red-naped sapsuckers, Williamson's sapsuckers, vermillion flycatchers, sage thrashers, northern and hooded orioles, bronzed cowbirds, pyrrhuloxias, black-headed grosbeaks, lazuli buntings, pine siskins, bridled titmice, magnolia warblers, and green-

tailed, rufous-sided, brown, and Abert's towhees (Cooper 1985, Dixon and Maack 1988, and BioSystems researchers 1987–1989). Peregrine falcons were sighted on two occasions in 1985, attempting to capture swallows nesting near the gaging station (Camara and Motzkin 1985, Cooper 1985).

D4.9.8 Management Recommendations

1. The current closure is not functional due to a lack of enforcement, proper posting, and road blocks (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, the closure area needs to be enlarged at the northern boundary, to block vehicle access into the nest area. This enlargement should include the cottonwood grove upstream of the USGS gaging station, and block the river ford upstream of the nest (Camara and Motzkin 1985, Cooper 1985, Nahstoll and Prescott 1987, Dixon and Maack 1988, Kuder and Sinor 1989, Mehling and Kershaw 1990).

2. The extended closure area should block vehicle access at the cattle guard, by locking the gate (which is already in place). In addition, a strong cable fence should be placed at the high gravel terrace, upstream of the gaging station, from the cliff to the river on the west bank. Vehicle traffic is already funneled around the gravel terrace and past a swampy pool. At this bottleneck, a strong gate should be placed across the road and locked (similar to the Bartlett gate). The lock would allow ranchers and USFS personnel access for their operations, but prohibit public users from entering the nest area. A large sign informing public users of the closure, and the fines for illegal entry, should be placed on the gate, with small plastic closure signs along the fence (Kuder and Sinor 1989, Mehling and Kershaw 1990).

   All closure signs should be identified with USFS and USFWS logos. The signs could also state that ABENWP personnel are on duty, and are likely on their way to inform the trespassers of their error. If the river is properly posted, no one can say they did not see a sign.

3. A berm should also be placed on the road leading to the nest, off the Mazatzal Wilderness access road on the east bank. ABENWP personnel have already placed a sign and large boulders here, but some "determined" off-road vehicles still gain access to the nest area (Kuder and Sinor 1989, Mehling and Kershaw 1990). In addition, the southern boundary of the closure should be posted and fenced.

4. Signs should be posted at the FS 42 and FS 161 road turn-offs from the main Horseshoe road, warning public users that the area is closed. Kuder and Sinor (1989) suggested posting a large permanent sign at these turn-offs, which explains the closure boundaries, dates, and fines for illegal entry. The large sign could also have a place to hang a small "open" or "closed" sign, so people always know the status of the closure, even at a glance. In addition, the sign should be used as an opportunity to educate the public about the eagles.

5. The amount of recreation pressure in the Cliff breeding area is increasing annually. The nest and eagles are readily visible from the gravel bar near the USGS gaging station. Kuder and Sinor (1989) set up a small public viewing station at this point in 1989 which was a tremendous success. Since ABENWP personnel will be present at Cliff during each breeding season, it seems advisable to set up a public viewing station on the gravel bar. The station could be advertised on the large closure

signs at the turn-offs on FS 161 and FS 42, and also on the closure gate. By educating the general public about the Cliff birds, and letting them actually see the eagles (and chicks) through spotting scopes, the closure's effectiveness would be greatly increased. Many people would take it upon themselves to tell violators to leave the area, or report violators to the proper agencies.

6. As discussed previously, shooting is a major problem at the Cliff breeding area. All of the available sources stated that shooting should be prohibited within a 300-m buffer zone surrounding the closure (Camara and Motzkin 1985, Cooper 1985, Williams 1985, Nahstoll and Prescott 1987, Dixon and Maack 1988, Kuder and Sinor 1989, Mehling and Kershaw 1990).

7. The closure gate on the road at the northern boundary of the Bartlett breeding area effectively prevents vehicle entry to that nest area. However, even this gate was broken by a truck ramming it in winter 1989. A similar gate is needed to block roads entering the Cliff breeding area. One way to avoid closure gates being broken by trucks and fences cut by trespassers is to place large boulders across strategic access bottlenecks.

8. To prevent disturbance to incubating adults, all closure signs, gates, fences, and other barriers should be in functional condition by November or December of each year. This task could promote eagle productivity, simply by reducing egg mortality due to disturbance during incubation.

9. It is apparent that lack of enforcement is reducing the effectiveness of the closure. A U.S. Forest Service, U.S. Fish and Wildlife Service, or Arizona Game and Fish Department representative with the authority to write citations should be present at Cliff on weekends to enforce closure laws. However, if the public viewing station is successful (see recommendation 5) enforcement personnel may not be necessary.

10. Due to the high level of recreational pressure at the Cliff breeding area, ABENWP personnel should begin coverage in January, instead of the normal February start date. This would provide protection prior to egg laying, and during early incubation, when the nest is most susceptible to failure.

11. The cable car at the USGS gaging station has become a toy for public users (Williams 1985, Nahstoll and Prescott 1987). If this device is no longer needed, it should be removed.

CLIFF BREEDING AREA

Date Discovered: 12 April 1984
Drainage: Verde River (Regulated)
Elevation (MSL): 1860 - 2000 ft
County: Maricopa
Latitude-Longitude Ten Minute Block: 335-1114
Land Management: U.S. Forest Service, Tonto National Forest, Cave Creek Ranger District
Closure: Tonto National Forest Closure
Order No. 12-58
Enacted 7 February 1985
Closed To All Entry 15 November - 15 July
Revised 1987 - Closed To All Entry 1 December - 30 June
Distance From Phoenix: Air - 65.5 km Northeast
Distance To Nearest Breeding Area Upstream: Horseshoe - 11.2 Km
Air - 9.0 km
Distance To Nearest Breeding Area Downstream: Bartlett - 30.5 Km
Air - 15.5 km
Distance From Salt River Confluence: 65.5 Km
Distance To Horseshoe Reservoir: 4.1 Km
Air - 2.8 km
Home Range: Km 50.0 on Verde River (Bartlett Reservoir) to Km 75.0 on Horseshoe Reservoir (Total = 25.0 Km)
Quadrangles: Horseshoe Dam 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff/Ground	1984-1985	Nest found 12 April 1984. Nest Fell July - November 1985.
2		Cliff		Existing - Artificial nest constructed by Teryl Grubb, USFS, November 1984.
3	Cottonwood	Live		Built December 1984 on great blue heron rookery. Nest and supporting branches fell June - December 1989.
4		Pinnacle	1986-1990	Existing - Built 1986. Nest is only a few sticks.

CLIFF BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1984	Failed	2	2	0	Two eaglets disappeared from nest 31 May - 5 June. One young found dead below nest on 6 June. Both adults banded, male on right tarsus and female on left tarsus.
1985	Successful	2	2	2	
1986	Failed	1+	0	0	
1987	Occupied				
1988	Successful	2+	2	2	Eye infections in both young, possibly avian pox. Fishing hook removed from nestlings' toe. Adult male banded as nestling in 1979 at Redmond breeding area by Robert Ohmart. Adult male would have been 5 years old in 1984. Black VID band added to left tarsus.
1989	Failed	3+	1	0	Young hatched 5 April, but disappeared before 12 April. Adults incubated unhatched eggs until 4 May. One egg collected.
1990	Occupied				Lots of disturbance and shooting. Near-adult male chased resident male from food, and perched with adult female.
Total		10+	7	4	
Years		7	7	7	
Mean		1.4	1.0	0.6	

D4.10 COOLIDGE BREEDING AREA

The Coolidge breeding area is located 145 km southeast of Phoenix, along the regulated Gila River 8.6 km below Coolidge Dam. Four airline km east, Coolidge Dam creates San Carlos Reservoir on the Gila River, with the San Carlos River entering from the north 15.2 km above the dam. The surrounding area is characterized by steep slopes and rugged terrain, with promontory cliffs bounding the Gila below the dam. The area above the dam is fairly open; however, cutbanks bound portions of the reservoir and steep slopes extend to the mountains in the distant south and north.

D4.10.1 Habitat

The biotic community in the Coolidge area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species typical of the Creosotebush–Crucifixion-thorn 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).

The riparian area below Coolidge Dam is lush, and among the best riparian habitat inhabited by bald eagles in Arizona. Hawk Creek flows passed an old stone ranch house and enters the Gila 8.5 km below

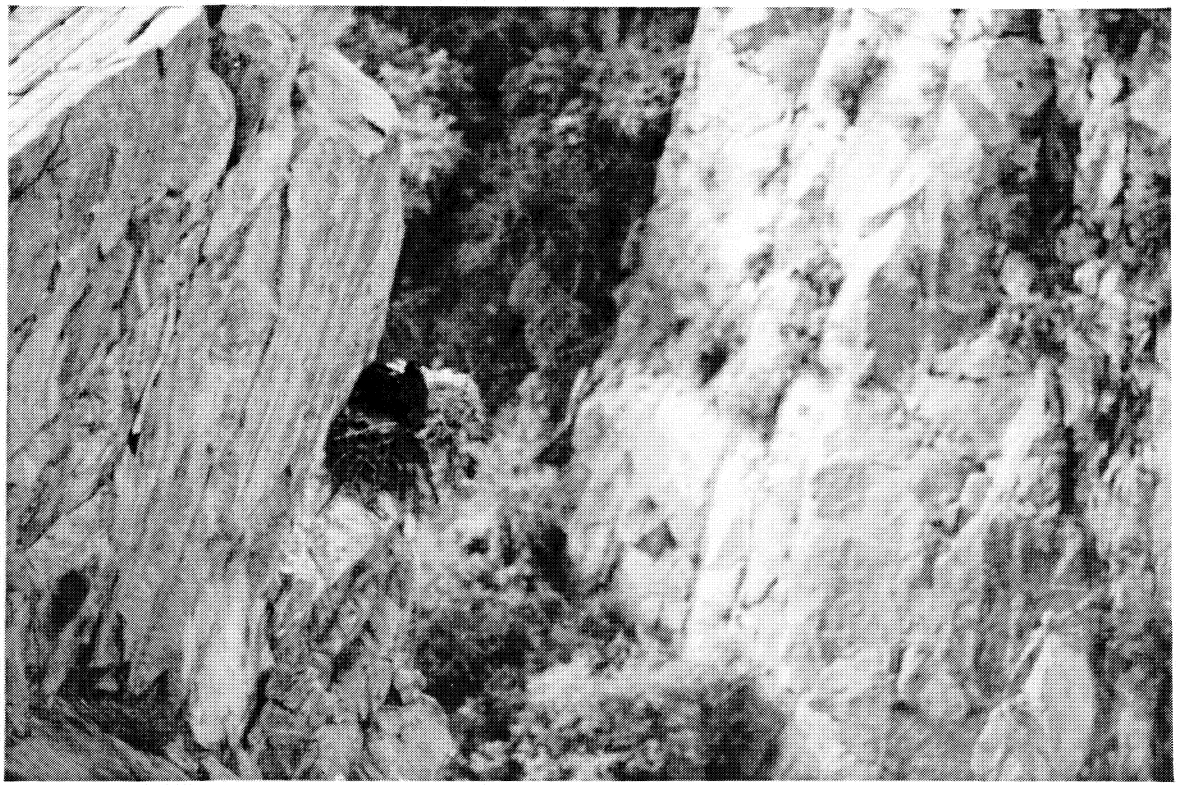

Plate D25. Coolidge cliff nest (3) containing two eaglets, April 1988 (photo by D. Driscoll).

the dam. The confluence area supports a cottonwood grove, with willows scattered along the banks. This riparian composition extends downstream until the river enters a canyon, bounded by large promontory cliffs.

Desert habitat extends to the shoreline of San Carlos Reservoir in some areas; however, large cutbanks exist in other areas. Large cottonwoods line the San Carlos River at its confluence with the Gila and the reservoir. Numerous small snags and emergent vegetation occur on the upper reservoir and in some of the bays. In winter, the reservoir holds a fairly large population of waterfowl.

D4.10.2 Reproductive History

Bald eagles were first reported on the Gila River below Coolidge Dam in 1976 (Stumph and Creighton 1977), although the Coolidge breeding area was not discovered by agency personnel until May 1985 (Eakle, pers. comm.). The Coolidge eagles have laid eggs from 25 January to 2 February, hatched eaglets from 1–10 March, and fledged young from 24 May to 2 June (Table D4.10-1).

Table D4.10-1. Nesting chronology of the Coolidge breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1985	—	—	—
1986	25 January	1 March	24 May
1987	2 February	10 March	2 June
1988	31 January	5 March	< 28 May
1989	—	—	—
1990	—	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

The Coolidge eagles have built three known nests, two in live cottonwood trees (1,2) and one on a cliff (3). Nest 1 was found in May 1985 and was used by the eagles from 1985–1987. Nest 2 was built in 1988, although the eagles laid eggs in nest 3 that year. The adults refurbished and sat in nest 2 in 1989 and 1990, but apparently no eggs were laid. Nest 3 was found 15 April 1988, on a cliff downstream of Hawk Creek. The nest, and supporting ledge, are very small, and could easily be mistaken for a red-tailed hawk nest. The adults used nest 3 in 1988; however, old eggshell fragments were found in the nest, suggesting it was also used prior to 1985. Nests 1, 2, and 3 are all still in existence.

In 1985, the Coolidge eagles laid two eggs, which failed to hatch (Grubb 1986a). During 1986–1988, the adults fledged five young. The Coolidge breeding area was occupied in 1989 and 1990, although no known eggs were laid.

When we entered the Coolidge eyrie to band the eaglets on 27 April 1988, the nest had a high infestation of Mexican chicken bugs. However, the two young fledged successfully, and upon climbing the nest for prey remains on 24 June, we found no bugs in the nest. See Section C3.4 for details on Mexican chicken bug infestations in Arizona bald eagle nests.

On 13 January 1990, while tracking a 1989 Bartlett juvenile (JC50) on San Carlos Reservoir, we observed two pairs of adult bald eagles on the upper (east) end of the reservoir. At this time, the upper end of the reservoir was 3 km below the San Carlos River confluence. The two pairs were perched 600 m apart, on cutbanks along the north shore. The female of one pair was a near-adult.

D4.10.3 Mortalities

When the Coolidge breeding area was found in 1985, one of the pair was a near-adult (Forbis 1985). Since adults had been sighted in the area during the breeding season prior to agency personnel finding the nest, and old eggshell fragments were found in nest 3 in 1988, it is assumed the breeding area was active prior to 1985. This suggests the near-adult replaced a previous adult in the pair.

In another case of mortality, a source who wishes to remain anonymous, claims to have found the carcass of an adult bald eagle in a wooden box, under a blue tarp, on a knoll near San Carlos Reservoir. The adults 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. See Section C3.8 for a discussion of the possibility of a black-market feather trade in Arizona.

D4.10.4 Known Foraging Areas and Food Habits

Data on the foraging ecology of the Coolidge pair is very limited. The Coolidge eagles are known to forage on the Gila River below Coolidge Dam, and also on San Carlos Reservoir. Prey remains collected from the nest from 1986–1988 are presented in Table D4.10-2. See Section B5.1.1 for a detailed analysis of these remains.

D4.10.5 Human Impacts

Information on human impacts in the Coolidge breeding area is virtually nonexistent. The road leading from the dam to the lower river is gated and locked, prohibiting unwarranted vehicle travel. Some fishing and hunting may occur along the Gila River below the dam, although no data are available on this type of recreation. San Carlos Reservoir is a popular fishing spot; however, the only information concerning fishing impacts on the Coolidge pair involves monofilament line found in the nest in 1988. The San Carlos Reservation is also a popular hunting location, although no data are available on the possible impacts of local hunting. A ranching operation exists on BLM land along the lower Gila, but the rancher is aware (and protective) of the eagles. A vacant old rock ranch house is located along Hawk Creek.

The regulated Gila River below Coolidge Dam was dry on 13 January and 6 February 1990. We do not know the duration of time the river remained dry or how fish populations were affected. It is possible that the dry river may have been a contributing factor to the eagles not laying eggs in 1990.

Table D4.10-2. Prey species observed taken by bald eagles or collected from the nest at the Coolidge breeding area.

Fish	Birds	Mammals
Carp	Eared grebe	Cottontail rabbit
Channel catfish	American coot	Blacktail jackrabbit
Bullhead (catfish)	Gambel's quail	Neotoma
Largemouth bass	Greater roadrunner	Ground squirrel
Black bass		Rock squirrel
Crappie		Deer
Unidentified Centrarchidae		
		Herptiles
		None found

D4.10.6 Wildlife Interactions

Due to the limited amount of data on the Coolidge breeding area, no interspecific interactions have been recorded. The only intraspecific interactions known involved vocalizing between two pairs of adult bald eagles on San Carlos Reservoir on 13 January 1990. A subadult bald eagle was also sighted in the nest vicinity on 6 February 1990.

D4.10.7 Wildlife Sightings

The Coolidge breeding area supports a variety of wildlife species, due to the combination of desert, riparian, and reservoir habitats. Black hawks nest in the cottonwoods below Coolidge Dam, and we always flushed waterfowl from the river when hiking to the eagle nest. We sighted osprey above and below the dam, and American coots, eared grebes, mallards, buffleheads, Canada geese, double-crested cormorants, and ring-billed gulls on the reservoir. An adult peregrine falcon was sighted in July, 1990, calling near the dam (T. Gatz, pers. comm.).

D4.10.8 Management Recommendations

1. More data are needed on the foraging ecology of the Coolidge eagles in order to accurately assess their use of San Carlos Reservoir, and the effects of water releases into the Gila River below Coolidge Dam.

2. River flows and reservoir levels necessary to sustain suitable bald eagle breeding and foraging habitat in the Coolidge breeding area should be established.

COOLIDGE BREEDING AREA

Date Discovered: May 1985. First Reports 1976.
Drainage: Gila River (Regulated)
Elevation (MSL): 2250 - 2600 ft
County: Pinal (South of Gila River)
Gila (North of Gila River)
Latitude-Longitude Ten Minute Block: 330-1103
Land Management: U.S. Bureau of Indian Affairs
San Carlos Indian Community (South of Gila River)
U.S. Bureau of Land Management (North of River)
Distance From Phoenix: Air - 145.0 km Southeast
Distance To Nearest Breeding Area Upstream: Ash - Air - 61.5 km
Distance To Nearest Breeding Area Downstream: Redmond
Air - 34.0 km
Distance From Gila River / Highway 77 Junction: 23.3 Km
Distance To San Carlos Reservoir: 8.6 Km
Air - 4.0 km
Home Range: Unknown. Known to utilize Gila River and San Carlos Reservoir.
Quadrangles: Coolidge Dam 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Live	1985-1987	Existing - Found May 1985
2	Cottonwood	Live	1989-1990	Existing - Built 1988
3		Cliff	1988	Existing - Found 15 April 1988. < 1985?

Nest used previously, possibly prior to 1985, old eggshell fragments in nest. Nest is very small, on small ledge.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1976	Unknown	?	?	?	Adults present on Gila River below Coolidge Dam during breeding season.
1985	Failed	2	0	0	New female, near-adult (ca. 4 years old).
1986	Successful	2+	1	1	
1987	Successful	2+	2	2	
1988	Successful	2+	2	2	Mexican chicken bugs in nest.
1989	Occupied				
1990	Occupied				Two pair of adults sighted on San Carlos Reservoir, below San Carlos River confluence, in January. Near-adult female in one pair.

COOLIDGE BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
Total		8+	5	5	
Years		6	6	6	
Mean		1.3	0.8	0.8	

< = Prior to

D4.11 DEVIL'S POST BREEDING AREA

The Devil's Post breeding area is located 178 km northwest of Phoenix, along Burro Creek. The creek is a free-flowing perennial stream which meanders through a deep and wide canyon on its way to the Big Sandy River. Francis Creek flows into Burro Creek within the Devil's Post territory. The two canyons created by the streams are vast, spanning about 1.5 km from rim to rim.

D4.11.1 Habitat

The biotic community in the Devil's Post area is of the Upper and Lower Sonoran Life Zones. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, and the Interior Chaparral Biome. 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). Large cottonwoods and sycamores grow along the creek bottom, along willows, red alder, and velvet ash.

D4.11.2 Reproductive History

Courtship behavior by a pair of adult bald eagles was observed along Burro Creek (in the current Devil's Post breeding area) in winter 1987, and again in winter 1988 (D. and J. Newbolds, pers. comm.). These

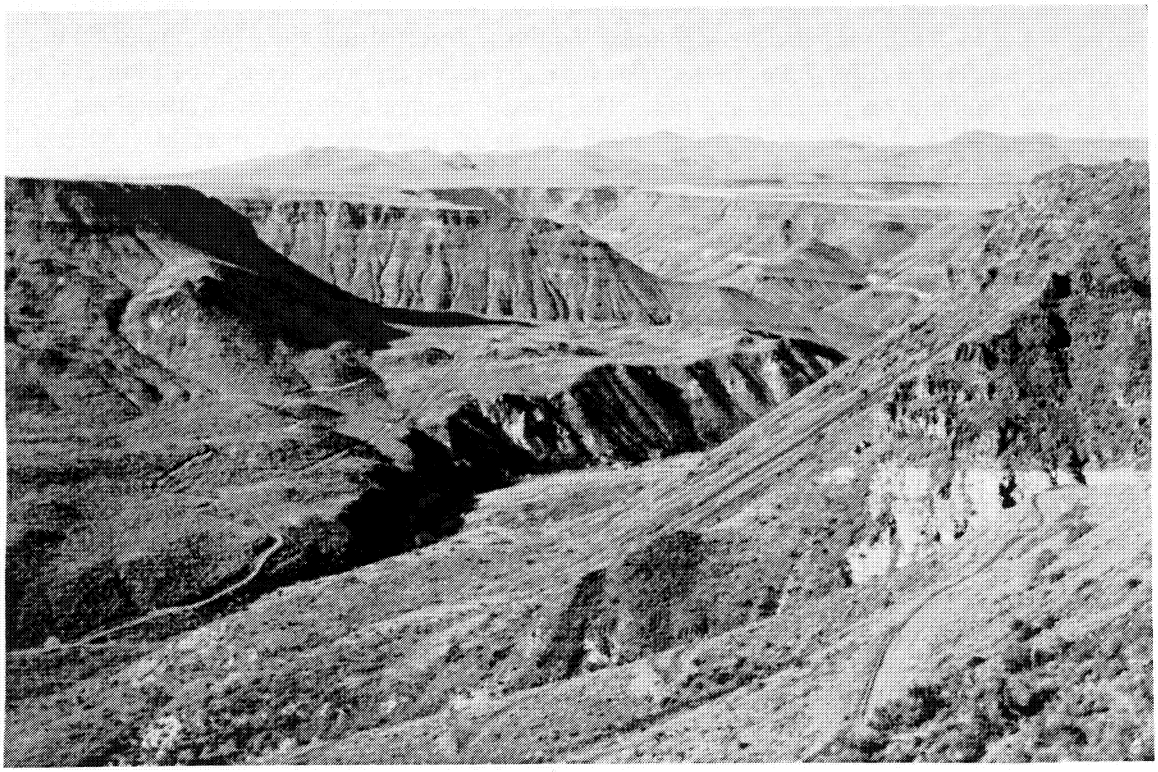

Plate D26. Devil's Post breeding area along Burro Creek, February 1988 (photo by T. Tibbitts).

reports prompted a search of the vicinity, resulting in the discovery of the Devil's Post breeding area on 23 February 1988. Nests and eagles had already been recorded in this same area in 1977, and in the early 1970s. In 1990, Jim Higgs (AGF) informed Tim Tibbitts (AGF) that bald eagles and nests were present at Devil's Post in the early 1970s, when Jim worked in that area (T. Tibbitts, pers. comm.). An eagle (species not specified) was observed incubating on 28 February 1977 in a cliff nest (1) on Francis Creek, just upstream from the Burro Creek confluence. In addition, an adult bald eagle was sighted perched in a sycamore, near an eagle-size cliff nest (2) on Burro Creek, just downstream of the Francis Creek confluence (Rubink, unpublished field notes, Glinski, unpublished field notes). Nest 3 was found in a live sycamore tree when the breeding area was rediscovered on 23 February 1988. On this same day, the Devil's Post pair was observed building a nest (4) in a sycamore tree on the west slope of the canyon. The adults refurbished nests 3 and 4 in 1989, and nest 4 again in 1990. With the exception of the incubating eagle observed in 1977, the Devil's Post eagles have not been known to lay eggs. Nests 3 and 4 are still in existence; however, the status of nests 1 and 2 are unknown.

D4.11.3 Mortalities

There have been no known mortalities at the Devil's Post breeding area, although this is likely due to the limited amount of data on the territory.

D4.11.4 Known Foraging Areas and Food Habits

No data are available on the foraging ecology of the Devil's Post eagles.

D4.11.5 Human Impacts

Although data is limited on the Devil's Post eagles, two separate parties reported the same observation at different times in 1990. M. Cross, AGF (pers. comm.), reported that the adults appeared to have oil marks on their heads and tails. Later in the year, R. Hall, BLM, reported seeing one adult that appeared to have grease smudges on its head and tail. The grease smudge appearance is sometimes visible on adults that have been feeding on (sticking their heads in) large bloody carcasses (Driscoll 1985). However, M. Cross said the soiling did not appear to be blood, nor was it reminiscent of the dark patches typical of near-adult plumage. If the Devil's Post eagles are indeed soiling their plumage in oil or grease as appears the case, the source is unknown. Bald eagles have been known to feed on waterfowl and other prey that land in open oil pools. Ingesting oil can be directly toxic, and there may be latent effects such as lung damage eventually leading to pneumonia (USFWS Bird Rehabilitation Center, Valdez, Alaska). In addition, oil can coat the eggshell, block the pores, and kill the embryo.

D4.11.6 Wildlife Interactions

No data are available on wildlife interactions with the Devil's Post eagles.

D4.11.7 Wildlife Sightings

No data are available on wildlife sightings in the Devil's Post breeding area.

D4.11.8 Management Recommendations

Data are needed on the foraging ecology of the Devil's Post eagles that might reveal the oil contamination problem, if one exists. If further observation indicates that the adults are somehow getting into an oil pool, the pair should be captured, telemetered, and blood samples taken. Foraging locations of the pair can be determined with telemetry, and perhaps explain why the pair consistently fails to lay eggs.

DEVIL'S POST BREEDING AREA

Date Discovered: 23 February 1988. First Reports 1987 (1977) (early 1970s).
Drainage: Burro Creek (Free-flowing - Perennial)
Elevation (MSL): 3080 - 3300 ft
County: Yavapai
Latitude-Longitude Ten Minute Block: 344-1131
Land Management: U.S. Bureau of Land Management, Kingman District
Distance From Phoenix: Air - 178.0 km Northwest
Distance To Nearest Breeding Area Upstream: None
Distance To Nearest Breeding Area Downstream: Chino - Air-48.5 km
Distance From Big Sandy River Confluence: 60.0 Km
Home Range: Unknown

Quadrangles:		
	Bozarth Mesa	7.5 Minute
	Burro Mesa	7.5 Minute
	Negro Ed	7.5 Minute
	Pilots Knob	7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	1977	Unknown - Found 28 February 1977.
2		Cliff	Unknown	Unknown - Found 28 February 1977.
3	Sycamore	Live	Unknown	Existing - Found 23 February 1988.
4	Sycamore	Live	1988 1990	Existing - Built February 1988.
*			1989	Adults rebuilt Nests 3 and 4.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
Early 1970s	Occupied	?	?	?	Bald eagles and nests present in early 1970s.
1977	Active	?	?	?	Eagle incubating (species not specified) 28 February. Adult bald eagle perched in tree near nest 2 on 28 February.
1987	Occupied				Courtship behavior by adults.
1988	Occupied				Adults building nest 4.
1989	Occupied				
1990	Occupied				Adults working on nest 4. Both adults observed on two separate occasions with grease or oil smears on head and tail.
Total		0	0	0	
Years		4	4	4	
Mean		0	0	0	

D4.12 EAST VERDE BREEDING AREA

The East Verde breeding area is located 100 km north of Phoenix, along the free-flowing Verde River near the East Verde River confluence. The East Verde River drains the Mogollon Rim and enters the Verde from the east. Fossil Creek is a free-flowing perennial stream which flows into the Verde from the east, above the East Verde River confluence. The surrounding area is characterized by rugged terrain with steep slopes and cliffs, although the land opens up downstream near Houston Creek. The canyon closes in again at Mule Shoe Bend to the south.

D4.12.1 Habitat

The biotic community in the East Verde area is of the Upper Sonoran Life Zone. At the confluence of the East Verde River vegetation is diverse, with representation of the Great Basin Conifer Woodland, Interior Chaparral, and Semidesert Grassland Biomes. 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).

Plate D27. East Verde cliff nest (6) containing two seven to eight-week-old eaglets, April 1989 (photo by D. Driscoll).

The Verde River flows through rugged country in the East Verde breeding area, bounded by steep slopes and large cliffs. The river is lined with cottonwoods in the Childs area, where the bottom is more open; however, the canyon closes in downstream. Isolated cottonwoods, sycamores, and willows are scattered along the river from Fossil Creek to the nest, although many are in a decaying state. The riparian habitat along Fossil Creek is lush, with green grass, willows, and emergent vegetation. Just upstream of the East Verde nests there is a mesquite bosque on the east bank with an undergrowth of green grass. Steep slopes and promontory cliffs bound the river as the Verde continues past the East Verde River confluence to Houston Creek, where the river opens up somewhat. A line of large cottonwoods once grew downstream of Houston Creek; however, the trees were burned in a wildfire between July and October 1986.

The East Verde River drains 320 square miles of the Mogollon Rim region of central Arizona. From its head at 7300 ft, the East Verde flows 43 mi to its confluence with the Verde River at 2500 ft (Carson 1986). The East Verde flows through rugged terrain, entering narrow canyons at some points, although open areas (such as LF Ranch) also exist where large cottonwoods and sycamores proliferate. Since 1965, the East Verde River has been supplemented by water imports from Blue Ridge Reservoir on East Clear Creek. Intermittent streamflow imports began in October 1965 by Phelps Dodge Corporation in exchange for using water in their copper mining operations in the upper Gila River drainage. Average daily imports from 1968–1984 ranged from a minimum of 4.5 cfs in January to a maximum of 21.1 cfs in June. East Verde River mean monthly flows in this same period ranged from a low of 26.5 cfs in July to a high of 208.3 cfs in February (Carson 1986). Mean monthly flows from November 1986 to June 1989 were similar to those of 1968–1984, ranging from 13–175 cfs. Carson (1986) states that all imported water added at the head of the river is considered to be available at the mouth, with evapotranspiration losses in the summer of less than 1 cfs.

D4.12.2 Reproductive History

The East Verde breeding area, discovered in 1973 (Rubink and Podborny 1976), is the second most successful bald eagle nest site in Arizona, following the Fort McDowell territory. East Verde has been successful 14 of the 17 known years of occupancy, producing 26 young, resulting in a mean of 1.5 fledged young per year. The East Verde eagles have laid eggs from 14 January to 18 February, hatched eaglets from 18 February to 23 March, and fledged young from prior to 7 May to after 5 June (Table D4.12-1).

The East Verde eagles have built seven known nests, four on cliffs (1, 3, 5, 6), two in live cottonwood trees (2, 4), and one in a cottonwood snag (7). In addition, a historical nest (H) possibly occurred in a live cottonwood tree at Eagle Nest Corral, near the East Verde River confluence, which was named prior to USGS mapping of the area in 1918 (Forbis, pers. comm.). Nest 1 was found in 1973 (Rubink, pers. comm.), but fell in January 1981 when a portion of the cliff gave way (Grubb, pers. comm.). Nest 2 was found on 7 February 1974 at the confluence of Fossil Creek, but the nest fell prior to May 1974 and the tree fell in 1981 (Rubink and Podborny 1976, Rubink, pers. comm.). Nest 3 was found in 1974, upstream of Fossil Creek (Rubink, pers. comm.); however, the nest fell prior to a search of the area in 1987.

Nest 4 was found on 1 March 1977, 6.5 Km up the East Verde River (Rubink, pers. comm.), although this nest had fallen prior to a search of the area in 1987. Nest 5 was also found on 1 March 1977, but fell prior to 1984 (Rubink, pers. comm., Eakle, pers. comm.). Nest 6 was an artificial nest constructed by Teryl Grubb, USFS, in January 1981, after nest 1 had fallen. Nest 6 was placed further upstream,

Table D4.12-1. Nesting chronology of the East Verde breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1973	—	—	—
1974	—	—	—
1975	< 20 February	< 24 April	> 5 June
1976	—	—	—
1977	3 February	10 March	2 June
1978	2 February	—	—
1979	—	—	—
1980	18 February	23 March	—
1981	—	—	—
1982	—	—	—
1983	14 January	18 February	—
1984	29 January	7 March	20 May
1985	19–22 January	22–25 February*	16–19 May
1986	17 January	21 February*	13, 17 May*
1987	21 January	26 February*	30 May*
1988	< 12 February	< 16 March	< 7 May
1989	26 Jan–2 Feb	2–9 March	< 27 May
1990	< 5 February	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

due to the cliff falling apart at the old site of nest 1 (Grubb, pers. comm.). Nest 6 was blown off the cliff between 27 May and 4 June 1989, then rebuilt by the eagles in the same location between July and December 1989. Nest 7 was built in a snag downstream of Houston Creek in 1981 (Haywood and Ohmart 1983), although the nest and supporting branches fell between July and October 1986. Nest 6 is the only known nest still in existence at the East Verde breeding area.

The East Verde breeding area was successful each year from 1973 to 1977, fledging a total of 10 young from nest 1 (Rubink and Podborny 1976, Haywood and Ohmart 1983). The two eggs laid in nest 1 in 1978 failed to hatch and were collected. One egg appeared infertile, but the other contained a partially developed embryo (Haywood and Ohmart 1983). The territory was apparently unoccupied at known nest locations in 1979; however, nests 3 and 4 likely were not surveyed since their locations were not widely known (Rubink, pers. comm., Hildebrandt, pers. comm.). The East Verde eagles fledged two young from nest 1 in 1980, and four from nest 7 in 1981-1982 (Haywood and Ohmart 1983). The eagles used nest 7 again in 1983, although the one eaglet died in the nest (Grubb *et al.* 1983). The East Verde pair

fledged three young in 1984–1985 from nest 6 (Grubb 1986a). In 1986 the adults fledged two eaglets from nest 7 (Berger and Von Gonten 1986), then returned to nest 6, fledging five young from 1987–1989. The eagles used nest 6 again in 1990, but failed.

D4.12.3 Mortalities

There have been two documented juvenile bald eagle deaths at the East Verde breeding area. One young died in the nest of unknown causes in 1983 (Grubb 1983). In 1987, one eaglet (the second to hatch) apparently froze while pipping out of the egg in a snowstorm. The adults had devoted all their attention to the newly hatched eaglet, and the pipping chick was left partially exposed to the weather.

There have been no documented incidents of adult mortality at the East Verde breeding area. However, it is difficult to determine if an adult has been replaced, unless the new adult is a near-adult or subadult eagle, or has been banded.

D4.12.4 Known Foraging Areas and Food Habits

Bald eagles at the East Verde breeding area were observed foraging on the Verde River in the vicinity of nests 1, 6, and 7 (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 personnel reported the eagles delivering prey to the nest from the direction of the East Verde River, no foraging was documented on this drainage (Canestorp 1984, Grubb 1984, Frazer and Tischendorf 1985, Grubb 1986a).

We captured and telemetered the East Verde male on 25 March 1987. We placed a silver (aluminum) USFWS band on his left tarsus, and a black color anodized aluminum Visual Identification (VID) band on his right tarsus. Prior to the male's capture and radio-tagging in 1987, foraging information was limited to areas observed by ABENWP and other research personnel watching the nest, resulting in a bias toward the river section below the nest. This same bias also resulted in small home ranges, restricted to river sections and areas visible from nest observation points (Haywood and Ohmart 1981, Haywood and Ohmart 1983, Grubb 1984, Grubb 1986a).

The East Verde male provided detailed information on foraging and movements throughout 1987 and 1988. Extensive use of the Verde and East Verde rivers and Fossil Creek was documented by telemetry, as well as shifts between the streams corresponding to prey availability. The home range of the East Verde male extended from Km 123–140 on the Verde River, from Km 0-20 on the East Verde River, and from Km 0–4 on Fossil Creek, totaling 41 Km.

Prey items described by Rubink and Podborny (1976), Haywood and Ohmart (1980), Haywood and Ohmart (1981), Haywood and Ohmart (1983), Grubb *et al.* (1983), Canestorp (1984), Grubb (1984), Frazer and Tischendorf (1985), Grubb (1986a), and Berger and Von Gonten (1986) are presented in Table D4.12-2, along with prey items taken by the eagles and prey remains collected at the nest from 1986–1989. See Sections B4.4 and B5.1.6 for a detailed analysis of prey species utilized by the East Verde eagles.

Some interesting events have been recorded at the East Verde breeding area over the years. Canestorp (1984) observed the adult male capture two catfish in one attempt, leaving one on the shore and delivering the other (at least 12 in. long) to the nest. Frazer and Tischendorf (1985) witnessed an adult attempt to capture a female common merganser in flight. They also observed some interesting interactions between

Table D4.12-2. Prey species observed taken by bald eagles or collected from the nest at the East Verde breeding area.

Fish	Birds	Mammals
Carp	Waterfowl	Cottontail rabbit
Channel catfish	Common merganser	Blacktail jackrabbit
Flathead catfish	Green-winged teal	Ringtail
Largemouth bass	Cinnamon teal	Skunk sp.
Smallmouth bass	Lesser scaup	Neotoma
Black bass	Anas sp.	Ground squirrel
Lepomis sp.	Unidentified waterfowl	Rock squirrel
Centrarchid sp.	Wading Birds	Chipmunk sp.
Sonora sucker	American coot	Unidentified rodent
Desert sucker	Passerines	Cow
	Jay sp.	
	Other Birds	**Herptiles**
	Gambel's quail	Spiny softshell turtle
	Gila woodpecker	Turtle sp.
	Ladder-backed woodpecker	Frog sp.
	Mourning dove	Western diamondback rattlesnake
	Whip-poor-will	Unidentified snake
		Unidentified lizard

the eagles and river otters. On 22 February 1985, the adult male left the nest and attempted to pirate a fish from a river otter feeding on shore. The otter darted forward, dragging the fish back into the water, and travelled upstream, while the male returned to the nest. About 40 minutes later, the female returned to the nest. Relieved of his incubation duties, the male flew perch to perch downstream and appeared to be searching for the otter. In a similar instance on 6 March, the adult female flew perch to perch following a river otter upstream (Frazer and Tischendorf 1985). In 1987, we observed an adult capture a rock squirrel as it attempted to swim across the Verde River.

The East Verde adults were observed stealing prey from ospreys and great blue herons in 1987. Frazer and Tischendorf (1985) observed the eagles steal a small mammal from a red-tailed hawk, as well as the attempted piracy from a river otter described above.

In addition to the East Verde eagles utilizing the East Verde River, a number of juvenile, subadult, and near-adult bald eagles we radio-tagged during 1987–1989 also utilized the river. See Sections A4 and C5 for details on the movements and habitat use of telemetered non-breeding bald eagles in Arizona.

D4.12.5 Human Impacts

Because of the remote location in very rugged terrain, human disturbance does not appear to be a detrimental factor in the East Verde breeding area. This is especially true when the eagles nest on the cliffs, far above river traffic. However, when the pair nested on the cottonwood snag (nest 7) in the river bottom, there were many disturbances from rafters and canoes (Berger and Von Gonten 1986). In 1986, all river craft disturbed the adults, causing flights from the nest and vocalizations. In one instance, the rafters remained in the area for over 30 minutes, deliberately trying to flush an eaglet (Berger and Von Gonten 1986). Canestorp (1984) also observed rafters (which camped below the cliff nest) deliberately trying to flush the female off the nest, even shooting guns in the process.

The most frequent intrusion into the nest area was low flying planes and helicopters, although the air traffic was usually ignored by the eagles (Haywood and Ohmart 1981, Canestorp 1984, Frazer and Tischendorf 1985, Berger and Von Gonten 1986). However, there were several times when low flying planes and helicopters elicited reactions from the eagles. Canestorp (1984) observed a helicopter flying directly at the nest from upstream. The helicopter pulled up and passed about 50 m over the nest, causing the female to crouch down and drop her wings. Berger and Von Gonten (1986) also reported adults flushing when helicopters passed within 100 m of the nest. In 1987, we observed the male and female flush and vocalize twice when planes flew over the nest area. We also recorded four different disturbances by the same law enforcement helicopter (ID number N310AZ). On 13 May at 1643 hours, the helicopter nearly collided with the adult female, then made a second pass by the nest at 1645 hours at about 750 ft AGL. On 14 May, the same helicopter made several low passes by the nest between 1702 and 1709 hours. Once again the helicopter was in the nest area on 15 May, and on 16 May it landed within 300 m of the nest. See Section B4.4 for details on disturbance at East Verde in 1987 and 1988.

The East Verde eagles were also disturbed when ABENWP personnel were erecting, entering, and leaving observation blinds that were apparently too close to the nest or to favorite perches (Haywood and Ohmart 1981, Canestorp 1984, Frazer and Tischendorf 1985). Each of these sources describe numerous accounts of adults flushing, circling, and vocalizing at nest watchers approaching or erecting blinds. These reactions sometimes lasted 15-20 minutes (Canestorp 1984).

Fishermen and hikers have been observed in the area, although they did not appear to disturb the eagles (Haywood and Ohmart 1981, Canestorp 1984, Frazer and Tischendorf 1985, and Section B4.4). Although fishermen occasionally drive down to Houston Creek, then gain access to the river bottom (Canestorp 1984), the problem has been all but eliminated by a large berm placed in the road at the Wilderness Boundary in 1987.

One secondary effect of fishermen on bald eagles is waste monofilament. We found monofilament and fishing weights in the East Verde nest and discovered a dead common raven along the river with monofilament line protruding from its beak. Monofilament not only kills bald eagles, but many other wildlife species as well (see Section C3.3). Eaglets in Arizona have also died from becoming entangled in monofilament at the nest (Section D4.22.3).

D4.12.6 Wildlife Interactions

At East Verde, interspecific interactions were observed with red-tailed hawks, peregrine falcons, common ravens, accipiters, subadult and adult golden eagles, osprey, turkey vultures, and river otters (Hildebrandt and Ohmart 1977, Haywood and Ohmart 1980, Canestorp 1984, Frazer and Tischendorf 1985, Berger

and Von Gonten 1986, and BioSystems personnel 1987–1988). Peregrine falcons nest near the East Verde River confluence, and golden eagles nest on Squaw Butte southwest of Houston Creek. Although no aggressive altercations have been recorded with the peregrines, the East Verde adults have struck golden eagles in the air (Frazer and Tischendorf 1985) and driven them from the air, subsequently fighting on ground (Berger and Von Gonten 1986). We also observed coyotes, ravens, and turkey vultures interacting with the eagles at cattle carcasses.

Many interactions with other bald eagles at East Verde simply involved escorting the intruder out of the area, although some were aggressively chased and attacked (Hildebrandt and Ohmart 1977, Canestorp 1984, Frazer and Tischendorf 1985, Berger and Von Gonten 1986, and BioSystems personnel 1987–1988). In 1986, one eaglet was clearly dominant, physically abusing its smaller sibling and preventing it from feeding on many occasions (Berger and Von Gonten 1986). In order to ensure that the smaller eaglet received enough food, USFS personnel provided four to five fish in a backwater pool. The adults subsequently took all the fish to the nest (Berger and Von Gonten 1986).

D4.12.7 Wildlife Sightings

The East Verde breeding area supports a variety of wildlife species, due to a diversity of vegetative communities and its isolation from human factors. Numerous sightings of river otters, their scat, and dens have been made in the East Verde area, from Childs to south of Houston Creek (Frazer and Tischendorf 1985 and BioSystems personnel 1987–1988). Javelina, white-tailed deer, mule deer, grey fox, coyotes, ringtails, coatis, and mountain lions also occur in the area. In addition to the nesting peregrine falcons and golden eagles, we have also sighted what appear to be common black hawk nests in the trees along Houston Creek, although the nests were not occupied. Herptiles of interest include western diamondback rattlesnakes, and black-tailed rattlesnakes.

D4.12.8 Management Recommendations

1. The East Verde River is an important foraging area of the East Verde pair, as well as many non-breeding eagles. In the event that water imports from Blue Ridge Reservoir are ever halted, a plan is needed to ensure the flows necessary to sustain bald eagle foraging habitat along this stream are maintained.

2. If the East Verde eagles build a tree nest along the river in the future, ABENWP personnel should be present during the breeding season to protect the nest from rafting and canoeing disturbances.

EAST VERDE BREEDING AREA

Date Discovered: 1973
Drainage: Verde River / East Verde River (Free-flowing)
Elevation (MSL): 2440 - 2800 ft
County: Yavapai (West of Verde River)
Gila (East of Verde River)
Latitude-Longitude Ten Minute Block: 341-1113
Land Management: U.S. Forest Service, Tonto National Forest,
Cave Creek Ranger District
Payson Ranger District (South of Fossil Creek and all of the East Verde River area).
Distance From Phoenix: Air - 100.0 km North
Distance To Nearest Breeding Area Upstream: Ladders - 21.6 Km
Air - 17.0 km
Distance To Nearest Breeding Area Downstream: Table Mountain - 9.3 Km
Air - 7.2 km
Distance From Salt River Confluence: 128.1 Km
Home Range: Km 123.0 to Km 140.0 on Verde River (Total = 17.0 Km)
Km 0.0 to Km 20.0 on East Verde (Total = 20.0 Km)
Km 0.0 to Km 4.0 on Fossil Creek (Total = 4.0 Km)
(Total = 41.0 Km)
Quadrangles: Wet Bottom Mesa 7.5 Minute
Verde Hot Springs 7.5 Minute
Cane Springs Mountain 7.5 Minute
Cypress Butte 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
H	Cottonwood	Live	< 1918?	Possible historical nest at Eagle Nest Corral in 1918.
1		Cliff	1973-1978 1980	Nest found 1973 - Rubink No. 23. Nest fell in January 1981.
2	Cottonwood	Live	Unknown	Nest found 7 February 1974 - Rubink No. 24. Nest fell prior to May 1974. Tree fell prior to 1981.
3		Cliff	Unknown	Nest found 1974 - Rubink No. 25. Nest fell prior to 1987.
4	Cottonwood	Live	Unknown	Nest found 1 March 1977. Nest fell prior to 1987.
5		Cliff	Unknown	Nest found 1 March 1977. Nest fell prior to 1984.

EAST VERDE BREEDING AREA (continued)

Nest Sites

No.	Species	Type	Utilized	Status
6		Cliff	1984-1985 1987-1990	Existing - Artificial nest constructed by Teryl Grubb, USFS, Jan 1981. Nest blown off cliff between 27 May and 4 June 1989. Adults rebuilt nest July-Dec 1989.
7	Cottonwood	Snag	1981-1983 1986	Built 1981. Nest and branches fell between July and October 1986.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1918	Unknown	?	?	?	Possible historical tree nest at Eagle Nest Corral.
1973	Successful	2+	2	2	
1974	Successful	3	3	3	
1975	Successful	1+	1	1	
1976	Successful	2+	2	2	
1977	Successful	2+	2	2	
1978	Failed	2	0	0	Two eggs collected, one infertile, other partially developed.
1979	Unoccupied				
1980	Successful	2+	2	2	
1981	Successful	2+	2	2	
1982	Successful	2+	2	2	
1983	Failed	1+	1	0	One eaglet died in nest.
1984	Successful	1+	1	1	
1985	Successful	2	2	2	
1986	Successful	2+	2	2	
1987	Successful	2	1	1	One young froze while pipping in a snow storm. Adult male banded on left tarsus, and black VID band placed on right tarsus.
1988	Successful	2+	2	2	
1989	Successful	2+	2	2	
1990	Failed	1+	?	0	Adults incubating on 5 February. No young in nest on 9 April.
Total		31+	27	26	
Years		17	16	17	
Mean		1.8	1.7	1.5	

< = Prior to

D4.13 FORT MCDOWELL BREEDING AREA

The Fort McDowell breeding area is located 45 km northeast of Phoenix, along the regulated Verde River, 13.3 km from the Salt River confluence. The surrounding area is open desert, with abundant vehicle access points to the river bottom. The river in this area is regulated by Bartlett Dam, located at Km 39.3 on the Verde River.

D4.13.1 Habitat

The biotic community in the Fort McDowell area is of the Lower Sonoran Life Zone. 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).

Through the Fort McDowell breeding area, the regulated Verde River supports cottonwood groves and a vast mesquite bosque; however, many of the cottonwoods are decaying and the mesquite bosques are being cut at a rapid rate for fuel wood. A gravel operation occurs in the river bottom at the upper end

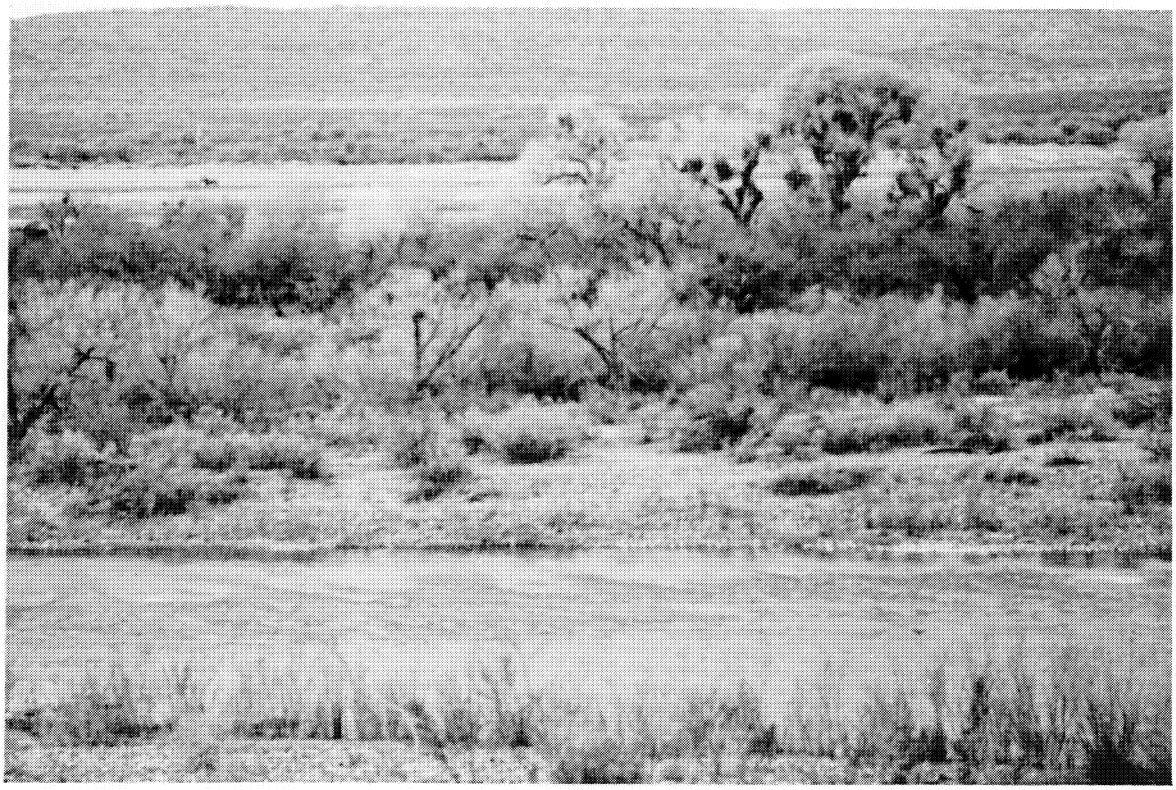

Plate D28. Fort McDowell cottonwood tree nest (11) along the regulated Verde River, March 1987. Note tractor plowing field adjacent to nest tree (photo by D. Driscoll).

of the reservation. A concrete irrigation canal has also been constructed to divert Verde River water for agricultural purposes. In the early 1980s, much of the riparian habitat (including vast mesquite bosques) was bulldozed to clear the land for agricultural crops. Crops grown on the reservation vary from corn and sorghum to cotton. Pesticides and herbicides are sprayed on the cotton fields.

The river is usually shallow, with deep pools scattered along the banks, although flows can change abruptly with releases from Bartlett Dam. Access roads have been worn through the mesquite bosques all along the river. Some four-wheel-drive vehicles ford the river at various points, although most travel is confined to the west bank. An access road also occurs on the east bank, but is located away from the river bottom. The river supports some emergent vegetation along scattered small cutbanks and flat level bottomland.

D4.13.2 Reproductive History

The Fort McDowell breeding area was discovered in 1968 by agency personnel (Rubink and Podborny 1976); however, the territory has been occupied at least since the 1940s (Rubink, pers. comm.), and, according to former Tribal Chief Haiawatha Hood (pers. comm.), bald eagles were breeding in this area prior to the arrival of the white man.

Fort McDowell is the most successful bald eagle nest site in Arizona, having fledged 33 young in 18 of the 21 known years of occupancy, resulting in a mean of 1.6 fledged young per year. The Fort McDowell eagles have laid eggs earlier than any other breeding area in Arizona, from 23 December to 5 February (excluding a second clutch laid on 9 March in 1988). Fort McDowell has hatched eaglets from 26 January to 12 March, and fledged young from 1 May to after 2 June (Table D4.13-1).

There are no cliffs suitable for nesting in the Fort McDowell breeding area, and all the known nests have been built in trees. This is a slight disadvantage, since tree nests blow out and limbs break in storms, whereas cliff nests are more permanent (see Section C2.2). Tree nests also put eagles closer to human disturbances than cliffs; however, tree nests supply more shade (in most cases), reducing heat stress. The Fort McDowell eagles have built 13 known nests, 11 in live cottonwood trees, and two (9, 13) in cottonwood snags.

Nest 1 was built prior to the 1950s, and fell in 1973 (Rubink and Podborny 1976). The eagles rebuilt nest 1 in 1976, but the nest fell again after its use in the 1976 breeding season (Rubink, pers. comm.). Nest 2 was built prior to 1968 and used by the adults in 1968, from 1970–1971, and in 1973 (Rubink and Podborny 1976), but had fallen prior to a search of the area in 1986. The eagles built nest 3 in 1974 and used it from 1974–1975, then the nest fell after the 1975 breeding season (Rubink, pers. comm.). Nest 4 was built and used in 1977 (Hildebrandt 1981, Rubink, pers. comm.), but had fallen prior to a search of the area in 1986. Similarly, nest 5 was built and used by the eagles in 1978 (Hildebrandt 1981), and fell prior to 1986. Nest 6 was built in 1979 (Hildebrandt 1981), the only year of its use. Most of this nest had fallen prior to 1986, although the base of the nest is still present.

The eagles built and used nest 7 in 1980 (Haywood and Ohmart 1980), but the nest fell prior to 1986. Nest 8 was built in 1981 and fell after its use that season (Forbis, pers. comm.). Nest 9 was built in a cottonwood snag in 1982 (Eakle, pers. comm.), the only year of its use, but the nest and supporting branches fell during the winter of 1985. The eagles built and utilized nest 10 in 1983, and it fell after that season (Eakle, pers. comm.). Nest 11 was built and used in 1984 (Eakle, pers. comm.). Nest 11 was also used from 1987–1990 and still exists. The eagles built nest 12 in 1985, used it from

Table D4.13-1. Nesting chronology of the Fort McDowell breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1968	—	—	—
1969	—	—	—
1970	—	—	—
1971	—	—	—
1972	—	—	—
1973	—	—	—
1974	—	—	—
1975	< 16 February	< 24 March	> 2 June
1976	—	—	—
1977	17 January	22 February	9–10 May
1978	5 February	12 March	11, 15 May*
1979	28 January	4 March	12 May
1980	10 January	—	—
1981	—	—	—
1982	—	—	—
1983	18 January	21 February	12 May
1984	18 January	22 February	15 May
1985	4–10 January	8–14 February	3–9 May*
1986	5 January	9, 11 February*	3, 5 May*
1987	23 December	26 January*	1 May*
1988	< 24 January	—	—
	9 March**	—	—
1989	20 January	21–24 February*	20–22 May*
1990	< 13 January	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

** Indicates second clutch laid on known date.

< Indicates "prior to"

> Indicates "later than"

1985–1986, 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 Analysis, Inc., on 9 October 1987. The artificial nest was reinforced with wire mesh at the base and still exists. The eagles built nest 13 in a cottonwood snag in 1988 and used it that year; however, the snag fell between June and December 1989. The only nests still existing at the Fort McDowell breeding area are nests 11 and 12, and the base of nest 6. The mesquite bosque surrounding nest 11 has been bulldozed within 30 m of the nest tree (for agricultural purposes) and is being thinned at a rapid rate by fuel-wood cutting.

The Fort McDowell breeding area was reported to be occupied prior to the arrival of white men (Hood, pers. comm.) and also in the late 1940s (Rubink, pers. comm.). The breeding area was first observed by agency personnel in 1968, when one young fledged. The area was not surveyed in 1969, but fledged three eaglets from 1970–1971 (Rubink and Podborny 1976, Rubink, pers. comm.). The territory was unoccupied at known nest locations in 1972. From 1973–1979 the Fort McDowell adults fledged 11 eaglets (Rubink and Podborny 1976, Hildebrandt 1981, Sell 1982, Ohmart and Sell 1980). The egg(s) failed to hatch in 1980, when flows of 60,000 to 80,000 cfs (Haywood and Ohmart 1983) blew through the area, subsequently washing out bridges in downtown Tempe and the Phoenix area (Salt River Project Archives). The site was successful each year from 1981 to 1987, fledging a total of 16 young (Haywood and Ohmart 1983, Grubb 1986a, and Section C2.5.

Bald eagles have been known to lay a second clutch of eggs following removal or early failure of the first clutch (Stalmaster 1987). Double-clutching has not been previously recorded for bald eagles in Arizona; however, we documented three incidents of second clutches during 1987–1990 (Redmond 1987, Fort McDowell 1988, and Bartlett 1990). 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.

In 1989, a new female, carrying a USFWS band on her left tarsus, entered the Fort McDowell pair. The pair fledged two young, despite heavy wood-cutting in the mesquite bosque below the nest and helicopters spraying pesticides and herbicides on a cotton field within 50 m of the nest.

In 1990, the Fort McDowell egg(s) did not hatch. The egg(s), laid prior to 13 January, 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 an unusually small "runt" egg. The egg was somewhat round, measuring 47.0 mm (length) × 40.0 mm (breadth). The average size for three Arizona bald eagle eggs collected in 1977 was 70.5 mm (length) and 53.9 mm (breadth) (Grubb and Rubink 1978). Minimum size for 263 bald eagle eggs from Florida was 64.4 mm (length) and 48.3 mm (breadth), while the average size was 71.2 mm (length) and 55.3 mm (breadth) (A. Jenkins, George Miksch Sutton Avian Research Center).

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 (*Falco peregrinus*) (Jenkins 1984). Rothstein (1973) states that "runt eggs, variously called dwarf, cock, wind, or witch eggs, are extremely rare." Runt eggs have been recorded occurring in the chicken (*Gallus*) 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 that "... dwarf eggs seem to be caused by temporary disturbances, accidents, or infections in the oviduct and apparently do not have a genetic basis."

D4.13.3 Mortalities

There has only been one documented juvenile bald eagle mortality at the Fort McDowell breeding area. In 1977, two eaglets fledged from the nest. One eaglet was displaced by its sibling at a perch and fell to the river, breaking its left humerus. The broken bone inspired water into the left lung, drowning the eaglet (Hildebrandt 1981).

There have been two documented adult replacements at Fort McDowell. In 1977, the adult male was replaced by a near-adult bald eagle (Hildebrandt 1981), and the female was replaced by a banded female in 1989. In addition, the resident pair apparently killed another adult in an aggressive altercation in 1985 when, on 30 April, Morgan and Sudar (1985) observed the Fort McDowell adults diving together twice upstream of the nest. The carcass of an adult was found in this same area on 3 May, with maggot-infested lacerations on the right side of the head. The autopsy indicated no "foul play," and the wounds (estimated to be 4–5 days old) were thought to be inflicted by the resident adults (Morgan and Sudar 1985).

D4.13.4 Known Foraging Areas and Food Habits.

Most foraging at Fort McDowell has been observed in the river below the nests. Over the years this data has accumulated, and since the eagles have built nests from Km 13–20 on the Verde River, the foraging has been recorded in this area (Hildebrandt and Ohmart 1977, Hildebrandt 1981, Sell 1982, Haywood and Ohmart 1980, Haywood and Ohmart 1981, Haywood and Ohmart 1983, Morgan and Sudar 1985, Grubb 1986a, Collie and Knoll 1986, Collie and Knoll 1987, McLuckie and McCarthey 1989). Although the eagles were observed flying to other areas and returning with prey, foraging was not observed away from the nests (Hildebrandt and Ohmart 1977, Hildebrandt 1981, Morgan and Sudar 1985, Collie and Knoll 1986, Collie and Knoll 1987, McLuckie and McCarthey 1989).

Because these observations were limited to areas observed by ABENWP and other research personnel watching the nest, the data cannot be used to estimate the actual foraging range (Hildebrandt 1981, Sell 1982, Haywood and Ohmart 1980, Haywood and Ohmart 1981, Haywood and Ohmart 1983, Grubb 1986a). Data on the movements of juveniles telemetered as nestlings at Fort McDowell in 1977, 1978, and 1980 showed limited home ranges because the young eagles did not forage for themselves (Hildebrandt 1981, Sell 1982). Hildebrandt and Ohmart (1977) observed eagles of unknown origin foraging up to 11 mi south of the Fort McDowell nest. They suspected these birds were the Fort McDowell pair, although the eagles were more likely the Orme adults (if active at the time), since the area 11 mi south of the 1977 nest (nest 4—also the northern-most nest area) is at the Salt River confluence, where the Orme nests are located.

We observed the adults on several occasions perching in a snag at Km 5, just upstream of the Highway 87 bridge. We also recorded the Orme adults utilizing the Verde River up to Km 4. The farthest successful downstream forage we observed by the Ft. McDowell pair was at Km 12, for an

unknown fish (thought to be a sucker) in 1987. Over our limited period of observations, we found the Fort McDowell eagles using the Verde River from Km 5–22, a total of 17 Km.

We observed numerous suckers spawning in the Verde River from the Fort McDowell breeding area to the confluence of the Salt River. Suckers were also noted spawning by Collie and Knoll (1987) and McLuckie and McCarthey (1989) from Km 16.5–16.7 in March. In addition, we collected body parts and tails of 20 suckers from the nest while banding the eaglets in 1989, and recorded four additional whole suckers in the nest. See Section E2 for details on fish communities in the Fort McDowell area.

Prey items observed taken by eagles and collected from the nests (Rubink and Podborny 1976, Hildebrandt 1981, Haywood and Ohmart 1981, Haywood and Ohmart 1983, Grubb 1984, Morgan and Sudar 1985, Grubb 1986a, Collie and Knoll 1986, Collie and Knoll 1987, McLuckie and McCarthey 1989) are presented in Table D4.13-2, along with prey items observed taken by eagles and prey remains collected from the nest from 1986-1989. See Section B5.1.4 for a detailed analysis of prey species utilized by the Fort McDowell eagles. Collie and Knoll (1986) observed the adults feeding on trout after an AGF stocking operation in 1986.

Table D4.13-2. Prey species observed taken by bald eagles or collected from the nest at the Fort McDowell breeding area.

Fish		**Mammals**
Carp	Wading Birds	Cottontail rabbit
Channel catfish	American coot	Blacktail jackrabbit
Bullhead (catfish)	Great blue heron	Neotoma
Largemouth bass	Raptors	Ground squirrel
Black bass	Sharp-shinned hawk	Rock squirrel
Sonora sucker	Passerines	Mouse sp.
Desert sucker	Northern oriole	
Trout	European starling	**Herptiles**
	Violet-green swallow	None found
Birds	Other Birds	
Waterfowl	Gambel's quail	
Common merganser	Mourning dove	
Green-winged teal	Dove sp.	
Unidentified waterfowl		

The Fort McDowell adults were observed stealing prey from great blue herons and ospreys (Morgan and Sudar 1985, Collie and Knoll 1986). In addition, McLuckie and McCarthey (pers. comm.) witnessed a coyote steal a fish from an adult bald eagle that was feeding on the shore.

In some interesting observations, both the 1986 fledglings and the one 1987 juvenile were observed foraging for themselves. On 7 May 1986 one eaglet caught a mouse which had been dug up by a coyote, while its sibling captured a starling which perched on the limb next to the eagle on 11 May (Collie and Knoll 1986). In 1987, the eaglet pirated a carrion fish from a turkey vulture (Collie and Knoll 1987).

D4.13.5 Human Impacts

Human disturbance is a problem of concern at the Fort McDowell breeding area due to the many types of activity near the tree nests. Agricultural operations, gravel operations, irrigation canal work, wood cutting, fishermen, shooters, hikers, partiers, river craft, swimmers, off-road vehicles, ATCs, trail bikes, light planes, and private and military helicopters create numerous disturbances. Since the Fort McDowell eagles nest in trees, they are closer to the disturbances and are often flushed from the nest and perches (Morgan and Sudar 1985, Collie and Knoll 1986, Collie and Knoll 1987, Farrara *et al.* 1988, McLuckie and McCarthey 1989, Fenske and Flesch 1990).

The Mesa office of McDonnell Douglas, Inc., 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 (Collie and Knoll 1986, Collie and Knoll 1987, Fenske and Flesch 1990). In addition, Fenske and Flesch (1990) observed an ultralight aircraft fly up the river at tree level, flushing the adults.

During 1986–1990, we have observed the mesquite bosques in the Fort McDowell area gradually disappear. Each year more of the bosque below nest 11 is cut for fuel-wood. We have 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 nest 11 was heavily thinned by wood cutting in 1989.

In 1984, the mesquite bosque surrounding nest 11 was bulldozed to within 50 m of the nest tree, for agricultural purposes (Grubb 1984), and subsequent land clearing has approached to within 30 meters. 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 was lined with sorghum stalks, heads, and leaves, and the nest also contained corn cobs and kernels. In 1989, cotton was planted in the fields adjacent to nest 11. Helicopters sprayed pesticides and herbicides on the fields while young were in the nest. There is serious concern for contamination of the eggs, young, and adults from herbicides and pesticides. The crop material is brought to the nest, coming in direct contact with the eggs, young, and adults. Also drifting mist from spraying likely spreads to the nest and river, possibly directly reaching the young, adults, and prey populations. See Section C4.3 for further details on the impacts of agriculture at Fort McDowell.

There are numerous access roads along the river, and others have been worn through the mesquite bosques. These roads carry recreationists below or very near nest trees, causing adults to flush from the nest and perches (Morgan and Sudar 1985, Collie and Knoll 1986, Collie and Knoll 1987, Farrara *et al.* 1988, McLuckie and McCarthey 1989, Fenske and Flesch 1990). It is possible that too much disturbance in January and February contributed to the nesting failure in 1988. See U.S. Fish and Wildlife Service (1989) and (1990) for detailed accounts of disturbance at the Fort McDowell breeding area in 1988 and 1989.

Fishermen also threaten the success of this breeding area, through the irresponsible disposal of waste monofilament line. We collected monofilament fishing line from the nest in 1986, 1987, and 1989. Monofilament not only kills bald eagles, but many other wildlife species as well (see Section C3.3); Arizona eaglets have died from becoming entangled in monofilament at the nest (Section D4.22.3).

D4.13.6 Wildlife Interactions

At the Fort McDowell nest site, interspecific interactions with Harris' hawks, nesting near the eagles, have been the most numerous. Other species interacting with the eagles include red-tailed hawks, osprey, golden eagles, turkey vultures, great blue herons, and ravens (Morgan and Sudar 1985, Collie and Knoll 1986, Collie and Knoll 1987, Farrara *et al.* 1988, McLuckie and McCarthey 1989, Fenske and Flesch 1990). In addition, starlings and phainopeplas harassed the eagles at the nest (Collie and Knoll 1986). Prey was stolen from great blue herons and osprey (Morgan and Sudar 1985, Collie and Knoll 1986). Also, osprey and golden eagles were aggressively chased (Collie and Knoll 1986). In another case, a coyote stole a fish from the eagles (McLuckie and McCarthey, pers. comm.). McLuckie and McCarthey (1989) also observed interactions with cows, horses, and crows.

On 30 April 1985, the Fort McDowell eagles apparently killed another adult bald eagle (Morgan and Sudar 1985)(see above). On 4 February 1986, a subadult landed in the nest tree (below the nest) while the adult female was incubating. The eagle remained in the tree for 20 minutes, although the female vocalized at it (Collie and Knoll 1986). In 1987, a subadult attempted to enter the nest on 19 February, but was chased off. A near-adult, carrying a USFWS band on its right leg, was aggressively attacked by both adults on 6 April 1987. Also in 1987, one of the adults locked talons with a subadult on 2 May (Collie and Knoll 1987).

D4.13.7 Wildlife Sightings

Herptiles sighted in the area include western diamondback rattlesnakes, black-tailed rattlesnakes, checkered garter snakes, common kingsnakes, glossy snake (being eaten by a kingsnake), coachwhip, and gopher snakes. Beaver occur in both the lower Salt and Verde rivers, and a black (cinnamon) bear was sighted in 1989; black bears have occasioned the lower Salt and Verde rivers in the past (R. Glinski, pers. comm.). Snowy egrets, great egrets, black-crowned night herons, green-backed herons, double-crested cormorants, Canada geese, greater and lesser yellowlegs, water pipits, least and spotted sandpipers, canvasbacks, gadwalls, American wigeon, and green-winged teal have been sighted along the river.

In addition to the usual desert raptors, golden eagles, northern harriers, osprey, Cooper's hawks, sharp-shinned hawks, American kestrels, merlins, prairie falcons, zone-tailed hawks, ferruginous hawks, barn owls, and screech owls have been sighted. Other birds observed in the area include red-naped sapsuckers, vermillion flycatchers, Crissal thrashers, hooded orioles, American robins, loggerhead shrikes, mountain bluebirds, lark buntings, grey vireos, yellow-breasted chats, and green-tailed, rufous-sided, brown, and Abert's towhees (McLuckie and McCarthey 1989, Fenske and Flesch 1990, and BioSystems personnel 1986-1990).

We have sighted osprey year round in the Fort McDowell breeding area, and although no known nests occur on the lower Salt and Verde rivers, it may be possible that these birds are expanding their range. Great blue heron rookeries occur upstream and downstream of eagle nest 11. Harris' hawks nest upstream of eagle nest 11, and on 11 March 1987 we sighted a Harris' hawk with a USFWS band on its

left tarsus. We could not read the whole band, but through a spotting scope we read the last three numbers (224).

D4.13.8 Management Recommendations

1. A closure should be created at the Fort McDowell breeding area. Since all the nests are in trees, the eagles are easily disturbed by human activity along the river (Morgan and Sudar 1985, Collie and Knoll 1986, Collie and Knoll 1987, Farrara *et al.* 1988, McLuckie and McCarthey 1989, Fenske and Flesch 1990). It is possible that too much disturbance near and below the nest contributed to the failure of the 1988 nesting attempt.

2. A strong gate should be placed (and locked) at the access road leaving the farm fields behind nest 11, preventing recreationists and wood cutters from entering the river bottom below the nest tree.

3. We recommend the continuance of a full-time ranger and regular patrols of the river. Collie and Knoll (1987) stated "The presence of a full-time ranger and regular patrols on week-ends has helped considerably to cut down recreational-type disturbances to the eagles in comparison to 1986."

4. Measures need to be taken to prohibit or restrict wood cutting near and below the bald eagle nest trees. The mesquite bosques which act as a buffer-zone between human activity and the nest trees are disappearing at a rapid rate. In 1989, the mesquite bosque below nest 11 was heavily thinned by wood cutting.

5. Agricultural activity near nest 11 should be monitored, and if possible, delayed until after the eaglets hatch. The Verde River and fish populations within the river, should be periodically sampled for pesticide and herbicide contamination. Crops should not be sprayed from airplanes or helicopters, as this method of application leads to chemicals blowing onto the nest, and its occupants, and likely contaminates the river.

6. The low level testing of Apache™ helicopters should be moved away from the river in the nest vicinity. McDonnell Douglas is provided with bald eagle nesting location maps annually, although adults continue to be flushed off the nests from low level helicopters. It should be recommended to McDonnell Douglas and the FAA that low level air traffic be restricted from an area of 1000 m on either side of the river.

7. As discussed previously, shooting is a problem at the Fort McDowell breeding area. Morgan and Sudar (1985), Collie and Knoll (1986), and Collie and Knoll (1987), stated that shooting should be prohibited in the nest area, and the tribal laws of "No Shooting" and "No ATC / Dirt Bike" riding along the river should be enforced.

8. The cottonwood pole planting project along the river should be continued; however, cattle and beaver will need to be fenced out of the planting area. The exclosure method which may facilitate cottonwood and willow poles could be a barbed wire fence, with chicken wire at the base.

9. Due to the high level of recreational pressure at the Fort McDowell breeding area, and the early egg laying dates recorded for this site, ABENWP personnel should begin coverage in January, instead of the normal February start date. This would provide protection prior to (or just after) egg laying, and during early incubation, when the nest is most susceptible to failure.

10. A flow regime should be established for the Verde River below Bartlett Dam to maintain the integrity of the bald eagle breeding area year round, and to ensure the existence of sucker spawning habitat on the lower Verde River.

FORT McDOWELL BREEDING AREA

Date Discovered: 1968. First Reports 1940. (Prior to 1900s).
Drainage: Verde River (Regulated)
Elevation (MSL): 1430 - 1480 ft
County: Maricopa
Latitude-Longitude Ten Minute Block: 334-1114
Land Management: U.S. Bureau of Indian Affairs
Fort McDowell Indian Community
Distance From Phoenix: Air - 45.0 km Northeast
Distance To Nearest Breeding Area Upstream: Bartlett - 14.2 Km
Air - 11.3 km
Distance To Nearest Breeding Area Downstream: Orme - 12.3 Km
Air - 12.0 km
Distance From Salt River Confluence: 13.3 Km
Home Range: Unknown. Known to utilize Verde River from Km 22.0 to Km 5.0. (Total = 17.0 Km).
Quadrangles: Granite Reef Dam 7.5 Minute
Fort McDowell 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Live	< 1950s	Nest built prior to 1950s. Nest fell 1973.
			1976	Nest rebuilt 1976. Nest fell after 1976 season. Rubink No. 17.
2	Cottonwood	Live	1968	Nest built prior to 1968.
			1970-1971	Nest fell prior to 1986.
			1973	Rubink No. 16.
3	Cottonwood	Live	1974-1975	Nest built 1974 - Rubink No. 15. Nest fell after 1975 season.
4	Cottonwood	Live	1977	Nest built 1977. Nest fell prior to 1986.
5	Cottonwood	Live	1978	Nest built 1978. Nest fell prior to 1986.
6	Cottonwood	Live	1979	Existing - Nest built 1979. Portion of nest fell prior to 1986.
7	Cottonwood	Live	1980	Nest built 1980. Nest fell prior to 1986.
8	Cottonwood	Live	1981	Nest built 1981. Nest fell after 1981 season.
9	Cottonwood	Snag	1982	Nest built 1982. Nest fell winter 1985.
10	Cottonwood	Live	1983	Nest built 1983. Tree fell after 1983 season.
11	Cottonwood	Live	1984	Existing - Built 1984.
			1987-1990	Adults moved here from nest 13 and laid a second clutch of eggs 9 March 1988.*
12	Cottonwood	Live	1985-1986	Existing - Built 1985. Nest fell July 1986. Artificial nest constructed in same location of same tree with original nest sticks by Robert Mesta, U.S. Fish and Wildlife Service, and Daniel Driscoll, BioSystems Analysis, Inc., 9 October 1987.

FORT McDOWELL BREEDING AREA (continued)

Nest Sites

No.	Species	Type	Utilized	Status
13	Cottonwood	Snag	1988	Nest built November 1987. Adults incubating prior to 24 January 1988, but failed 11 February and moved to nest 11. Snag fell June - December 1989.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
< 1900s		?	?	?	Bald eagles reported nesting prior to arrival of white man.
1940s	Occupied	?	?	?	Nest 1 built prior to 1950s.
1968	Successful	1+	1	1	
1969	Unknown				
1970	Successful	2+	2	2	
1971	Successful	1+	1	1	
1972	Unoccupied				
1973	Successful	1+	1	1	
1974	Successful	1+	1	1	
1975	Successful	2+	2	2	
1976	Successful	2+	1	1	
1977	Successful	2+	2	2	New male, near-adult (ca. 4 yr old). One young drowned post-fledging. Displaced at perch by sibling and fell to river breaking left humerus, which inspired water into left lung.
1978	Successful	2+	2	2	
1979	Successful	2+	2	2	
1980	Failed	1+	0	0	High river flow.
1981	Successful	2+	2	2	
1982	Successful	2+	2	2	
1983	Successful	3	3	3	
1984	Successful	3	3	3	Mesquite bosque bulldozed within 30 m of nest tree.
1985	Successful	3	3	3	Resident pair killed an intruding adult.
1986	Successful	2+	2	2	
1987	Successful	1+	1	1	

FORT McDOWELL BREEDING AREA (continued)

Productivity (cont'd.)

Year	Status	Eggs	Young	Fledged	Comments
1988	Failed	2+	0	0	Adults incubating in nest 13 on 24 Jan. 1988. Much disturbance from farming, wood-cutting, and vehicles. Adults laid 1+ eggs in nest 13 but failed 11 Feb. On 9 March 1988, the adults laid a second clutch of eggs in nest 11 and incubated until 9 May, 26 days past the normal incubation period of 35 days.* One egg collected.
1989	Successful	2+	2	2	New female—banded on left tarsus. Heavy cutting in mesquite bosque below nest. Helicopters spraying cotton within 50 m of nest.
1990	Failed	1+	0	0	One very small "runt" egg (47.0 × 40.0 mm) collected. Adults incubated until 7 April.
Total		38+	33	33	
Years		21	21	21	
Mean		1.8	1.6	1.6	

< = Prior to

* Second documented incidence of double-clutching in Arizona bald eagles.

D4.14 HORSE MESA BREEDING AREA

The Horse Mesa breeding area is located 69 km east of Phoenix, along the regulated Salt River between Apache and Canyon reservoirs. The nest area is a deep narrow canyon, opening up on the main body of the two reservoirs. High above the river and reservoirs, the surrounding mesa areas are fairly open desert. The river flowing into Apache Reservoir is regulated by Theodore Roosevelt Dam, while Horse Mesa Dam controls flow into Canyon Reservoir, which is backed up by Mormon Flat Dam.

D4.14.1 Habitat

The biotic community in the Horse Mesa area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Paloverde-Cacti-Mixed Scrub Series and the Jojoba-Mixed Scrub Series. The riparian habitat, confined to the river-like sections below the dams and the streams entering the reservoirs, is of the Sonoran Riparian Deciduous Forest and Woodlands Biome (see Section D2).

From Theodore Roosevelt Dam, the regulated Salt River flows through a deep narrow canyon and quickly enters Apache Reservoir. The upper portion of the reservoir is contained in the deep canyon, but the area opens up at the main body of the reservoir. The reservoir is bounded by large promontory cliffs and

Plate D29. Horse Mesa pinnacle nest (2) containing two 11-week-old eaglets, April 1986 (photo by D. Driscoll).

steep slopes, with limited access from the Apache Trail on the south side. Similarly, Canyon Reservoir flows through a deep canyon to the main body of the reservoir. To the north and west, Canyon Reservoir is bounded by large promontory cliffs, with access limited to the south shore along the Apache Trail. Many small mountain springs are created following heavy rains, with run-off falling from the high cliffs and concentrating in narrow springs as it enters the reservoirs. Vegetation abounds in these side canyons, which also serve as travel corridors for wildlife moving between the reservoirs and the high mesas.

Horse Mesa Dam and Mormon Flat Dam both have pump-back capabilities, and this feature will also be included in the Theodore Roosevelt Dam renovations. Pump-back capabilities allow water to be pumped from the lower reservoir, back into the upper reservoir, by reversing the turbines during periods of low power demand. This capability creates large fluctuations in water levels, especially in the narrow canyons. Reservoir levels can fluctuate 5 or 6 ft within one or two hours.

Fish Creek enters Canyon Reservoir 2.7 km below Horse Mesa Dam. The intermittent stream flows through a deep narrow canyon, although large sycamores and cottonwoods grow in the more open areas. The reservoir backs up into the creek at high water levels and allows fish to pass into upper pools.

D4.14.2 Reproductive History

The Horse Mesa breeding area was discovered in December 1982 by agency personnel (Forbis, pers. comm.); however, the territory has been occupied at least since the 1950s (Gibbons, pers. comm.). The Horse Mesa eagles have laid eggs during 3–6 January to a period from 13 January to before 3 February, with eaglets hatching during 7–10 February to 18 February, and young fledging from before 29 April to 12 May (Table D4.14-1).

Table D4.14-1. Nesting chronology of the Horse Mesa breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1983	< 24 January	—	—
1984	< 3 February	—	—
1985	< 24 January	—	—
1986	6 January	10 February*	8 May*
1987	13 January	18 February	9, 12 May*
1988	—	< 16 March	< 29 April
1989	< 6 February	—	—
1990	3–6 January	7–10 February	< 11 May

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

< Indicates "prior to"

> Indicates "later than"

The Horse Mesa eagles have built two known nests, one on a cliff (1), and one on a pinnacle (2). In addition, a possible historical nest (H) may have been built on a cliff below Horse Mesa Dam prior to the 1980s. This nest was used by golden eagles in the early 1980s (Horse Mesa Dam personnel, pers. comm.) and had fallen prior to 1986. Nest 1 was built on the cliffs northeast of Horse Mesa Dam prior to the 1950s, and used by the eagles from the 1950s-1970s and again in 1977 (Gibbons, pers. comm.). Nest 1 had fallen prior to 1986. Nest 2 was built on a pinnacle above Horse Mesa Dam prior to the 1960s, and used by the eagles from the 1960s-1980s (Gibbons, pers. comm.). Nest 2 was also used from 1983-1990 and is still in existence.

Nest 1 fledged young in the 1950s, although it is unknown if nest 2 was used during this period. In the 1960s, nests 1 and 2 fledged young, and golden eagles also nested in the area. The adults and juveniles would feed on carp placed on the boat dock above the dam by Horse Mesa Dam personnel. The eagles were not seen during a 6-7 year period in the late 1960s and early 1970s, when the breeding area was apparently unoccupied at known nest locations. Nests 1 and 2 fledged young again from the 1970s-1980s, and golden eagles were still nesting in the area. During this period, Horse Mesa Dam personnel again placed carp on the boat dock above the dam for the adults and eaglets (Gibbons, pers. comm.). The nesting eagles (in nest 1) were reported to agency personnel in 1977 by Phil Clemens of Salt River Project (Stumph and Creighton 1977). The eagles were reported again in December 1982 (at nest 2) by Horse Mesa Dam personnel.

During 1983-1985, the Horse Mesa pair laid at least four eggs; however, the eggs did not hatch (Grubb 1986a). One whole egg was collected in 1983, which contained 4.4 ppm DDE, 1.6 ppm PCB's, and 0.17 ppm mercury (Grubb *et al.* 1983). These levels are high for Arizona eggs, exceeded only by the 1977 Ladders and Horseshoe eggs, the latter of which contained 27-day-old embryos (see Section C2.3).

A near-adult female, with a brown stripe from her crown to her nape (Driscoll and Buckley 1986) replaced the old female in 1986. The Horse Mesa adults fledged five young from 1986-1988. We also collected one whole egg (which did not hatch) in 1986, containing a 26-day-old embryo. The egg(s) did not hatch in 1989, and one whole (but crushed) egg was collected from the nest. In 1990, two young fledged from the site.

D4.14.3 Mortalities

No juvenile bald eagle mortalities have been recorded at the Horse Mesa breeding area; however, there have been two documented adult mortalities. In 1986, the adult female was replaced by a near-adult bald eagle with a brown stripe from her crown to her nape (Driscoll and Buckley 1986). In 1987, the adult male at Horse Mesa died the night of 11 April. 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 occurred, except for scrapes on top of the eagle's feet. It is possible that the eagle was being pursued by a peregrine falcon and inadvertently struck the cliff or a powerline. Peregrine falcons were observed chasing and stooping on the adult eagles in 1986, occasionally striking the eagles and knocking them off perches (Driscoll and Buckley 1986). Peregrine falcons were sighted regularly in the Horse Mesa breeding area in 1986, and a falcon eyrie exists nearby (R. Glinski, pers. comm.). The Horse Mesa female raised the eaglets alone for the remaining four weeks, and both young fledged successfully. The male had been replaced by a new male prior to the 1988 breeding season.

Miller and Smillie (1987) reported the adult male to be very lethargic, not assisting much with nest attendance or prey deliveries; but Driscoll and Buckley (1986) reported the male delivered 68.6 percent of the prey items, while the female delivered 29.3 percent (gender was unknown in 2.1% of the deliveries). This comparison raises questions concerning the health of the adult male prior to his death in April 1987.

D4.14.4 Known Foraging Areas and Food Habits

Most known foraging at Horse Mesa has been documented in the reservoirs below the nest cliff (Shepherd and Chadbourne 1983, Ruesch and Browne 1984, Sudar and Morgan 1985, Grubb 1986a, Driscoll and Buckley 1986, Miller and Smillie 1987, Smillie 1987). Since the nest occurs above Horse Mesa Dam, the eagles can easily forage in the calm water above the dam or in the tailrace below the dam. Although the eagles were observed flying to other areas and returning with prey, foraging was not observed away from the nest area (Shepherd and Chadbourne 1983, Ruesch and Browne 1984, Sudar and Morgan 1985, Grubb 1986a, Driscoll and Buckley 1986, Miller and Smillie 1987, Smillie 1987).

It is important to note that visual foraging information was limited to areas observed by ABENWP and other research personnel watching the nest, resulting in a bias toward the river section below the nest. This bias was noted by Driscoll and Buckley (1986), who commented that, "Most foraging attempts observed occurred in the immediate vicinity of the dam, although the winding canyon precludes distant observations of the eagles flying at low levels, and the cliff walls prevent access to many observation points along the lakes."

Driscoll and Buckley (1986) observed the eagles coming out of Fish Creek canyon and flying to the nest on several occasions. They also observed both adults perched 700–800 m up Fish Creek on 7 April 1986. Fish Creek varies from 1 to 2 ft in depth, with many large pools ranging from 4 to 6 ft deep. The only fish observed in the upper portions of the creek were minnows; however, the reservoir backs up into the creek near the confluence and allows carp, rainbow trout, and sunfish to enter the stream.

Ruesch and Browne (1984) reported an adult foraging at Pine Cove on Apache Reservoir in February 1984, which they suspected was a Horse Mesa eagle. This cove is located 16.4 Km upstream of the nest, and although it would not be unreasonable for the pair to travel this far to forage, the adult could have easily been a wintering bird or part of a yet undiscovered breeding area. Adults have been sighted from Theodore Roosevelt Dam downstream to Pine Cove in all seasons of the year, and it seems likely that an undiscovered nest site exists in this area. Similarly, Miller and Smillie (1987) observed adults near the Marina on Canyon Reservoir.

Driscoll (unpublished field notes) observed large schools of shad "running" the reservoir perimeters both above and below the dam in April 1986. When this shad-run occurred, rainbow trout congregated in the tailrace below the dam, and became available as eagle prey. Trout were not observed taken as prey in other parts of the nesting season. On 27 April 1986, Driscoll and Buckley (1986) reported the adult female made 13 forage attempts between 1807 and 1900 hours. She perched on boulders and made low flights over the river below the dam, and on several occasions two capture attempts were made on one flight. These attempts were thought to be unsuccessful, since prey was not visible or delivered to the nest, although it is possible the female was catching shad and eating them on the wing.

Driscoll (unpublished field notes) also observed large numbers of carp, as many as 98 in one school, swimming in a linear fashion along the shore below the dam. These fish were very visible from the top

of the dam, and so they must have been equally visible to the eagles on the nest. Although the adults did take carp during the season, they did not attempt to capture these carp, though they appeared readily available.

Prey items observed taken by eagles and collected from the nest (Shepherd and Chadbourne 1983, Ruesch and Browne 1984, Sudar and Morgan 1985, Grubb 1986a, Driscoll and Buckley 1986, Miller and Smillie 1987, Smillie 1987) are presented in Table D4.14-2, along with prey remains collected in the nest from 1986–1989. See Section B5.1.3 for a detailed analysis of prey species utilized by the Horse Mesa eagles. In addition, Shepherd and Chadbourne (1983) observed an adult attempting to capture a Canada goose.

Table D4.14-2. Prey species observed taken by bald eagles or collected from the nest at the Horse Mesa breeding area.

Fish	**Birds**	**Mammals**
Carp	Waterfowl	Lagomorph sp.
Channel catfish	None found	Rock squirrel
Flathead catfish	Grebes	Cliff chipmunk
Bullhead (catfish)	Pied-billed grebe	Unidentified Sciuridae
Yellow bass	Grebe sp.	
Black bass	Wading Birds	**Herptiles**
Bass sp.	American coot	Chuckwalla
Unidentified Centrarchidae	Passerines	Unidentified snake
Sonora sucker	Cactus wren	
Rainbow trout	Northern cardinal	**Other**
Walleye pike	Western meadowlark	Flies
Black crappie	Unidentified passerine	
Crappie sp.	Other Birds	
	Greater roadrunner	

Although the Horse Mesa adults were not observed stealing prey from other species, a common raven unsuccessfully attempted to pirate a 6–12 in. carp from the adult male (Driscoll and Buckley 1986).

In some interesting observations, both adults began capturing flies as prey items accumulated in the nest after hatching. This behavior was observed daily as the adults brooded the young, and was also performed by the eaglets as they grew. The adults and eaglets succeeded in capturing flies in many instances, and swallowed them following several movements of the beak (Driscoll and Buckley 1986). In a possibly related observation, on 11 occasions the 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 (Driscoll and Buckley 1986).

D4.14.5 Human Impacts

Human disturbance is not a problem at the Horse Mesa breeding area. The area is closed to all non-Salt River Project personnel at all times, due to dam operations. Locked gates at Km 50.0 block the road which leads to the dam from Fish Creek. In addition, boat barricades exist at Km 50.5 on Canyon Reservoir and at Km 52.5 on Apache Reservoir, preventing access to the area by water. The nest is located 200 m above Canyon Reservoir and 75 m west of the dam, which isolates the eagles from most of the dam activity. The eagles seem to be acclimated to normal dam operations and may watch the trucks below, but are not disturbed by them. Boaters and skiers have flushed the eagles from perches on Apache Reservoir, though this does not appear to be a common or serious disturbance (Shepherd and Chadbourne 1983, Ruesch and Browne 1984, Sudar and Morgan 1985, Driscoll and Buckley 1986, Miller and Smillie 1987, Smillie 1987).

However, low-level aircraft, especially helicopters, are a problem. All available sources reported low flying light planes, military jets, and helicopters as disturbances, sometimes passing within 50 m of the nest (Shepherd and Chadbourne 1983, Ruesch and Browne 1984, Sudar and Morgan 1985, Driscoll and Buckley 1986, Miller and Smillie 1987, Smillie 1987). Of low level aircraft, helicopters elicited the most agitated response from the eagles. Two incidents involved Channel 12 and Channel 10 TV-news helicopters hovering near the nest. One of these was serious enough to deserve special attention.

The most traumatic disturbance noted during the 1986 breeding season occurred on 14 February when a Channel 12 News helicopter violated the nest area. The helicopter entered the area from the west at 1243 hours and flew passed the nest at a distance of 70m to the north and 20-25m above the nest. The aircraft continued east, over the dam and around the bend in Apache Reservoir at Km 53. At 1244 hours, the helicopter returned over Apache Reservoir and flew over the cliffs east of the nest, approaching the nest from the south. The helicopter hovered approximately 16–17 m over the nest for about 30 seconds, then flew east around the bend in Apache Reservoir at Km 53. The female covered the eaglets in a very low posture as the aircraft hovered over the nest. Observations through the spotting scope showed the feathers on her head and back were roused by the wind from the helicopter's blades.

At 1251 hours the helicopter returned again over Apache Reservoir. At this time, the male had returned to the area and soared along the cliffs east of the nest. The helicopter turned in the cove at Km 52.7 and followed the male around the bend at Km 53 on Apache Reservoir. At 1253 hours, the helicopter returned over Apache Reservoir, flying 7–10 m behind and above the male eagle. The helicopter pursued the male into the cove at Km 52.7, turned around, and followed the eagle over the cliffs east of the nest. The helicopter could still be heard in the area until 1256 hours, totaling 13 minutes of disturbance to the eagles (Driscoll and Buckley 1986). It was assumed the occupants of the Channel 12 news helicopter were filming the eagles during the incident.

Fishermen also threaten the success of this breeding area through the irresponsible disposal of waste monofilament line. In addition, fish may break the line then later die, and are brought to the nest as prey, with fish hooks in their stomachs. The first incident known to us involving monofilament and fish hooks in Arizona bald eagles or nests occurred at the Horse Mesa breeding area in 1986. The adult female returned to the nest with a fish hook lodged in her tongue and monofilament hanging from her beak; the hook was out 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). We also collected monofilament line and fishing hooks from the nest in 1987 (see Section C3.3 and Section D4.22.3).

D4.14.6 Wildlife Interactions

At the Horse Mesa nest site, interspecific interactions have been recorded with red-tailed hawks, golden eagles, ravens, peregrine falcons, and Cooper's hawks (Shepherd and Chadbourne 1983, Ruesch and Browne 1984, Sudar and Morgan 1985, Driscoll and Buckley 1986). In addition, hummingbirds and flycatchers buzzed around the nest, occasionally causing the female eagle to vocalize (Driscoll and Buckley 1986).

Common ravens and peregrine falcons initiated many interactions by stooping on the adult eagles. In one instance, an adult peregrine falcon stooped on the female eagle, knocking her off the pinnacle above the nest and dislodging feathers from her back. The subsequent tail-chase, in which the peregrine teasingly remained just out of reach of the eagle, lasted seven minutes (Driscoll and Buckley 1986).

Subadult bald eagles were usually chased out of the area, although two interactions in 1986 involved stooping and physical contact. On 16 April 1986, a subadult eagle stooped on the adult female at the nest, knocking her off the nest and dislodging feathers from her back. On 20 April 1986, a subadult (thought to be the same bird) was forced to the ground by both adults. The adults perched above the subadult eagle as it walked off to the west (Driscoll and Buckley 1986).

D4.14.7 Wildlife Sightings

ABENWP personnel were plagued with keeping the scorpions, tarantulas, raccoons, ringtails, and mice out of their tent in 1986. Other mammals sighted in the area included a bobcat, mule deer, javelina, and desert bighorn sheep. The latter, some of which carried radio-collars around their necks, were observed fairly often feeding on the slope above the north side of the dam. On one occasion, the sheep were observed walking across the top of the dam (Driscoll, unpublished field notes).

Great blue herons were seen daily walking along the boat barricade, feeding on the fish attracted to the structure. In an unusual sighting, a pair of white-throated swifts engaged in mid-air copulation fell through the sky and landed in the reservoir above the dam. One was rescued with a net; however, the other bird swam under the ridge of the dam and drowned (Driscoll, unpublished field notes).

Birds of interest observed in the area included pied-billed, horned, and eared grebes, herring and ring-billed gulls, a female hooded merganser (for about three weeks) amongst the many common mergansers, blue-winged and green-winged teal, a dipper, and bronzed and brown-headed cowbirds. In addition to the usual desert raptors, golden eagles, osprey, Cooper's hawks, sharp-shinned hawks, American kestrels, merlins, peregrine falcons (all season), prairie falcons, common black hawks, and zone-tailed hawks have been sighted. Other birds observed in the area include American crows, poor-wills, western meadowlarks, vermillion flycatchers, hooded orioles, verdins, common bushtits, loggerhead shrikes, black-tailed and blue-grey gnatcatchers, ruby-crowned kinglets, canyon, rock, and cactus wrens, rufous-crowned, black-throated, and white-crowned sparrows, and yellow warblers (Shepherd and Chadbourne 1983, Driscoll and Buckley 1986, and BioSystems personnel 1986–1990).

Peregrine falcons were sighted on many occasions near Horse Mesa Dam. The falcons were observed foraging on swallows nesting along the dam structure. Falcons were also heard calling from an amphitheater of cliffs on the north side of Canyon Reservoir, just below the dam. On several occasions peregrines were observed flitting in and out of crevices across from Fish Creek. A pair of peregrines flew over the dam on one occasion, and continued to Painted Cliffs. Another pair was spotted on Canyon Reservoir, where the reservoir enters the narrows heading to Horse Mesa Dam just around the corner

from Mormon Flat Dam. The female was examining the cliff, while the tiercel chased a group of pintails. It is likely that three peregrine eyries occur in the Horse Mesa area, one at the narrows off Canyon Reservoir, one in the amphitheater below Horse Mesa Dam, and one on Painted Cliffs. The amphitheater pair often chased the eagles back toward the dam when the adults flew downstream (Driscoll and Buckley 1986, Driscoll, unpublished field notes, and BioSystems personnel 1986–1990).

D4.14.8 Management Recommendations

The Horse Mesa breeding area is protected due to the closure already existing for dam operations. Low level aircraft, especially helicopters should be encouraged to avoid the dam area, except when necessary for dam operations.

HORSE MESA BREEDING AREA

Date Discovered: December 1982. First Reports 1977. (1950s).
Drainage: Salt River / Apache Reservoir / Canyon Reservoir
Elevation (MSL): 1660 - 2600 ft
County: Maricopa
Latitude-Longitude Ten Minute Block: 333-1112
Land Management: Salt River Project (Horse Mesa Dam area)
U.S. Forest Service, Tonto National Forest,
Tonto Basin Ranger District (East of dam)
Mesa Ranger District (West of dam)
Closure: Closed to all non-Salt River Project personnel at all times from Km 50.5 on Canyon Reservoir to Km 52.5 on Apache Reservoir. Road closed at Km 50.0.
Distance From Phoenix: Air - 69.5 km East
Distance To Nearest Breeding Area Upstream: Pinto - 49.1 Km
Air - 33.5 km
Distance To Nearest Breeding Area Downstream: Blue Point -26.9 Km
Air - 18.0 km
Distance From Granite Reef Dam: 52.4 Km
Home Range: Unknown. Known to utilize Apache Reservoir, Canyon Reservoir, and Km 0.0 - 2.0 of Fish Creek.
Quadrangles: Mormon Flat Dam 7.5 Minute
Horse Mesa Dam 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
H		Cliff	Unknown	Possible historical nest. Nest built prior to 1980s. Used by golden eagles in 1980s. Nest fell prior to 1986.
1		Cliff	1950s-1970s 1977	Nest built prior to 1950s. Nest fell prior to 1986.
2		Pinnacle	1960s-1980s 1983-1990	Existing - Built prior to 1960s.

HORSE MESA BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1950s	Successful			Yes	Young fledged from nest 1. Unknown if nest 2 was used.
1960s	Successful			Yes	Young fledged from nest 1 and nest 2. Adults and young fed on carp placed on boat dock by Horse Mesa Dam personnel. Golden eagles also nesting in area.
>1965-<1975	Unoccupied				Period of 6-7 years when no bald eagles were sighted at the two known nest sites.
1970s-1980s	Successful			Yes	Young fledged from nest 1 and nest 2. Adults and young fed on carp placed on boat dock by Horse Mesa Dam personnel. Golden eagles also nesting in area.
1977	Occupied	?	?	?	Nest 1 reported.
1982	Occupied	?	?	?	Nest 2 reported December 1982.
1983	Failed	1+	0	0	One egg collected.
1984	Failed	2+	0	0	
1985	Failed	1+	0	0	
1986	Successful	3	2	2	New female, near-adult, with brown stripe down nape. Fishing hook lodged in adult female's tongue. Hook gone within 24 hours. Both young with monofilament protruding from beak. Monofilament gone same day. One egg collected.
1987	Successful	2+	2	2	Adult male died 11 April 1987, with broken procoracoid (shoulder) and ruptured liver. Female raised young for remaining 4 weeks on her own.
1988	Successful	1+	1	1	New male.
1989	Failed	1+	0	0	
1990	Successful	2+	2	2	
Total		13+	7	7	
Years		8	8	8	
Mean		1.6	0.9	0.9	

> = After < = Prior to

D4.15 HORSESHOE BREEDING AREA

The horseshoe breeding area is located 72 km north of Phoenix where the free-flowing Verde River enters Horseshoe Reservoir. The surrounding area is fairly open, although the river is alternately bounded by cliffs on the east or west bank above the reservoir.

D4.15.1 Habitat

The biotic community in the Horseshoe area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Paloverde-Cacti-Mixed Scrub Series and the Creosotebush-Crucifixion-Thorn Series. 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 above Horseshoe Reservoir meanders through an area alternately bounded by 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. In this area, which is lacustrine at high reservoir levels and riffles at low levels, pockets of quicksand are scattered along the

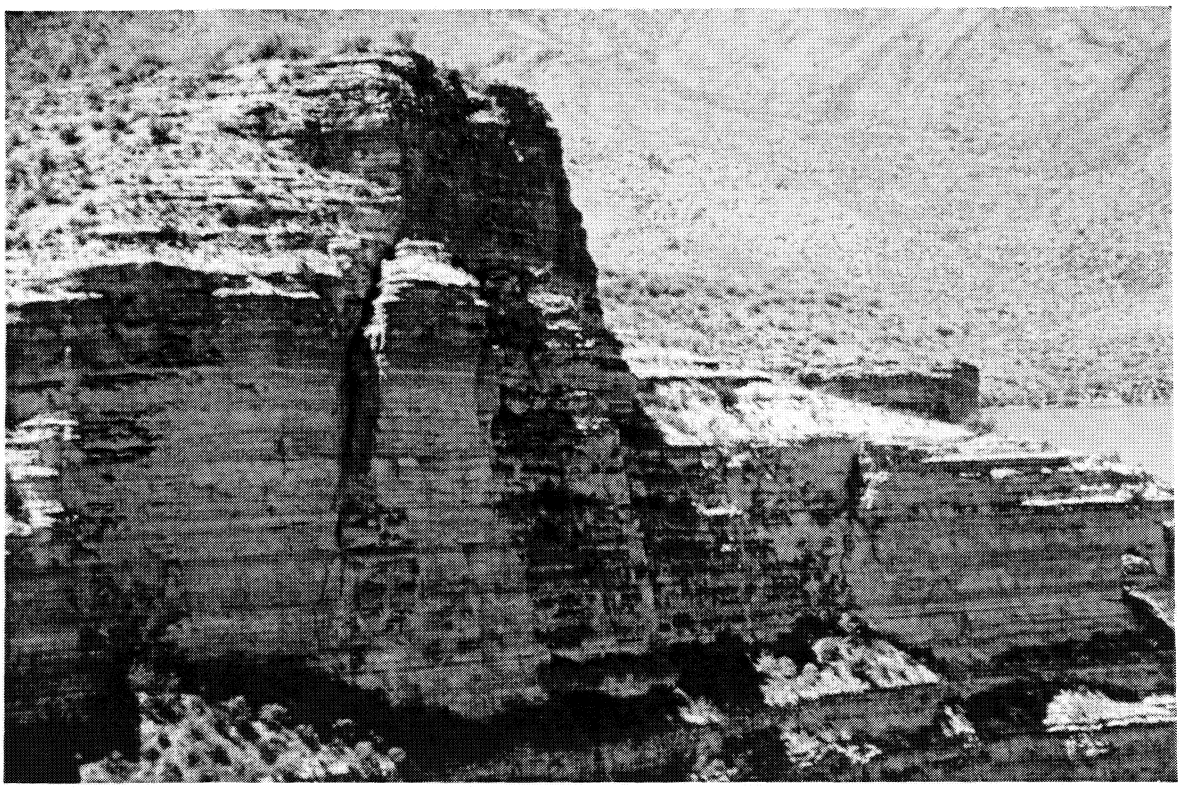

Plate D30. Horseshoe nest (8) cliff, May 1991 (photo by D. Driscoll).

stream. One large willow stands alone where the river turns south to the main body of the reservoir. This tree was fully leaved in 1987, but is now dying.

The reservoir contains some small willow and mesquite snags scattered in coves and along the east shore, although at high water levels these are inundated. Horseshoe Reservoir varies from being only a river channel during many summers to a fairly large reservoir in winters and springs. However, the area has remained a river channel since the summer of 1989. Emergent vegetation, grasses, and cocklebur proliferate at low levels, and waterfowl abound. When the reservoir is full, largemouth bass attract many fishermen to the area. Most of the reservoir is devoid of bald eagle perching habitat, with open country to the east and west.

A single line of cottonwoods grow along the regulated river below Horseshoe dam, with promontory cliffs giving way to open bottomland. A large mesquite bosque, which has been transformed into a campground, exists downstream of the dam. In this section, the river is braided and supports some emergent vegetation with isolated cottonwoods.

D4.15.2 Reproductive History

Eagles at the Horseshoe breeding area have been dependable nesters, having laid eggs every year, excluding 1981, since the territory's discovery in 1975. However, the Horseshoe pair has been plagued by nest inundation, due to fluctuating reservoir levels, and falling nest trees. The Horseshoe eagles have laid eggs from 20 January to 18 February, hatching young from 25 February to 25 March, with eaglets fledging from 14–17 May to 13 June (Table D4.15-1).

The Horseshoe breeding area was discovered in 1975 (Rubink and Podborny 1976) and the eagles have built eight nests, all located on the free-flowing river or upper reservoir (depending on water levels) near Chalk Mountain. In addition, five artificial nests have been constructed by Teryl Grubb, USFS, due to rising reservoir levels inundating tree nests.

The Horseshoe eagles have built two nests on the cliff of 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.).

Table D4.15-1. Nesting chronology of the Horseshoe breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1975	< February	—	—
1976	—	—	—
1977	30 January	—	—
1978	< 2 February	—	—
1979	—	—	—
1980	—	—	—
1981	—	—	—
1982	—	—	—**
1983	18 February	25 March	9 June
1984	2 February	6–9 March*	17–21 May*
1985	8 February	15 March	13 June
1986	5 February	11, 13 March*	1, 3 June**
1987	20 January	25 February	16, 20, 21–25 May*
1988	27 January	1 March	2 June*
1989	3 February	10 March	—
1990	28 January	4 March	14–17, 22 May*

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

** Two young fledged at Ladders breeding area in 1982, and Chino in 1986.

< Indicates "prior to"

> Indicates "later than"

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.

The adults built nest 7 in a snag in 1986, but once again rising reservoir levels inundated the nest on 24 March and the supporting branches broke. The two eaglets, hatched on 11 and 13 March, were

removed to the Phoenix Zoo prior to inundation (Mesta 1986). During this same 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 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).

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.

As mentioned above, the Horseshoe breeding area has been plagued by nest inundation, due to fluctuating reservoir levels, and falling nest trees. In 1975, two eggs were laid, but failed to hatch (Rubink and Podborny 1976). Two young fledged in 1976, and the nest tree (with two eggs) fell in 1977 (Rubink, pers. comm.). In 1978, two eggs were laid, but failed to hatch (Forbis, pers. comm.). In 1979 and 1980, the eagles laid eggs in the tripod nests, but the nests were inundated (Forbis, Grubb, and Eakle, pers. comm.). Apparently, no eggs were laid in 1981; and, in 1982, the two young were removed from the Horseshoe nest (prior to its inundation and fall) and fostered into the Ladders breeding area where they fledged successfully (Forbis, Grubb, and Eakle, pers. comm., Haywood and Ohmart 1983). The two eggs laid at Ladders in 1982 had failed to hatch, and were collected for analysis (Haywood and Ohmart 1983).

In 1983, one young was rescued from the reservoir after premature fledging and was returned to the nest, later successfully fledging (Eakle, pers. comm.). Two eaglets fell with the nest in 1984, but later fledged from a reconstructed artificial nest (Chorpenning and Crane 1984). Two young fledged in 1985 (Forbis 1985), and two young were fostered into the Chino breeding area (where they fledged) prior to inundation of the Horseshoe nest in 1986 (Mesta 1986). Three young fledged in 1987 and one in 1988. One young was killed, apparently by a great horned owl in 1989, and two young fledged in 1990.

The Horseshoe eagles fledged three young out of nest 1 during 16–25 May 1987. We climbed the eyrie on 4 October 1987 to obtain nest measurements and found a severe infestation of Mexican chicken bugs, a blood-sucking parasite. Meanwhile, the Horseshoe adults had built a new nest (8), between July and September 1987, further west on Chalk Mountain. It is possible that the new nest was built in response to the parasite infestation in nest 1. We also documented a moderate infestation of Mexican chicken bugs in nest 8 while banding the eaglet in 1988. Mexican chicken bugs have been suspected of contributing to the mortality of Arizona eaglets in the nest. See Section C3.4 for details on parasite infestations in Arizona bald eagle nests.

There has been considerable discussion in the past about the size of the ledge area of nest 1 and the site has been expanded by the use of explosives in the past (Grubb, pers. comm.) and further expansion of the cliff area was being considered in 1986. We banded the young in the nest in 1987, and found the site large enough for three eight week old eaglets and one biologist. In addition, the nest ledge continues east and west around the cliff. Heisler (1985) and Becker and Hein (1987) both noted the eaglets moved east and west along the ledge area for extended periods prior to fledging.

Nest 9 was built in a dying willow on the upper reservoir during November and December 1989; however the eagles laid eggs in nest 8 in 1990. The area surrounding nest 9 is popular for fishing and hunting. A well used duck hunting blind is located 300–400 m south of nest 9, and may have precluded nesting in this location in 1990.

D4.15.3 Mortalities

There has only been one documented juvenile bald eagle death at the Horseshoe breeding area. In 1989, the 3–3.5 week old eaglet was decapitated in the nest on 1 or 2 April, apparently by a great horned owl. It is typical behavior of great horned owls to take the heads off their prey, a behavior observed elsewhere by BioSystems biologists and widely reported by poultry and game farmers. A great horned owl was also suspected of killing a telemetered juvenile bald eagle at the Ladders breeding area which had been out of the nest for over a month (see Section C3.2).

In addition, a Horseshoe eaglet banded in 1987 was found dead in 1990 near the Salt and Verde River confluence. 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 both wings, tail, and left leg removed. There is little doubt this subadult bald eagle was shot (see Section C3.6). The officer who discovered the eagle said he had also found several shot Harris' hawks in the area. Also, a person was seen shooting at one of the Orme adults in this area in December 1990.

No adult mortalities have been documented at the Horseshoe breeding area. Both adults are currently banded, so a replacement may be readily detected should it occur.

D4.15.4 Known Foraging Areas and Food Habits

Before the BioSystems study, most known foraging at Horseshoe has been documented in the river (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 one time outside the immediate nest area (Chorpenning and Crane 1984). The ABENWP personnel noted that, although eagles returned with fish from the south, foraging on the main body of the reservoir was difficult to document due to the visual obstruction of Chalk Mountain (Chorpenning and Crane 1984, Lett 1984, Heisler 1985, Hein, pers. comm.). This created a bias in the foraging data, and resulted in small home range estimates, restricted to the river sections below the nest. Adults were observed on the river below Horseshoe Dam; however, it was uncertain whether these eagles were the Horseshoe or Cliff pair (Chorpenning and Crane 1984, Hein, pers. comm.).

We captured and radio-tagged the Horseshoe adult female on 30 March 1987, and the male on 13 January 1988. We tracked the pair during 1987–1989 and recorded extensive use of the reservoir, especially the shoreline along the shallow coves. We also observed forages on the open water in the center of the reservoir. The Horseshoe pair used the free-flowing Verde River, north of Chalk Mountain, to a point near Sheep Bridge. The eagles also utilized the regulated Verde River, below Horseshoe Dam. The home range of the Horseshoe eagles is now known to extend from Km 71.5 on the regulated Verde River to Km 88.0 on the free-flowing Verde above the reservoir, totaling 16.5 Km. The area from Km 71.5,

below Horseshoe Dam, to Km 75.0, on Horseshoe Reservoir, is shared with the Cliff eagles which nest downstream. See Section B4.5 for details on the foraging ecology and movements of the Horseshoe pair.

Prey items observed taken by eagles (Haywood and Ohmart 1981, Chorpenning and Crane 1984, Lett 1984, Heisler 1985, Grubb *et al.* 1983, Grubb 1986a, Hein *et al.* 1986, Becker and Hein 1987, Kennedy and Richey 1990, Richey 1990) are presented in Table D4.15-2, along prey items observed taken by eagles and prey remains collected in the nest from 1986–1989. See Sections B4.5 and B5.1.5 for detailed analysis of prey species utilized by the Horseshoe eagles. In addition, the eagles were observed attempting to capture shovelers (Heisler 1985).

The Horseshoe adults were observed stealing prey from great blue herons and also scavenging fish remains left by fishermen (Becker and Hein 1987, and Section B4.5.

D4.15.5 Human Impacts

Human disturbance is not a major problem at the Horseshoe breeding area, as long as the eagles use the cliff nests (1, 8) on Chalk Mountain. Fishermen, shooters, campers, off-road vehicles, light planes, jets, helicopters, boats, and hikers utilize the nest area, although most are ignored by the eagles. Jets, helicopters, and planes have caused the eagles to flush off the nest and vocalize, though this has not been a common occurrence (Chorpenning and Crane 1984, Lett 1984, Heisler 1985, Hein *et al.* 1986, Becker and Hein 1987, Kennedy and Richey 1990, Richey 1990).

However, when the eagles nest in trees or snags along the river, they are susceptible to disturbance from fishermen, canoes, hikers, and shooters (Chorpenning and Crane 1984, Lett 1984, Heisler 1985, Hein *et al.* 1986). Details on human disturbance at the Horseshoe breeding area during 1987–1989 are provided in Section B4.5.

Another human impact at the Horseshoe breeding area involves the fluctuating reservoir levels, which have resulted in the nests being inundated in 1979, 1980, 1982, and 1986. Although the nest trees have also been completely inundated in other years (Heisler 1985), the eagles used the cliff nests and were not directly affected by the high water. The only suitable nest tree left on the reservoir contains nest 9. All the other nest trees have since fallen, or no longer have enough branches to support a nest. Other trees exist upstream of Chalk Mountain and are located on higher ground on the east bank, with main branches above the high water level. The tree housing nest 9 has been inundated in the past, and if it is utilized by the eagles in the future, it should be monitored for disturbance and rising water levels.

Fishermen also threaten the success of this breeding area. Adults have been flushed off the nest by boats approaching too close to the nest trees. Another matter of vital environmental importance is waste monofilament. Monofilament is present in an abundance on Horseshoe Reservoir. Each cottonwood snag, including the nest trees, have monofilament, hooks, and lures in them. Monofilament not only kills bald eagles, but many other wildlife species as well (see Section C3.3); eaglets have also died from becoming entangled in monofilament at the nest (Section D4.22.3).

D4.15.6 Wildlife Interactions

At the Horseshoe nest site, interspecific interactions have been recorded with common ravens, turkey vultures, red-tailed hawks, osprey, prairie falcons, Cooper's hawks, American kestrels, golden eagles and great blue herons (Chorpenning and Crane 1984, Heisler 1985, Kennedy and Richey 1990, and BioSystems personnel). Chorpenning and Crane (1984) observed a Horseshoe adult lock talons with a golden eagle, and the two birds spiralled down near ground level before separating. In 1990, an

Table D4.15-2. Prey species observed taken by bald eagles or collected from the nest at the Horseshoe breeding area.

Fish	Birds	Mammals
Carp	Waterfowl	Cottontail rabbit
Channel catfish	Common merganser	Blacktail jackrabbit
Flathead catfish	Green-winged teal	Rock squirrel
Largemouth bass	Anas sp.	Ground squirrel
Black bass	Unidentified waterfowl	Unidentified Sciuridae
Unidentified Centrarchidae	Grebes	
Black crappie	Eared grebe	
Crappie sp.	Grebe sp.	**Herptiles**
Desert sucker	Wading Birds	Spiny softshell turtle
Sucker sp.	American coot	Unidentified snake
Threadfin shad	Great blue heron	Unidentified reptile
	Passerines	
	Cactus wren	
	Other Birds	
	Gambel's quail	
	Northern flicker	

immature golden eagle attempted to land in the Horseshoe nest, although the adult male drove the intruder off (Kennedy and Richey 1990).

During 16–19 February, Lett (1984) observed the Cliff and Horseshoe pairs interacting over the reservoir. The Cliff pair was building a nest on top of a great blue heron rookery below Horseshoe Dam at the time, but subsequently laid eggs in a cliff nest downstream. Chorpenning and Crane (1984) observed a Horseshoe adult lock talons with a subadult bald eagle, and the two birds fell through the sky to near ground level before separating. They also recorded territorial displays with the Cliff pair throughout the 1984 season. Interactions with other bald eagles were also documented by Heisler (1985) and BioSystems personnel during 1987–1989.

D4.15.7 Wildlife Sightings

Horseshoe is an area known by ABENWP and BioSystems personnel mostly for its slippery, muddy roads, but limited access at times is rewarding in wildlife sightings. Herptiles of interest in the area include desert tortoises, western diamondback rattlesnakes, longnose snakes, red coachwhip, desert patchnose snake, gopher snakes, regal horned lizards, and short-horned lizards. Snowy and great egrets have been sighted, as well as American avocets, green-backed herons and double-crested cormorants. Great blue heron rookeries are located upstream of Chalk Mountain, as well as below Horseshoe Dam. Waterfowl are common at high water levels, but are more numerous at low water levels. When the

reservoir was reduced to a river over the 1989 winter, flocks of 200 mallards and pintails were common, along with green-winged and cinnamon teal.

From 1987–1989, we continually sighted wood ducks entering and leaving the nest cliff throughout the bald eagle breeding season. Wood ducks are not known to nest in this area, although these observations suggest that the species may be expanding its nesting range. Along with the usual desert raptors, golden eagles, peregrine falcons, Cooper's hawks, sharp-shinned hawks, northern harriers, osprey, prairie falcons, zone-tailed hawks, and black hawks have been sighted. Other birds of interest include solitary vireos, yellow warblers, verdins, Lucy's warblers, hairy woodpeckers, blue-grey gnatcatchers, northern and hooded orioles, Steller's jays, yellow-headed blackbirds, bronzed and brown-headed cowbirds, black-headed grosbeaks, and black-chinned hummingbirds (BioSystems personnel 1987–1989, Kennedy and Richey 1990). In addition, we heard mountain lions calling from Chalk Mountain and observed their tracks along the river and reservoir from 1987–1989.

D4.15.8 Management Recommendations

1. As stated previously, there has been much discussion about the size of the ledge area at nest 1. When banding the eaglets in 1987, we found the nest area to be of sufficient size for three eight-week-old eaglets and one biologist. The young also are able to move east and west along the ledge, and have done so prior to fledging in 1985 and 1987. The nest area is suitable as it currently exists.

2. If the Horseshoe pair uses nest 9 in the future, a closure will likely need to be created to protect the nest. The area is used by bass fishermen quite extensively when water levels are high, and they often tie their boats to the nest tree. In addition, a waterfowl hunting blind, which was heavily used in 1989, is located 300–400 m south. This nest tree has been inundated in previous years and should be monitored if reservoir levels rise and the eagles use nest 9.

3. No further artificial nest structures should be constructed at the Horseshoe breeding area. All artificial nesting structures in the past have been built below the high water level, and subsequently were inundated. In several years, this adversely affected reproduction. Two cliff nests are available and appear to be the most desirable locations for the eagles, keeping them away from human disturbance and flooding.

HORSESHOE BREEDING AREA

Date Discovered: 1975
Drainage: Verde River / Horseshoe Reservoir
(Free-flowing / Reservoir)
Elevation (MSL): 2000 - 2200 ft
County: Yavapai
Latitude-Longitude Ten Minute Block: 340-1114
Land Management: U.S. Forest Service, Tonto National Forest, Cave Creek Ranger District
Distance From Phoenix: Air - 72.5 km North
Distance To Nearest Breeding Area Upstream: Table Mountain 26.7 Km
Air - 16.5 km
Distance To Nearest Breeding Area Downstream: Cliff - 15.0 Km
Air - 9.0 km
Distance From Salt River Confluence: 80.5 Km
Distance From Horseshoe Dam: 7.1 Km
Air - 6.5 km
Home Range: Km 71.5 to Km 88.0 on the Verde River
(Total = 16.5 Km)
Quadrangles: Horseshoe Dam 7.5 Minute
Chalk Mountain 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	1975-1976	Existing - Built prior to 1975.
			1978	Rubink No. 22.
			1983	
			1985	
			1987	Severe infestation of Mexican chicken bugs in October 1987.
2	Willow	Live	1977	Nest found 1975 - Rubink No. 21. Nest tree fell (with eggs) in 1977.
		Tripod	1979	Artificial tripod nest constructed in same location by Teryl Grubb, USFS, September 1977. Tripod nest inundated 1979. Tripod moved November 1979 to location of nest 3.

HORSESHOE BREEDING AREA (continued)

Nest Sites (cont'd.)

No.	Species	Type	Utilized	Status
3		Tripod	1980	Adults built onto tripod nest, but nest was inundated, 1980. A superstructure was added to tripod and adults built nest on top of superstructure, which was also inundated.
			1981	Adults rebuilt tripod nest in 1981. Tripod fell after 1981 season.
4	Willow	Live	1982	Nest built 1982. Nest inundated and tree fell in 1982. Young fostered to Ladders.
		Tower		Artificial tower nest constructed in same location by Teryl Grubb, USFS, in 1982. Tower fell March 1986.
5	Willow	Live	1983	Nest built 1983. Tree fell 1983.
		Tower		Artificial tower nest constructed in same location by Teryl Grubb, USFS in 1983. Adults moved to nest 1. Tower fell 1989.
6	Willow	Snag	1984	Nest built 1984. Nest branch broke and nest fell (with young) 25 April. Artificial nest constructed lower in same snag by Teryl Grubb, USFS, 25 April, and young placed in nest. Snag fell prior to 1986.
7	Willow	Snag	1986	Nest built 1986. Nest inundated and branches broke 24 March. Young fostered to Chino.
8		Cliff	1988-1990	Existing - Built July–September 1987. Severe infestation of Mexican chicken bugs in nest 1 May have induced early nest building.
9	Willow	Live		Existing - Built November–December 1989.

HORSESHOE BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1975	Failed	2	0	0	
1976	Successful	2+	2	2	
1977	Failed	2	0	0	Nest tree fell in February. Two eggs collected.
1978	Failed	2	0	0	High water levels.
1979	Failed	1+	0	0	Nest inundated.
1980	Failed	2	0	0	Nest inundated.
1981	Occupied				
1982	Successful/Foster	2+	2	2	Nest inundated. Young fostered to Ladders breeding area and fledged.
1983	Successful	1+	1	1	Young rescued from reservoir after prefledging and returned to nest.
1984	Successful	2+	2	2	Nest branch broke 25 April. Young fell onto shore. Artificial nest constructed by Teryl Grubb, USFS, lower in same snag 25 April, and young placed in new nest.
1985	Successful	2+	2	2	
1986	Successful/Foster	2+	2	2	Nest inundated 24 March. Young fostered to Chino breeding area and fledged.
1987	Successful	3	3	3	Severe infestation of Mexican chicken bugs in nest in October 1987. Adult female banded on left tarsus and black VID band placed on right tarsus.
1988	Successful	1+	1	1	Mexican chicken bugs in nest. Adult male banded on left tarsus and black VID band placed on right tarsus.
1989	Failed	2+	1	0	Young decapitated 1 or 2 April. Apparently great horned owl predation. One egg collected.
1990	Successful	2+	2	2	
Total		28+	18	17	
Years		16	16	16	
Mean		1.8	1.1	1.0	

D4.16 IVE'S WASH BREEDING AREA

The Ive's Wash breeding area is located 166 km northwest of Phoenix along the regulated Bill Williams River below Alamo Dam and on Alamo Reservoir. The Bill Williams River has cut a steep canyon bounded by large promontory cliffs below Alamo Dam, while the area surrounding the reservoir is fairly open. The Ive's Wash pair shares the upper reservoir with the Alamo eagles, which nest less than one km apart at the northern end of Alamo Reservoir. 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 was marked by buoys placed at 100 m surrounding the nest (2) and a sawhorse across the road leading to Woody's Cove.

Plate D31. Ive's Wash nest cliff along the regulated Bill Williams River, May 1987 (photo by D. Driscoll).

D4.16.1 Habitat

The biotic community in the Ive's Wash area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with associated Mohave Desertscrub Biome species. The riparian habitat along the regulated Bill Williams River is a mixture of the Sonoran Riparian Deciduous Forest and Woodlands Biome and the Sonoran Riparian Scrubland Biome (see Section D2).

Below Alamo Dam, the habitat along the river supports willows and mesquites along the banks. However, beaver have been cutting the trees, reducing some of their potential for eagle nest or perch sites, and off-road vehicles have been traveling up the river from Lincoln Ranch at low flows, causing compaction, and erosion, and removing vegetation. The canyon closes in about two km below the dam and the river is dominated by large promontory cliffs as it continues downstream to Lincoln Ranch, where the area is more open. High above the river, the upland habitat near the Ive's Wash nest is rugged desert country.

On upper Alamo Reservoir, the habitat surrounding the Ive's Wash and Alamo nests is a salt cedar jungle. Although cattle grazing is no longer permitted in the upper portion of Alamo Reservoir, trespass cattle are a common sight, and there is little regeneration of cottonwoods and willows. The cottonwood snags which supply nest and perch sites are deteriorating, and no large live trees exist in this area. Since the grazing moratorium went into effect, some small willows and cottonwoods are beginning to work their way above the salt cedar. It will be many years, however, until these trees are large enough to supply nesting and perching habitat for eagles.

Due to the shallow water in the upper (northern) portion of the reservoir, small inlets harbor various species of emergent vegetation and support a large population of waterfowl and shorebirds through the bald eagle breeding season. The reservoir also contains a healthy population of channel catfish, carp, tilapia, and largemouth bass, the latter drawing many fishermen to the nest area.

D4.16.2 Reproductive History

The Ive's Wash breeding area was found on 6 May 1987, after sightings of a second pair of adults on Alamo Reservoir during the 1986 breeding season. Eagles at Ive's Wash have been early nesters, building nests in November and December, laying eggs from 13–27 January, and hatching young from 17 February to 6 March, which fledge between 5 and 14 May (Table D4.16-1).

The Ive's Wash eagles have built two known nests, one on a cliff (1) high above the regulated Bill Williams River below Alamo Dam, and one in a live (dying) cottonwood tree (2) at Woody's Cove on upper Alamo Reservoir. Nest 1 was found on 6 May 1987, and was used by the eagles during 1987–1989. Nest 2 was built by the Ive's Wash pair in November 1987, but not used until 1990. Both nests are still in existence.

The Alamo pair fledged at least one young in 1987, which was sighted near the nest upon its discovery on 6 May. In 1988, the eaglet fledged at only 69 days old (less than ten weeks) but still survived. In 1989, two eaglets hatched, although one died when it jumped from the nest at 8.5 weeks of age. In 1990, the egg did not hatch, most likely due to continual disturbances flushing the adults off the nest.

One young at the Ive's Wash breeding area was removed from the nest on 11 April 1989 after ABENWP biologists 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 nursed the eaglet back to health, and on 17 April we returned it to the nest where it fledged successfully on 9 May.

Table D4.16-1. Nesting chronology of the Ive's Wash breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1987	—	—	5–6 May
1988	27 January	6 March*	14 May*
1989	13 January	17 February*	9 May*
1990	< 21 January	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

D4.16.3 Mortalities

There has only been one documented juvenile bald eagle death at the Ive's Wash breeding area. In 1989, both of the Ive's Wash young jumped from the nest on 19 April, at nine weeks of age, during unusually high temperatures. One eaglet (the one taken from the nest on 11 April—see above) climbed back to the nest, while the other remained on a ledge overnight. On 20 April the eaglet 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, so ABENWP biologists and USFWS biologist Robert Mesta searched the canyon bottom for the eaglet. 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. See Section C3.5 for further details on nestling mortalities linked to heat stress.

No parasites have been found in the Ive's Wash nests. However, Dr. Kathy Ingram, Liberty Wildlife Foundation, extracted an unknown worm species from the throat of each Ive's Wash eaglet in 1989, one while in surgery, the other during necropsy.

One adult death has been documented at the Ive's Wash breeding area. In 1988, the male was replaced by a near-adult male.

D4.16.4 Known Foraging Areas and Food Habits

The Ive's Wash eagles are known to forage on the regulated Bill Williams River below Alamo Dam and on Alamo Reservoir to Km 52.0. Most foraging, however, occurs on the upper portion of Alamo Reservoir (Sweitzer and Moller 1988, Newbold and Newbold 1988, Moller *et al.* 1989, Thiesfeldt and Linskens 1990, Bock and McLuckie 1990). In 1988, flows on the regulated Bill Williams River decreased from 300 cfs to 50 cfs on 12 March, then down to 10 cfs on 18 March. Foraging was not documented on the river until flows were reduced to 10 cfs, although most foraging still occurred on the reservoir after that point. The river was maintained at 10 cfs through the 1989 breeding season. One adverse effect of the low flow was the off-road vehicles which traveled up the river from Lincoln Ranch at Km 34 (Sweitzer and Moller 1988, Moller *et al.* 1989). The Ive's Wash and Alamo eagles shared foraging areas on upper Alamo Reservoir; thus many of the Ive's Wash forages were observed by the Alamo nest watchers.

Prey items identified by Moller *et al.* (1989) are presented in Table D4-32 along with prey items collected at the nest from 1986–1989. See Section B5.1.1 for a detailed analysis of prey remains collected from 1986–1989. Thiesfeldt and Linskens (1990) reported a large tilapia die-off in 1990, although the eagles were not observed utilizing this abundant source of carrion fish.

Table D4.16-2. Prey species observed taken by bald eagles or collected from the nest at the Ive's Wash breeding area.

Fish	**Birds**	**Mammals**
Carp	Waterfowl	Cottontail rabbit
Channel catfish	Green-winged teal	Skunk sp.
Flathead catfish	Cinnamon teal	Rock squirrel
Bullhead (catfish)	Anas sp.	Ground squirrel
Tilapia	Unidentified waterfowl	Unidentified Sciuridae
Largemouth bass	Grebes	Unidentified rodent
Black bass	Eared grebe	
Striped bass	Wading Birds	**Herptiles**
Crappie sp.	American coot	None found

The Ive's Wash eagles were not observed stealing prey from other species, but ravens were recorded attempting to steal prey from of the eagle nest.

D4.16.5 Human Impacts

Human impacts at the Ive's Wash breeding area include light planes, low level military jets, off-road vehicles, ATCs, hikers, campers, fishermen, hunters, and boaters. The eagles are relatively well protected when they use nest 1 below Alamo Dam. However, at low river flows off-road vehicles venture upstream from Lincoln Ranch at Km 34 and make their way to the nest area. In addition, military aircraft on low level flight training, as well as sonic booms, also occur, but many are ignored or simply watched by the eagles. (Sweitzer and Moller 1988, Moller *et al.* 1989).

However, human disturbance is a serious problem at the Ive's Wash breeding area when the eagles use nest 2 at Woody's Cove on Alamo Reservoir. Fishermen, campers, hunters, shooters, boaters, and off-road vehicles come within 20 m of the nest (a road runs down to the shore of Alamo Reservoir, 20–25 m from the nest tree) and set up their camps at Woody's Cove. Many fishermen proceeded immediately below the nest, often tieing their boats to the nest tree (Sweitzer and Moller 1988, Newbold and Newbold 1988, Moller *et al.* 1989, Thiesfeldt and Linskens 1990, Bock and McLuckie 1990).

The Ive's Wash pair laid at least one egg in the Woody's Cove tree nest prior to 21 January 1990. Disturbance abounded at the site, 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 this point definitively: "The failure of this nest is undoubtedly due to numerous human disturbances."

Sweitzer and Moller (1988) wrote, "The major potential for nest failure at Alamo (Reservoir) is disturbance and harassment by boaters/fishermen. On numerous occasions boats were observed purposefully flushing adult eagles of both the Ive's Wash and Alamo nests off perches and then pursuing them from perch to perch."

While telling fishermen and boaters to stay away from the nest area, ABENWP personnel were often subjected to criticism, argument, and verbal abuse (Sweitzer and Moller 1988, Theisfeldt and Linskens 1990). Sweitzer and Moller (1988) believed that "... a feeling of animosity towards the eagles ..." existed among the public and even among some of the Alamo Reservoir Park officials. Sweitzer and Moller maintain that without more effective protection, the nest at Woody's Cove is "... doomed to failure due to the high usage of the area by boaters and campers." Moller *et al.* (1989) recommended a closure for the Alamo and Ive's Wash nests.

Alamo reservoir is managed by the Army Corps of Engineers, the surrounding land by BLM, and the wildlife by AGF. Robert Mesta, USFWS, and Robert Hall, BLM, began measures to erect a closure at the Woody's Cove area immediately following confirmation of incubation. Unfortunately, the erection of the closure was delayed until 6 March, nine days after the nest had failed. Even then, the closure consisted merely 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. Theisfeldt and Linskens (1990) felt that the closure markers were insufficient to deter public users from the area; people claimed not to have seen the buoys.

Waterfowl hunting in the immediate nest vicinity may pose a serious threat to this breeding area. The Alamo and Ive's Wash eagles begin nest construction in November and lay their eggs in December and early January each year. The period just prior to and including incubation is critical because the birds may abandon their nest or not lay eggs if disturbed. The Alamo eagles have been stealing ducks from hunters, taking the duck off the surface before the dog is able to retrieve it. Lead shot has not been required until the 1990–1991 waterfowl season. Thus there are possibilities of lead poisoning or shooting.

Fishermen also threaten the success of these breeding areas. Adults have frequently been flushed off the nests by boats approaching too close to the nest trees. Also there is the matter of monofilament, present in abundance on Alamo Reservoir; monofilament, hooks, and lures have been found in the Chino, Ive's Wash, and Alamo nests. All the cottonwood snags, including the nest trees, have monofilament, hooks, and lures in them. Monofilament not only kills bald eagles, but many other wildlife species as well (see Section C3.3). In 1988 the Alamo eaglet fell from the nest, and when found on the ground it had a fishing lure lodged in its tongue. A white-faced ibis, brought to the nestling by the adults, was hanging from the opposite end of the lure. Eaglets have also died from becoming entangled in monofilament at Arizona nests (Section D4.22.3).

The problems of human disturbance have been reiterated each year by ABENWP personnel at the Ive's Wash and Alamo breeding areas. Weiss (1987) wrote that, "I feel that human disturbance is the main problem with this nest site ..." and "... the best solution for eagle management is to restrict the immediate access to the area." Newbold and Newbold (1988), Sweitzer and Moller (1988), Moller *et al.*

(1989), Bock and McLuckie (1990) and Theisfeldt and Linskens (1990) all voiced similar opinions based on their observations. See U.S. Fish and Wildlife Service (1989) and (1990) for accounts of disturbance at Ive's Wash and Alamo in 1988 and 1989.

D4.16.6 Wildlife Interactions

Interspecific interactions were a daily occurrence with a pair of ravens that nest across the canyon (40 m) from nest 1. On 30 April 1988, one such interaction lasted 6.5 minutes, and on 1 May another lasted 4.5 minutes. In both cases, one raven hovered over the adult female and eaglet in the nest and mobbed the female, while the other raven hopped vigorously around the edge of the nest, harassing the adult and possibly attempting to steal prey from the nest (Sweitzer and Moller 1988). Interactions were also observed with nesting red-tailed hawks, and with turkey vultures, golden eagles, great egrets, osprey, and great blue herons (Sweitzer and Moller 1988, Moller *et al.* 1989, Theisfeldt and Linskens 1990).

Due to the close proximity of the Ive's Wash and Alamo breeding areas (1 km by air), intraspecific interactions are common. In one instance, the two males locked talons in flight, and on another occasion actually plummeted from a perch into Alamo Reservoir, still locked together as they hit the water. In 1989, about half of the 89 observed interactions involved the Alamo and Ive's Wash, as well as other bald eagles (Moller *et al.* 1989). In 1990, Bock and McLuckie estimated 116 intraspecific interactions between the Ive's Wash and Alamo eagles, which nested within one km of each other, but many of these interactions simply involved perching at territory boundaries and vocalizing.

In one interesting interaction, the four Ive's Wash and Alamo adults teamed up to drive a fifth eagle out of the area (Theisfeldt and Linskens 1990). Sweitzer and Moller (1988) noted the Ive's Wash adult male's left eye was swollen shut on 30 April 1988, and was still closed on 13 May. This injury may have been caused by one of the many altercations with ravens or the Alamo eagles.

D4.16.7 Wildlife Sightings

American white pelicans are common winter visitors to Alamo Reservoir. In 1990, adult and immature brown pelicans were also present (Bock and McLuckie 1990, Theisfeldt and Linskens 1990). A great blue heron rookery is located in the Ive's Wash area, at the upper end of Alamo Reservoir, south of Brown's Crossing. Double-crested cormorants also nest in this rookery. Other species of interest include black-crowned night herons, loons, horned grebes, western grebes, great, snowy, and cattle egrets, red-breasted mergansers, hooded mergansers, long-billed curlews, and American avocets. Waterfowl observed are mallards, gadwall, green-winged, blue-winged, and cinnamon teal, northern shovelers, redheads, canvasbacks, pintails, lesser scaup, buffleheads, American wigeon, ring-necked ducks, and Canada geese.

Other birds of interest include black-chinned, broad-tailed, and Costa's hummingbirds, ladder-backed woodpeckers, mountain bluebirds, loggerhead and northern shrikes, and western wood-pewees. Peregrine falcons are sighted throughout the bald eagle nesting season on Alamo Reservoir, and it is likely an eyrie occurs nearby. Other raptor species of interest include merlins, black-shouldered kites, northern harriers, Cooper's hawks, sharp-shinned hawks, ferruginous hawks, black hawks, osprey, Harris' hawks, and zone-tailed hawks. In addition, feral burros and beaver occur below Alamo Dam (Newbold and Newbold 1988, Moller *et al.* 1989, Bock and McLuckie 1990, Theisfeldt and Linskens 1990).

D4.16.8 Management Recommendations

1. A closure should be enacted for the upper portion of Alamo Reservoir, which would include the Alamo and Ive's Wash nest sites from 1 December until 30 June. Closure boundaries should include a minimum 200-m buffer on the southern border, from the nest sites into Alamo Reservoir, and be marked with floating buoys. The northern boundary should be closed south of Brown's Crossing, and the road into Woody's Cove closed on the eastern border. All borders should be clearly posted (see Section D4.1.5 and D4.16.5).

2. Since a moratorium on grazing already exists for the upper portion of Alamo Reservoir, all trespass cattle should be removed immediately and kept out of the riparian areas. This would give young willows and cottonwoods a chance to grow above the salt cedar jungle. The planting of cottonwood poles may also be necessary to provide future nest trees and perches, since no large live trees exist in the area and the existing snags are falling apart (see Section D4.1.1 and D4.16.1). In addition, a program of salt cedar eradication may be necessary.

3. Reservoir levels necessary to sustain the three bald eagle breeding areas (Alamo, Chino, and Ive's Wash) associated with Alamo Reservoir should be established.

4. Off-road vehicles should be prohibited from driving up the river bottom from Lincoln Ranch.

IVE'S WASH BREEDING AREA

Date Discovered: 6 May 1987
Drainage: Bill Williams River / Alamo Reservoir (Regulated/Reservoir)
Elevation (MSL): 1080 - 1200 ft
County: La Paz
Latitude-Longitude Ten Minute Block: 341-1133
Land Management: U.S. Bureau of Land Management, Kingman District
U.S. Army Corps of Engineers
Arizona Game and Fish Department
Closure: Arizona Game and Fish Department Closure
U.S. Army Corps of Engineers Closure
Enacted 6 March 1990
"No Entry" Area 100 m surrounding nest 2
Road blocked to Woody's Cove
Distance From Phoenix: Air - 166.0 km Northwest
Distance To Nearest Breeding Area Upstream: Alamo - 0.2 Km
Air - 1.0 km
Distance To Nearest Breeding Area Downstream: None
Distance From Colorado River Confluence: 42.3 Km
Home Range: Unknown. Known to utilize the Bill Williams River and Alamo Reservoir to Km 52.0
Quadrangles: Artillery Peak 15 Minute
Alamo Dam 15 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	1987-1989	Existing - Found 6 May 1987.
2	Cottonwood	Live	1990	Existing - Built November 1987.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1987	Successful	1+	1+	1+	One fledgling in area 6 May.
1988	Successful	1+	1	1	New male, near-adult (ca. 4-5 years old). Young prefledged 14 May (69 days old) and survived.

IVE'S WASH BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1989	Successful	2+	2	1	One young removed from nest on 11 April, after regurgitating food for 3 days, and taken to a rehabilitation facility, where a large fish bone (spinal column with fin rays) was extracted from its throat. Fin rays had lodged in sides of esophagus, preventing food passage. Eaglet nursed to health and returned to nest 17 April. Both young jumped from nest 19 April (8.5 weeks old). One eaglet climbed back to the nest, other remained on a ledge overnight, then jumped into the canyon. Young found 23 April with a broken left radius and ulna (wing), and severely dehydrated. Nestling transported to a rehabilitation facility, but died of dehydration and shock 25 April.
1990	Failed	1+	0	0	Lots of disturbance from camping and fishing. Fishing boats flushed adults off eggs. Closure erected 6 March 1990, after nest had failed (eggs laid prior to 21 January). One egg collected.
Total		5+	4	3	
Years		4	4	4	
Mean		1.2	1.0	0.8	

D4.17 LADDERS BREEDING AREA

The Ladders breeding area is located 114 km north of Phoenix along the free-flowing Verde River below Camp Verde. West Clear Creek is a free-flowing perennial stream which enters the Verde from the east 10 km south of Camp Verde. Bull Run, Sycamore, and Chasm Creeks are free-flowing intermittent streams which flow into the Verde south of Beasley Flat. From Camp Verde to Beasley Cliffs the river meanders through the Verde Valley, a wide agricultural bottomland. Below Beasley Cliffs the surrounding area is characterized by rugged terrain with steep slopes and promontory cliffs.

The Ladders breeding area received its name from a series of ladders extending from the bottom of Chasm Creek, near the Verde River confluence, to the upper mesa. The ladders were built by early land managers, apparently to facilitate access to and from the river. In response to abundant recreation and the close proximity (and visibility) of some of the nests at Ladders to the upper mesas, closures were enacted by the Prescott National Forest in 1981 and the Coconino National Forest in 1982. These closures were 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.

Plate D32. Ladders cliff nest (3) along the free-flowing Verde River, October 1986 (photo by D. Driscoll).

D4.17.1 Habitat

The biotic community in the Ladders area is of the Upper Sonoran Life Zone, with vegetation in the upland habitat characteristic of the Semidesert Grassland Biome. 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).

From Camp Verde to Beasley Cliffs, the Verde River meanders through agricultural bottomland lined with large cottonwoods. Several large 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.

D4.17.2 Reproductive History

The Ladders breeding area was discovered by agency personnel in 1972 (Rubink and Podborny 1976); however, Floyd Thompson (USFWS) reported the nest site had been active every year since 1962 (Forbis 1979). The breeding area has been active in 15 of the 19 years since 1972. The Ladders eagles have laid eggs from 19 January to 2 February, hatched eaglets from 20 February to 8 March, and fledged young from 14 May to 9 June (Table D4.17-1).

The Ladders eagles have built five known nests, all found in 1972, on cliffs near the confluences of Bull Run Creek (1, 2) and Chasm Creek (3, 4, 5) (Rubink and Podborny 1976, Rubink, pers. comm.). Nest 1 is located on the west cliff at the confluence of Bull Run Creek, and was used by the eagles in 1972 (Rubink, pers. comm.). Nest 2 is located on the east cliff upstream of the confluence of Bull Run Creek, and was used in 1973 (Rubink and Podborny 1976, Rubink, pers. comm.). Nest 3, located on the west cliff at the confluence of Chasm Creek, was used by the eagles during 1977–1980 (Rubink, pers. comm., Haywood and Ohmart 1983), 1986–1987, and in 1989. Nest 4 is located on the east cliff upstream of the Chasm Creek confluence (Rubink, pers. comm.), and was used by the eagles during 1981–1983, and in 1985 (Haywood and Ohmart 1983, Eakle, pers. comm.), 1988, and 1990. Nest 5 is located just south of, and above, nest 4 and has only been used in 1984 (Rubink, pers. comm., Eakle, pers. comm.). All five nests are still in existence. Interestingly, in 1989 golden eagles raised young in nest 1.

In addition to the five existing cliff nests, Floyd Thompson USFWS) reported a cottonwood tree nest right in Camp Verde (Forbis 1984). The exact location of this nest is not known, but the telemetered Ladders adults utilized the Verde River up to the Camp Verde bridge (Km 157.0), and we did not see any nests large enough to be bald eagle nests in this section of the river.

The Ladders egg(s) failed to hatch in 1972, but the pair fledged at least one young in 1973. The breeding area was apparently unoccupied at known nest locations during 1973–1976, and egg(s) were laid in 1977, but failed to hatch (Rubink and Podborny 1976, Rubink, pers. comm.). The Ladders eagles apparently did not lay eggs in 1978, and the eggs failed to hatch in 1979 (Haywood and Ohmart 1983). The eagles fledged four young during 1980 and 1981. Although the eggs did not hatch in 1982, two 10 day old eaglets were fostered into Ladders from the inundated nest at the Horseshoe breeding area, and subsequently fledged (Haywood and Ohmart 1983). Two young fledged in 1983, the egg(s) did not hatch in 1984, and two eaglets fledged in 1985 (Grubb 1986a). Two young fledged in 1986, and two were raised to nine weeks of age in 1987, but died in the nest. Four eaglets fledged during 1988–1989, and the eggs failed to hatch in 1990.

Table D4.17-1. Nesting chronology of the Ladders breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1972	—	—	—
1973	—	—	—
1974	—	—	—
1975	—	—	—
1976	—	—	—
1977	< 1 March	—	—
1978	—	—	—
1979	—	—	—
1980	—	—	—
1981	—	—	—
1982	—	—	—**
1983	31 January	8 March	29 May
1984	2 February	—	—
1985	27 January	27 Feb, 1 March*	26, 29 May*
1986	27 January	3, 6 March*	20, 23 May*
1987	26 January	1 March*	—
1988	19 January	20, 21 February*	14, 16 May*
1989	30 January	6, 8 March*	25 May, 9 June*
1990	24 January	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

** Two young fostered from Horseshoe breeding area.

< Indicates "prior to"

> Indicates "later than"

D4.17.3 Mortalities

There have been three documented juvenile bald eagle deaths at the Ladders breeding area. Of these, two young died in the nest, and one was killed after fledging. In 1987, 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 (Morgan and Sudar 1987). 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 pre-fledged 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. The nest climb on 7 May and retrieval of JP09 on 8 May revealed a very heavy infestation of Mexican chicken bugs, which likely caused premature fledging and contributed to the eaglets demise. Cause of

death could not be determined from necropsies. A high density of Mexican chicken bugs were found in the nest again in 1989, after the young had fledged. See Section C3.4 for details on Mexican chicken bugs in Arizona bald eagle nests.

The 1988 Ladders juveniles 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. In addition, it is typical behavior of great horned owls to eat the heads off of their prey. This behavior has been observed by BioSystems biologists on several occasions, and is widely reported by poultry and game farmers.

There have been two documented incidents of adult mortality at the Ladders breeding area. We captured and telemetered the Ladders male (AM08) on 2 April 1989 and, while tracking the eagle on 3 April, BioSystems biologists observed a peregrine falcon stoop on AM08, striking him in the back of the head. AM08's flight abilities appeared immediately affected as he awkwardly flew to, and crash landed at, the nest. AM08 remained sluggish for days, not foraging again until 14 April. During this time the adult female foraged to feed the two eaglets. AM08 died 6–10 May 1989, possibly as a result of brain damage from the peregrine attack (see Section C3.7 for a more detailed account). Meanwhile, the Ladders female foraged for and successfully raised the two eaglets for the remaining six to eight weeks until fledging in 1989, and also foraged for the young after they had left the nest. We monitored prey deliveries to the nest after the male's death, to ensure the two eaglets would get enough food. When prey deliveries were lacking, we placed fish on the sand bar below the nest during the night. The female took all of these fish to the nest.

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. The carcass was very decomposed, and not collected by the person who found the eagle, so cause of death remains unknown. However, the USFWS band was removed and turned in to AGF. The 6.5-year-old male (629-14562) was banded as a nestling in 1984 at the Horseshoe breeding area by Teryl Grubb, USFS.

D4.17.4 Known Foraging Areas and Food Habits

Before the BioSystems study, most foraging by the Ladders eagles was 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). This data from nest observation points resulted in a bias toward the river section below the nest. Poelker and Palmiotto (1985) and Collie and Knoll (1988) both noted most prey was delivered from upriver of the nest from February to April, then the eagles brought prey in from both downstream and upstream in April and May.

We captured the Ladders female on 1 April 1988, for banding and telemetry purposes. On this date we placed a silver (aluminum) USFWS band on her left tarsus, and a black color anodized aluminum Visual Identification (VID) band on her right tarsus. The adult male, telemetered on 2 April 1989, provided

little information on foraging after his encounter with the peregrine (see above), but we did observe him visually during 1988 and early 1989 in connection with tracking the female. We found that both birds foraged extensively on the Verde River, from south of Bull Run Creek to north of the Camp Verde bridge. In addition, there were seasonal shifts among the different river sections, West Clear Creek, and local ponds. The home range of the Ladders pair extends from Km 157-187 on the Verde River, totaling 30 Km.

Prey items observed taken by eagles (Haywood and Ohmart 1982, Haywood and Ohmart 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) are presented in Table D4.17-2, along with prey items taken by the eagles and prey remains collected at the nest during 1986–1989. See Sections B4.3 and B5.1.6) for a detailed analysis of prey species utilized by the Ladders eagles.

Table D4.17-2. Prey species observed taken by bald eagles or collected from the nest at the Ladders breeding area.

Fish

Carp
Channel catfish
Flathead catfish
Bass sp.
Unidentified Centrarchidae
Sonora sucker
Desert sucker

Birds

Waterfowl
Common merganser
Wood duck
Unidentified waterfowl

Grebes
Grebe sp.

Wading Birds
American coot

Passerines
Great-tailed grackle
American robin
Western meadowlark
Blackbird sp.
European starling
Blue grosbeak
Unidentified passerine

Other Birds
Woodpecker sp.
Mourning dove
Greater roadrunner

Mammals

Cottontail rabbit
Blacktail jackrabbit
Ringtail
Muskrat
Neotoma
Pocket gopher
Ground squirrel
Rock squirrel
Javelina
Coyote
Deer sp.

Herptiles

Sonoran mud turtle
Turtle sp.
Racer sp.
Unidentified snake

Other

Crayfish sp.

Poelker and Palmiotto (1985) recorded the eagles removing old prey remains from the nest, a behavior observed at other bald eagle breeding areas in Arizona (*e.g.*, Horse Mesa, Redmond).

Warrick and Hardwick (1986) observed the eagles attempting to catch common mergansers, and on three occasions, the eagles hovered over otters in the river below the nest. The Ladders adults were observed stealing prey from ospreys and great blue herons (Collie and Knoll 1989, Collie and Knoll 1990, and BioSystems personnel 1987–1989).

In addition to the Ladders eagles, many wintering bald eagles utilize the Verde River near Camp Verde. We recorded numerous eagles in the Ladders territory, especially at Beasley Cliffs, where foraging was observed. While attempting to capture the Ladders male, we radio-tagged five of these subadult and near-adult eagles (see Sections A4 and C5). The Ladders adults did not appear to act aggressively toward the wintering birds in January and February 1989.

D4.17.5 Human Impacts

The closure at Ladders effectively reduces disturbance near the nest and thus human impacts do not appear to be a detrimental factor. Light planes, helicopters, rafters, canoes, hikers, gunshots, and sonic booms have been reported at the Ladders breeding area (Haywood and Ohmart 1981, Poelker and Palmiotto 1985, Warrick and Hardwick 1986, Morgan and Sudar 1987, Collie and Knoll 1988, Collie and Knoll 1989, Collie and Knoll 1990). Although most aircraft are ignored by the eagles, Warrick and Hardwick (1986) and Haywood and Ohmart (1981) recorded adults flushed from the nest by helicopters, and Collie and Knoll (1989) reported a disturbance during incubation by an Apache™ helicopter.

Rafters and people in canoes stopping below the nest cliffs caused the adults to flush off the nest, and in some cases, these people were observed harassing the eagles. The adults would circle and vocalize at people which beached rivercraft below the nest cliffs. In addition, hikers and vehicles which entered the closure and ventured above and below the nest cliffs caused similar reactions from the eagles, with adults flushing off the nest and perches (Haywood and Ohmart 1981, Poelker and Palmiotto 1985, Warrick and Hardwick 1986, Morgan and Sudar 1987, Collie and Knoll 1988, Collie and Knoll 1989, Collie and Knoll 1990). See Section B4.3 and U.S. Fish and Wildlife Service (1989, 1990) for details on disturbance at Ladders in 1988 and 1989.

It is important to note that, although the closure protects the eagles near the nest, they leave the closure area on a regular basis to forage. In 1989, we observed a person shooting at the Ladders male outside the closure boundary.

D4.17.6 Wildlife Interactions

Interactions with other bald eagles (intraspecific) and with other species (interspecific) are common among bald eagles. These interactions can be aggressive, as in territorial defense and attempts to pirate prey, but occasionally are not, such as soaring with other raptors. At Ladders, interspecific interactions were observed with red-tailed hawks, peregrine falcons, common ravens, Cooper's hawks, sharp-shinned hawks, subadult and adult golden eagles, osprey, turkey vultures, great horned owls, American kestrels, pinyon jays, and a Say's phoebe, as well as cows, and river otters (Haywood and Ohmart 1980, Haywood and Ohmart 1981, Chorpenning and Crane 1984, Poelker and Palmiotto 1985, Warrick and Hardwick 1986, Morgan and Sudar 1987, Collie and Knoll 1988, Collie and Knoll 1989, Collie and Knoll 1990, and BioSystems personnel 1988-1989).

In 1985, Poelker and Palmiotto (1985) reported that a subadult eagle (of unknown species) attempted to land on the Ladders nest twice in one minute, then perched downstream. The adult female spread her wings over the eaglets and vocalized until the male returned and drove the intruder off. In a similar incident, Warrick and Hardwick (1986) noted that a sharp-shinned hawk landed on the nest and was driven off by the adult male eagle. A Say's phoebe was observed flycatching over the incubating female in 1989 (Collie and Knoll 1989).

Peregrine falcons are sighted annually at Ladders and may nest nearby; however no eyrie has been found to date. The Ladders eagles have been observed interacting with peregrines in 1986, 1988, 1989, and 1990 (Warrick and Hardwick 1986, Collie and Knoll 1988, Collie and Knoll 1989, Collie and Knoll 1990, and BioSystems personnel 1988–1989). As discussed previously, the Ladders male was fatally injured by a peregrine falcon in 1989. Great horned owls nest in Chasm Creek, as well as on Beasley Cliffs, and have interacted with the eagles in the past (Collie and Knoll 1988, Collie and Knoll 1989, Collie and Knoll 1990). In addition, great horned owls were suspected of killing one of the Ladders juveniles in 1988.

Golden eagles also nest nearby, and many wintering bald eagles utilize the Ladders area, resulting in numerous interactions with subadult and adult bald and golden eagles. Some of these eagles were very aggressively attacked by the Ladders pair (Haywood and Ohmart 1980, Haywood and Ohmart 1981, Chorpenning and Crane 1984, Poelker and Palmiotto 1985, Warrick and Hardwick 1986, Morgan and Sudar 1987, Collie and Knoll 1988, Collie and Knoll 1989, Collie and Knoll 1990, and BioSystems personnel 1988–1989). Many interactions with other bald eagles at Ladders simply involved escorting the intruder out of the area. Collie and Knoll (1990) reported a second pair of adults defending the Verde River upstream of West Clear Creek. This is an interesting observation, since in the 1960s Floyd Thompson (USFWS) reported a cottonwood tree nest right in Camp Verde (Forbis 1984).

In addition, river otters have been sighted at Ladders every year at least since 1985. The eagles vocalized at otters below the nest cliff, and in 1986 hovered over the otters in the river (Poelker and Palmiotto 1985, Warrick and Hardwick 1986, Morgan and Sudar 1987, Collie and Knoll 1988, Collie and Knoll 1989, Collie and Knoll 1990, and BioSystems personnel 1988–1989). Morgan and Sudar (1987) also observed the Ladders eagles vocalizing at cattle in the river.

D4.17.7 Wildlife Sightings

Numerous sightings of river otters, scat, and dens have occurred in the Ladders vicinity. Javelina, white-tailed deer, mule deer, fox, coyotes, ringtails, and mountain lions also occur in the area. In addition to the peregrine falcons, golden eagles, and great horned owls nesting in the area, we also sighted two pairs of common black hawks near the Camp Verde bridge in March, 1990, and found numerous pairs nesting along West Clear Creek. Other raptors of interest include merlins, prairie falcons, American kestrels, northern harriers, Cooper's hawks, sharp-shinned hawks, ferruginous hawks, osprey, and zone-tailed hawks (Poelker and Palmiotto 1985, Collie and Knoll 1988, Collie and Knoll 1989, Collie and Knoll 1990, and BioSystems personnel 1988-1989). In addition, Collie and Knoll (1988) sighted a Harris' hawk in the area, which is a one of the most northern records for this species.

Other species of interest include green-backed herons, great egrets, and cattle egrets, and a great blue heron rookery is located at the confluence of West Clear Creek. Waterfowl abound on ponds in the area, and hooded mergansers, mallards, wood ducks, gadwall, green-winged and cinnamon teal, northern shovelers, redheads, pintails, lesser scaup, common goldeneye, American wigeon, ring-necked ducks, and Canada geese have been sighted. Other birds of interest include black-chinned, broad-tailed, and

Costa's hummingbirds, ladder-backed woodpeckers, loggerhead shrikes, Scott's and hooded orioles, blue and black-headed grosbeaks, and western bluebirds (Poelker and Palmiotto 1985, Collie and Knoll 1988, Collie and Knoll 1989, Collie and Knoll 1990, and BioSystems personnel 1988-1989). In addition, Collie and Knoll (1989) made several noteworthy observations of ravens knocking cliff swallow nests off the cliff and carrying away the baby swallows.

We had several interesting encounters with mountain lions while attempting to capture the Ladders adults for banding and telemetry purposes. On 1 February 1989, a lion visited our camp site, and awakened us in our tents by rustling and snorting; when we turned on our lights, the lion quickly departed. Upon closer inspection the next day, we found the lion had examined our camp thoroughly (tracks all over camp), and dug a depression under one tent (near a biologist's head), removing the ground cloth. Mountain lions entered two other camps we had in the same area in January and February, 1989, examined our presence and gear, then departed.

D4.17.8 Management Recommendations

People have been reported beaching rivercraft below the nest cliffs each year. All watercraft must portage around "The Falls" at Km 165.0, upstream of the nest cliffs. Signs stating "No Stopping, Bald Eagle Nesting Area" should be placed at the falls and just prior to the nest cliffs. In addition, a sign stating "OK To Stop After This Point" should 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.

LADDERS BREEDING AREA

Date Discovered: 1972. Earliest Records 1962.
Drainage: Verde River (Free-flowing)
Elevation (MSL): 2920 - 3080 ft
County: Yavapai
Latitude-Longitude Ten Minute Block: 342-1114
Land Management: U.S. Forest Service, Prescott National Forest, Verde Ranger District (West of Verde River)
U.S. Forest Service, Coconino National Forest, Beaver Creek Ranger District (East of River)
Closure: Coconino and Prescott National Forest Closure
Order No. 16-52
Enacted 23 October 1984
Closed To All Entry 1 December - 15 June
Revised 1987 - Closed To All Entry 1 December - 30 June
Distance From Phoenix: Air - 114.0 km North
Distance To Nearest Breeding Area Upstream: Perkinsville—108.2 Km; Air—60.0 km
Distance To Nearest Breeding Area Downstream: East Verde—21.6 Km; Air—17.0 km
Distance From Salt River Confluence: 157.9 Km
Home Range: Km 157.0 to Km 187.0 on Verde River (Total = 30.0 Km)
Quadrangles: Horner Mountain 7.5 Minute
Camp Verde 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	1972	Existing - Found 1972. Rubink No. 26. Used by golden eagles in 1989.
2		Cliff	1973	Existing - Found 1972. Rubink No. 27.
3		Cliff	1977-1980 1986-1987 1989	Existing - Found 1972. Rubink No. 29.
4		Cliff	1981-1983 1985 1988 1990	Existing - Found 1972. Rubink No. 30.
5		Cliff	1984	Existing - Found 1972. Rubink No. 28.

LADDERS BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1962–1971	Active	?	?	?	Active every year since 1962.
1972	Failed	1+	0	0	
1973	Successful	1+	1+	1+	At least one young fledged.
1974	Unoccupied				
1975	Unoccupied				
1976	Unoccupied				
1977	Failed	1	0	0	One egg collected.
1978	Occupied				
1979	Failed	1+	0	0	
1980	Successful	2+	2	2	
1981	Successful	2+	2	2	
1982	Failed/Foster	2	0(2)	0(2)	Two eggs collected. Two young from Horseshoe breeding area fostered into nest and fledged.
1983	Successful	2+	2	2	
1984	Failed	1+	0	0	
1985	Successful	2+	2	2	
1986	Successful	2+	2	2	
1987	Failed	2+	2	0	One eaglet died in nest 5 May. Other young prefledged 5 May. Returned eaglet to nest 7 May, but it died within minutes. Severe Mexican chicken bug infestation in nest.
1988	Successful	2+	2	2	One juvenile died 10 June (4 weeks after fledging), apparently killed by a great horned owl (decapitated). Adult female banded on left tarsus and black VID band placed on right tarsus.
1989	Successful	2+	2	2	Mexican chicken bugs in nest. Adult male banded on left tarsus and black VID band placed on right tarsus. Male hit in head by stooping peregrine falcon on 3 April. Male's flight immediately hampered by head injury and crash landed at nest. Male did not forage until 14 April and remained lethargic. Male died 6–10 May apparently from brain damage.

LADDERS BREEDING AREA (continued)

Productivity (cont'd.)

Year	Status	Eggs	Young	Fledged	Comments
1990	Failed	2	0	0	New male—banded on right tarsus. Adults incubated until 24 March. Two eggs collected. Second pair of adults defending area upstream of West Clear Creek. Male found dead in Verde River, near confluence of West Clear Creek, on 21 Dec 1990. Male was banded as nestling in 1984 at Horseshoe breeding area by Teryl Grubb, USFS.
Total		25+	17	15	
Years		16	16	16	
Mean		1.6	1.1	0.9	

D4.18 LONE PINE BREEDING AREA

The Lone Pine breeding area is located 173.5 km east of Phoenix, along the free-flowing Salt River in the remote country near the Black and White River confluence. In this area the Salt River flows through a canyon bounded by steep slopes and large promontory cliffs. The free-flowing Black and White rivers both meander through deep, narrow canyons, with vast stands of ponderosa pine on the mesas high above the rivers. Cave Creek is an intermittent stream which flows through a narrow canyon and enters the Salt River two km below the Black and White confluence. The white-water in this section of the Salt River is treacherous, and thus rarely does anyone raft or kayak here. The surrounding area is composed of rugged terrain filled with canyons.

D4.18.1 Habitat

The biotic community in the Lone Pine area is of the Upper Sonoran Life Zone. The upland habitat is characteristic of the Interior Chaparral Biome and the Great Basin Conifer Woodland Biome (see Section D2). Manzanita, prickly pear, and grasses grow among junipers and live oaks on the mesas, with ponderosa and pinyon pines scattered through the area. The riparian habitat in the canyon bottom is of the Sonoran Riparian Deciduous Forest and Woodlands Biome. Portions of the river bottom are bounded by cliff walls, although more open areas and side canyons support cottonwoods, sycamores, and pines.

Plate D33. Lone Pine cliff/ground nest (4), containing two 4 to 4.5-week-old eaglets along free-flowing Salt River, May 1988 (photo by D. Driscoll).

D4.18.2 Reproductive History

The Lone Pine breeding area may have existed prior to 1937 when Jenks and Stevenson (1937), reporting on bald eagles in Arizona, wrote, "Many sight records have been made for every month of the year, and several nests have been discovered in trees along rivers within the White Mountains." However, agency personnel did not find the nest site until 3 February 1984 (Grubb 1984). Due to its remote location in rugged terrain, data on the Lone Pine territory is limited to nest checks during ORA helicopter flights. Although the pair has laid at least eight eggs in the seven years of known occupancy, only three young have hatched and fledged. The Lone Pine eagles normally have not laid eggs prior to the first ORA flights in early February; however, they are usually incubating by the second flight in mid-March. The eagles have laid eggs from late-January to mid-March, which hatch from 5 March to 12 April, with young fledging from 28 May to 6 July (latest fledging date on record) (Table D4.18-1).

Table D4.18-1. Nesting chronology of the Lone Pine breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1984	< 20 March	—	—
1985	< 30 January	—	—
1986	< 29 January	5 March	28 May
1987	< 17 March	—	—
1988	8 March	12 April	6 July
1989	—	—	—
1990	< 21 March	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

Four nests have been found in the Lone Pine breeding area, one on a cliff (4), one in a pinyon pine snag (1), and two in live ponderosa pine trees (2, 3). Nest 1, found on 3 February 1984 (Grubb 1984), has been used by the eagles during 1984–1986, and in 1990. Nest 2 was also found on 3 February 1984 and was used by the Lone Pine pair in 1987. Nest 3 was found on 14 April 1987, about one km upstream of the Salt River confluence, on Cave Creek, and has not been used since its discovery. Nest 4, found on 28 April 1988, is situated on top of a cliff, and is basically a ground nest. The Lone Pine eagles used nest 4 during 1988–1989. All four nests are still in existence.

The Lone Pine eggs failed to hatch in 1984, 1985 (Grubb 1986a), and 1987; however the site fledged one young in 1986 and two in 1988. The breeding area was occupied in 1989; however, the eagles did not lay eggs in any known nest locations. Eggs were laid in 1990, although it is not known if young hatched. The eagles were incubating on 21 March, and the nest was empty when checked on 1 June.

The Lone Pine eagles appear to have a productivity problem. Although the pair has laid at least eight eggs in the seven years of known occupancy, only three eaglets have hatched and fledged. Since the pair fledged young in 1986 and 1988, pesticide contamination, an infertile adult, or one adult being part of another pair, are likely ruled out as possible reasons for nest failure. It is possible that the prey base in the nest area can not support the pair through incubation, or the river conditions in some years are such that prey is not available, and the adults must leave the nest to forage.

Although data on the prey base of the Lone Pine breeding area 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 taken in periods when fish become unavailable (see Section B4); non-fish prey have been found in the Lone Pine nest (see Section D4.18.4). It may be possible that a lack of prey availability is limiting productivity at Lone Pine; however, virtually no data exist on the foraging ecology of the Lone Pine eagles, and more information is needed to accurately determine the reasons for nest failure.

D4.18.3 Mortalities

No incidents of mortality have been recorded at the Lone Pine breeding area; however, this is likely due to the limited amount of data on the site.

D4.18.4 Known Foraging Areas and Food Habits

Virtually nothing is known about the foraging ecology of the Lone Pine eagles. The only data on prey utilization is limited to prey items observed delivered to the nest, and prey remains collected in the nest during 1986–1988 (Table D4.18-2). The presence of crappie remains in the nest suggests the Lone Pine eagles travel to upland lakes (reservoirs and stock ponds) for at least some foraging. See Section B5.1.7 for a detailed analysis of prey remains collected during 1986–1988.

Table D4.18-2. Prey species observed taken by bald eagles or collected from the nest at the Lone Pine breeding area.

Fish	Birds	Mammals
Channel catfish	Waterfowl	Unidentified lagomorph
Sucker sp.	Unidentified Anatidae	Elk
Smallmouth bass		Cow
Unidentified Centrarchidae		
Crappie sp.		**Herptiles**
		None found

D4.18.5 Human Impacts

The remote location of the Lone Pine breeding area likely precludes human disturbance. Due to the treacherous white-water, even rafters and kayakers rarely (if ever) float this section of the Salt River. However, a fishing stringer was found in the nest in 1984 (Grubb 1984); the item may have washed down from the White or Black rivers, although no data on fishing activity are available for this area.

D4.18.6 Wildlife Interactions

Due to the limited amount of data on the Lone Pine breeding area, no wildlife interactions have been recorded at this site.

D4.18.7 Wildlife Sightings

The Lone Pine breeding area supports a variety of wildlife due to the vegetation form, plant species composition, and the lack of human activity. Common black hawks are often sighted in the area, as are golden eagles, and non-breeding or wintering bald eagles. Ospreys nest on the Black and White rivers, although no nests are known to occur along the Salt. A great blue heron rookery is located at the confluence of Cave Creek, on the Salt River. Black (cinnamon) bears and mountain lions also occur in the area, and we have observed their tracks and scat along the river and on the mesas.

D4.18.8 Management Recommendations

1. More data are needed on the foraging ecology and nesting activities of the Lone Pine eagles in order to determine why the eggs fail to hatch in most years.

2. Scheduling ORA flights on a once per month basis from February through June could provide more data on egg or nestling mortality at Lone Pine.

LONE PINE BREEDING AREA

Date Discovered: 3 February 1984 (1937)
Drainage: Salt River (Free-flowing)
Elevation (MSL): 4180 - 4400 ft
County: Gila
Latitude-Longitude Ten Minute Block: 334-1101
Land Management: U.S. Bureau of Indian Affairs
San Carlos Indian Community
(South of Salt and Black rivers)
Fort Apache Indian Community
(North of Salt and Black rivers)
Distance From Phoenix: Air - 173.5 km East
Distance To Nearest Breeding Area Upstream: None
Distance To Nearest Breeding Area Downstream: Cedar Basin-14.1 Km
Air - 11.0 km
Distance From Black and White River Confluence: 2.1 Km
Distance From Granite Reef Dam: 241.4 Km
Home Range: Unknown
Quadrangles: Carrizo SE 7.5 Minute
Popcorn Canyon 7.5 Minute
Cone Butte 7.5 Minute
Forks Butte 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Pinyon	Snag	1984–1986 1990	Existing - Found 3 Feb 1984.
2	Ponderosa	Live	1987	Existing - Found 3 Feb 1984.
3	Ponderosa	Live	Unknown	Existing - Found 14 April 1987.
4		Cliff/Ground	1988–1989	Existing - Found 28 April 1988.

LONE PINE BREEDING AREA (continued)

Productivity Year	Status	Eggs	Young	Fledged	Comments
1937	Unknown	?	?	?	Reports of tree nests along rivers within the White Mountains.
1984	Failed	2	0	0	
1985	Failed	1+	0	0	
1986	Successful	1+	1	1	
1987	Failed	1+	0	0	
1988	Successful	2+	2	2	
1989	Occupied				
1990	Failed	1+	?	0	Adults incubating on 21 March. No young in nest on 1 June.
Total		8+	3	3	
Years		7	6	7	
Mean		1.1	0.5	0.4	

D4.19 MULE HOOF BREEDING AREA

The Mule Hoof breeding area is located 149 km east of Phoenix, along the free-flowing Salt River below the Highway 60 bridge, upstream of Cibecue Creek. In this area, the Salt River flows through a narrow canyon (Salt River Canyon) bounded by large promontory cliffs. Cibecue Creek is a free-flowing perennial stream which meanders through a deep chasm bounded by large cliffs and enters the Salt River from the north. Cibecue Creek has three waterfalls on it, the first one, occurring 2–3 mi upstream of the Salt River, is 30–40 m high. The surrounding area is composed of rugged terrain filled with canyons.

Upstream of the Highway 60 bridge, the Salt River Canyon is joined by Walnut Canyon and Flying V Canyon from the north, and Sawmill Canyon from the south. In the Mule Hoof Bend area, Cienega Creek, Mule Hoof Canyon, and Phillips Canyon enter from the south, followed by Coyote Canyon from the north. The high slopes in this section of the Salt River Canyon display the tailings of abandoned mining operations, and the trails used by miners.

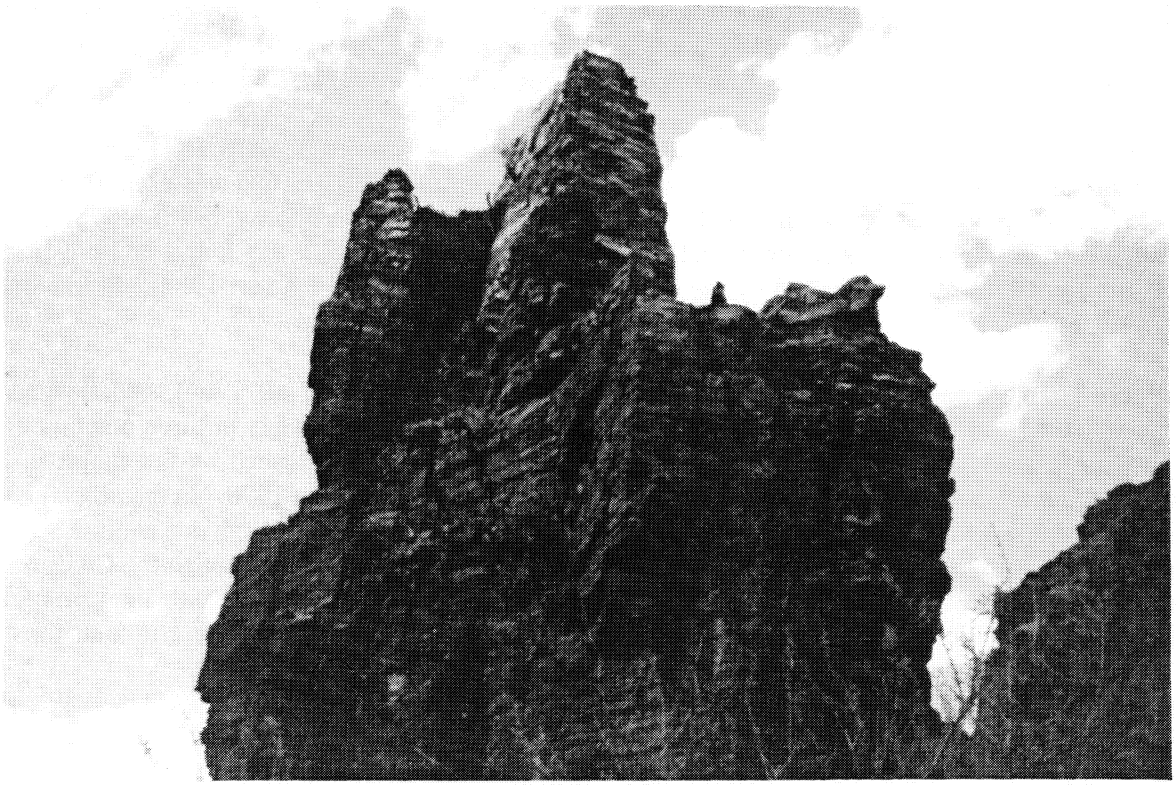

Plate D34. Mule Hoof pinnacle nest (1) which has been present since at least 1935, and is still in good condition, May 1987 (photo by D. Driscoll).

D4.19.1 Habitat

The biotic community in the Mule Hoof area is of the Upper Sonoran Life Zone. The upland habitat is characteristic of the Interior Chaparral Biome and the Great Basin Conifer Woodland Biome (see Section D2). Manzanita, prickly pear, and grasses grow amongst junipers and live oaks on the mesas above the canyon. Riparian habitat along the creeks and river in the canyon bottom is a mixture of the Sonoran Riparian Deciduous Forest and Woodlands Biome, the Sonoran Riparian Scrubland Biome, and the Sonoran Interior Strands Biome. Portions of the Cibecue Creek are bounded by cliff walls, although more open areas support large cottonwoods and sycamores.

The free-flowing Salt River contains variable flows, and due to the narrow canyon, heavy rains (especially during spring snowmelt) can be transformed into a wall of destruction. During heavy rains in mid-March 1985, a 12-foot wall of water came through the Mule Hoof area.

D4.19.2 Reproductive History

The Mule Hoof breeding area was discovered by agency personnel in 1974 (Rubink and Podborny 1976); however, nesting activity was reported at this site prior to the 1930s. The nest site was active in 1935, and Housholder, in Phillips *et al.* (1964), reported, "This nest said by Indians to have been used for many years; birds seen again there in 1944 and 1949." The only data on nesting chronology available for the Mule Hoof eagles are from ORA helicopter flights on 20 Feb. 1975 (Rubink and Podborny 1976) and 3 Feb. 1978 (Rubink, unpublished field notes), when adults were observed incubating. No data exist on hatching or fledging dates from the one known successful year in 1974 (Table D4.19-1).

Two known nests have been built by the Mule Hoof eagles, one on a rock pinnacle (1), and one on a juniper snag (2) 25–30 m west of nest 1. Nest 1 was built prior to the 1930s, and was used by the eagles in 1935, 1944, 1949 (Phillips *et al.* 1964), 1974, 1975 (Rubink and Podborny 1976), 1978 (Rubink, unpublished field notes), 1979 (Ohmart and Sell 1980), and 1990. Nest 2 was found in 1974 (Rubink and Podborny 1976) and refurbished by the eagles in 1982 (Haywood and Ohmart 1983). Both nests are still in existence.

The Mule Hoof breeding area was reported as active in 1935 (Phillips *et al.* 1964), and fledged two young in 1974 (Rubink and Podborny 1976). The Mule Hoof eagles laid eggs in three other years for which data is available (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. A pair of adults was sighted in nest 1 on 5 February 1990, although the Cibecue birds (which nest 6 km downstream) were not seen on that date. It is possible the Cibecue pair were perched in the Mule Hoof nest, although it is also possible the Cibecue eagles were elsewhere in their territory.

The two known Mule Hoof nesting locations were unoccupied during 1976–1977 and 1980–1989. There are several hypothesis that may explain the apparent lack of occupancy at the Mule Hoof breeding area.

Hypothesis 1. The Mule Hoof eagles have alternate nests upstream of the Highway 60 bridge.

Hypothesis 2. The habitat can not support two bald eagle breeding areas in this section of the Salt River. (The Cibecue eagles nest is 6 km downstream).

Table D4.19-1. Nesting chronology of the Mule Hoof breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1974	—	—	—
1975	< 20 February	—	—
1976	—	—	—
1977	—	—	—
1978	< 3 February	—	—
1979	—	—	—
1980	—	—	—
1981	—	—	—
1982	—	—	—
1983	—	—	—
1984	—	—	—
1985	—	—	—
1986	—	—	—
1987	—	—	—
1988	—	—	—
1989	—	—	—
1990	—	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

Hypothesis 3. The Mule Hoof and Cibecue eagles are the same pair.

Hypothesis 4. The Mule Hoof and Ash eagles are the same pair.

The third hypothesis has been debated in the past among biologists involved with bald eagles in Arizona, and the fourth was presented as a possibility in Grubb (1986a).

Discussion of Hypothesis 1. In addition to the two known nests, the Mule Hoof pair may have other nest sites upriver. White-water rafting and kayaking have become popular on the upper Salt River, and the main launching location is within one km of the Mule Hoof nests. The white-water season is also concurrent with the bald eagle breeding season. In addition, a well worn trail runs from the river access road to a point directly under the pinnacle nest. The Salt River Canyon and side canyons upstream of the Highway 60 bridge contain numerous of cliffs. It is possible that the Mule Hoof pair have alternate nests upriver, away from human disturbance. However, in an area of such plentiful potential nesting locations, finding the pair without telemetry would be very difficult.

Discussion of Hypothesis 2. Mule Hoof may be a territory with marginal foraging habitat, further aggravated by recreation pressure and disturbance. Although data on the cause of nest failure at Mule Hoof are limited, the Mule Hoof and Cibecue eagles have not hatched eggs or fledged young in the same year. The Cibecue breeding area was discovered in 1973, and even though early records existed for Mule Hoof, agency personnel were not aware of the nests until 1974 (Rubink and Podborny 1976). Cibecue successfully fledged one young in 1973, although no data exist for Mule Hoof in 1973. In 1974, Mule Hoof fledged two eaglets; however, no data exist for Cibecue in 1974. In 1975, Cibecue produced one young and the Mule Hoof eggs failed to hatch. Both sites were unoccupied at known nest locations in 1976. In 1977, Mule Hoof remained unoccupied, while at Cibecue one eaglet disappeared from the nest. Cibecue fledged two young in 1978, when the Mule Hoof eggs failed to hatch. Both nest sites failed in the egg stage in 1979. The Mule Hoof breeding area has been recorded as unoccupied during 1980–1981, and 1983–1989. The site was occupied in 1982, and 1990, but apparently no eggs were laid. Cibecue, however, continues to produce young (Rubink and Podborny 1976, Haywood and Ohmart 1983, Grubb 1986a, this report).

The Salt River upstream of Mule Hoof runs fast through a narrow canyon. At Mule Hoof Bend and downstream, riffles begin to appear, and the habitat becomes more suitable for bald eagle foraging (see Section A3). BioSystems' air surveys of river habitat revealed what appeared to be exceptional eagle foraging habitat (super-riffles) in the Mule Hoof vicinity. But, recreation pressure is also high. White-water rafting and kayaking have become popular on the upper Salt River, and the main launching location is within one km of the Mule Hoof nests. The white-water season also coincides with the bald eagle breeding season. In addition, a well worn trail runs from the river access road to a point directly under the pinnacle nest.

Although the foraging habitat in the Mule Hoof area appears to be suitable to bald eagles, it is possible that the natural habitat, further degraded by recreation pressure, will not support two productive bald eagle breeding areas in this section of the Salt River.

Discussion of Hypothesis 3. It has been debated in the past that the Cibecue and Mule Hoof eagles (which nest 6 km apart) are the same pair; however, productivity data at each territory effectively rule out this possibility. In 1975, both pairs laid eggs, and the Cibecue eagles fledged one young, while the Mule Hoof eggs failed to hatch. Both sites were unoccupied at known nest locations in 1976. In 1978, both pairs were observed incubating on the same ORA flight, and the Cibecue eagles subsequently fledged two young, while the Mule Hoof eggs failed to hatch (Rubink, pers. comm., Hildebrandt 1981). Eggs were laid at both nest sites again in 1979, although both failed in the egg stage.

Discussion of Hypothesis 4. Grubb (1986a) presented the possibility that the Ash eagles may be the Mule Hoof pair, which moved inland. Both breeding areas have a history of remaining unoccupied at known nest locations, although each pair may have alternate nests we have not found yet. The two Ash nests were reported as occupied in 1982 (B. Jackson, pers. comm.), although the breeding area was not found by agency personnel until 2 May 1984. Mule Hoof was also occupied in 1982 (Haywood and Ohmart 1983), although exact dates of sightings are unavailable for both sites. Data on the Ash pair is limited, since the nest was only active for two years (1984–1985) at known nest locations. Even then, data collection was limited to scattered sporadic nest checks in 1985 (Driscoll 1985b). It is possible (due to lack of data on each site) that the Mule Hoof and Ash sites may be the same eagles; however, this is unlikely given our current knowledge of bald eagles, their nesting and foraging ecology, and nest

distribution in Arizona. No productivity data exist to support or negate this hypothesis, since both territories have been unoccupied at known nest locations in recent years.

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). This may seem like a considerable distance; however, Arizona bald eagles have been known to travel 22 Km up tributaries to forage (see Section D4.12). Thus, by nesting inland the Ash pair can easily access either section of the river, and likely avoid the Cibecue and Canyon pairs which nest in between. The Mule Hoof breeding area occurs at Km 191 on the Salt River, and if nests 1 or 2 were active, the Mule Hoof eagles would likely exclude the Ash pair from this area. Currently, the status of both breeding areas remains a mystery, and it is not known where the Ash or Mule Hoof eagles forage.

D4.19.3 Mortalities

No incidents of mortality have been recorded at the Mule Hoof breeding area; however, this is likely due to the limited amount of data on the site.

D4.19.4 Known Foraging Areas and Food Habits

No data exist on the foraging ecology or food habits of eagles at the Mule Hoof breeding area.

D4.19.5 Human Impacts

Human disturbance would be a problem at the Mule Hoof breeding area if the site is used in the future. This section of the Salt River, from Mule Hoof Bend to just above Cibecue Creek, is the launching spot for numerous rafters and kayakers that float the Salt River. De Candido (1985) reported that during high volumes of rafting and kayaking traffic, one group passed below the Cibecue eagle nest (6 km downstream) at least every ten minutes. Rafters and kayakers also congregate at a launch site within one km of the Mule Hoof nest site, and the white-water season coincides with the bald eagle breeding season. In addition, a well worn trail runs from the river access road to a point directly under the pinnacle nest.

D4.19.6 Wildlife Interactions

Due to the limited amount of data on the Mule Hoof breeding area, no wildlife interactions have been recorded at this site.

D4.19.7 Wildlife Sightings

Peregrine falcons nest in the Mule Hoof area and are commonly sighted, occasionally interacting with the Cibecue bald eagles. Other raptors observed include red-tailed hawks, Cooper's hawks, sharp-shinned hawks, ospreys, golden eagles, American kestrels, and zone-tailed hawks. Anna's, Costa's, and rufous hummingbirds have been sighted in the area, along with vermillion flycatchers, rose-breasted grosbeaks, blue grosbeaks, lazuli buntings, indigo buntings, purple finches, verdins, loggerhead shrikes, acorn and ladder-backed woodpeckers, Stellar's jays, common crows, hooded and Scott's orioles, and snowy egrets (De Candido 1985, Kershaw and Mehling 1990). Ringtails and raccoons are common mammals. Herptiles of interest include western diamondback rattlesnakes, gopher snakes, black-necked garter snakes, and Sonoran mud turtles (Kershaw and Mehling 1990).

D4.19.8 Management Recommendations

1. If the Mule Hoof breeding area is found active in the future, a closure will be necessary to protect the birds; however, without a closure disturbance may preclude any occupancy or nest activity. The

large amount of recreation in the area and the accessibility of the nests are very possibly the reasons the site is not used. Foraging habitat in the Mule Hoof Bend area appears very suitable to bald eagles.

2. A study of the foraging ecology of the Cibecue and Ash eagles and the prey base in the Mule Hoof area might help to explain why the Mule Hoof breeding area has not been active in recent years. This study might also determine: (1) if the Ash eagles utilize the Mule Hoof Bend area of the Salt River; (2) if the Mule Hoof eagles have unknown nest locations upstream of the Highway 60 bridge; and, (3) if the Cibecue eagles utilize the Mule Hoof Bend area.

MULE HOOF BREEDING AREA

Date Discovered: 1974. Earliest Records 1935. (1920s and 1930s).
Drainage: Salt River (Free-flowing)
Elevation (MSL): 3280 - 3480 ft
County: Gila
Latitude-Longitude Ten Minute Block: 334-1103
Land Management: U.S. Bureau of Indian Affairs
Fort Apache Indian Community (North of River)
San Carlos Indian Community
(South of Salt River and West of Mule Hoof Bend)
U.S. Forest Service, Tonto National Forest,
Globe Ranger District
(South of Salt River and East of Mule Hoof Bend)
Distance From Phoenix: Air - 149.5 km East
Distance To Nearest Breeding Area Upstream: Cedar Basin - 29.6 Km
Air - 14.0 km
Distance To Nearest Breeding Area Downstream: Cibecue - 7.0 Km
Air - 6.0 km
Distance From Granite Reef Dam: 189.6 Km
Distance From Highway 60: Air - 0.5 km
Home Range: Unknown
Quadrangles: Blue House Mountain 15 Minute
Mule Hoof Bend 7.5 Minute
Becker's Butte 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Pinnacle	1935 1944 1949 1974–1975 1978–1979 1990	Existing - Built prior to 1935. Rubink No. 8.
2	Juniper	Snag	1982	Existing - Found 1974. Rubink No. 9.

MULE HOOF BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1920s	Occupied	?	?	?	Bald eagles reported nesting for
1930s	Occupied	?	?	?	many years prior to 1935.
1935	Active	1+	?	?	
1944	Occupied	?	?	?	
1949	Occupied	?	?	?	
1974	Successful	2+	2	2	
1975	Failed	1+	0	0	
1976	Unoccupied				
1977	Unoccupied				Adult sighted in nest 2.
1978	Failed	1+	0	0	
1979	Failed	1+	0	0	
1980	Unoccupied				
1981	Unoccupied				
1982	Occupied				Nest 2 rebuilt.
1983	Unoccupied				
1984	Unoccupied				
1985	Unoccupied				
1986	Unoccupied				
1987	Unoccupied				
1988	Unoccupied				Adult sighted in nest 1 on 1 February.
1989	Unoccupied				
1990	Occupied				Pair of adults at nest 1 on 5 February.
Total		6+	2	2	
Years		7	6	6	
Mean		0.8	0.3	0.3	

D4.20 ORME BREEDING AREA

The Orme breeding area is located 38 km east of Phoenix, at the confluence of the Salt and Verde rivers. The Salt River is regulated by Stewart Mountain Dam, while the Verde is regulated by Bartlett Dam. The Salt River is backed up by Granite Reef Diversion Dam, 5.5 km below the confluence of the Verde, creating a small impoundment (Maxwell Reservoir). Granite Reef Dam diverts the river water into canals for use in the Phoenix Metropolitan Area and the Salt riverbed is thus dry through Phoenix. The surrounding area is bottomland riparian and desert, with steep slopes bounding the valley. Due to the large amount of recreation pressure on the Salt River below Stewart Mountain Dam, 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 glass containers.

D4.20.1 Habitat

The biotic community in the Orme area is of the Lower Sonoran Life Zone. 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

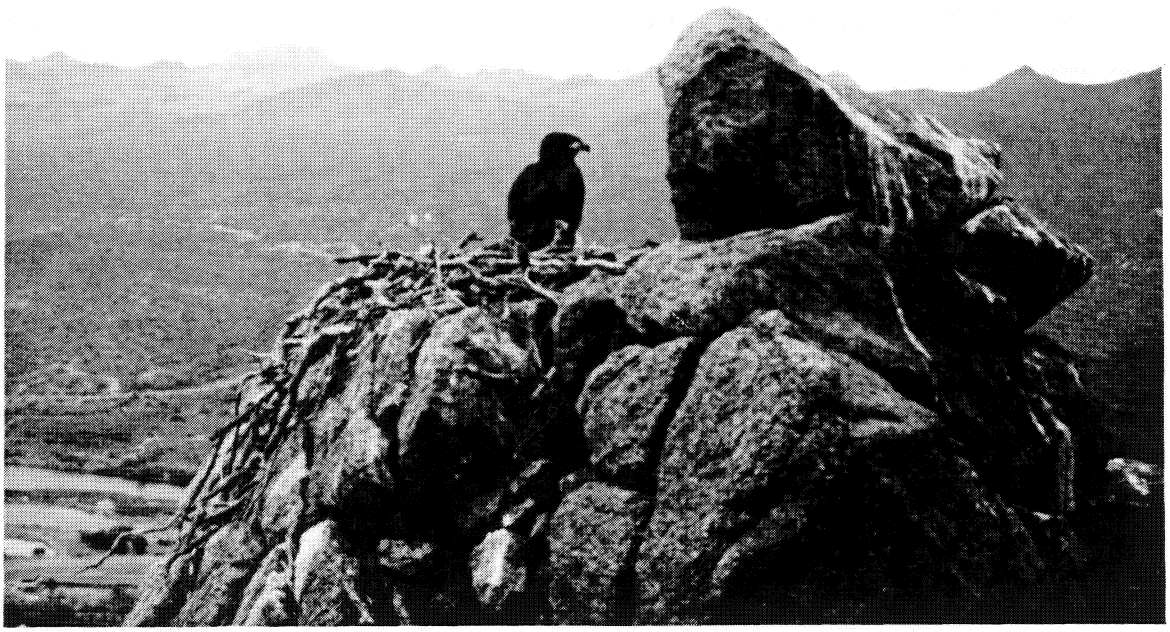

Plate D35. Orme pinnacle nest (1) containing one 8 to 8.5-week-old eaglet, April 1988 (photo by D. Driscoll).

Deciduous Forest and Woodlands Biome, the Sonoran Riparian Scrubland Biome, and the Sonoran Interior Strands Biome (see Section D2).

The regulated Salt River below Stewart Mountain Dam contains highly variable flows. Portions of the river are dry part of the year, with isolated pools in the riverbed from the dam to the Verde River confluence. The river remained completely dry (0 cfs) from 22 January to 5 March 1989, and again in the winter and spring (until 28 March) of 1990. Cottonwoods and mesquite bosques in various stages of decay are scattered along the river. The entire cottonwood grove near the Blue Point Ranger Station burned in November 1987. Large promontory cliffs (Bulldog Cliffs) exist near the dam, followed by the smaller Blue Point Cliffs, and a small set of cliffs near Blue Point Ranger Station. After the Verde River confluence the Salt continues to Granite Reef Dam, where it is diverted into canals for irrigation and the Phoenix Metropolitan Area. Maxwell Reservoir, a small impoundment created by the diversion dam, supports waterfowl through winter and spring.

The regulated Verde River also contains variable flows, controlled by Bartlett Dam and diversions for agricultural fields on the Fort McDowell Reservation. Cottonwood trees and scattered mesquite bosques, in various stages of decay, line the lower Verde as it flows to its confluence with the Salt River. The Verde River in the Orme area has been bulldozed to modify flow.

D4.20.2 Reproductive History

The Orme breeding area was discovered by agency personnel in 1986; however the site was reported active since the 1970s (Water Treatment Plant Operators). The Orme eagles have laid eggs from 30 December to 12–15 February, hatching young from 2 February to 19–22 March, and fledging eaglets from 3 May to 9 June (Table D4.20-1).

Table D4.20-1. Nesting chronology of the Orme breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1986	—	—	—
1987	30 December	2 February	3, 5 May*
1988	18 January	21 February	7 May*
1989	—	—	—
1990	12–15 February	19–22 March*	9 June*

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

The Orme eagles have built three known nests, a pinnacle nest (1) on Arizona Dam Butte, a cliff nest (3) on Mount McDowell, and a nest in a snag-top cottonwood tree (2) on the regulated Salt River below the Verde River confluence. Nest 1 was built prior to the 1970s (Water Treatment Plant Operators); however, the nest was not found by agency personnel until 27 March 1987. Nest 1 successfully fledged

young in the 1970s, 1980s, 1987, and 1988. Nest 1 may have also fledged young in 1986. Nest 2 was built in 1986 on top of a great blue heron rookery; however, no eggs were laid in nest 2 that year. A juvenile bald eagle was sighted several times at the Verde and Salt River confluence in June 1986, indicating young likely fledged from nest 1 or nest 3 which were unknown at the time.

Nest 2 fell, along with the supporting branches, between July and November 1987. Nest 3 was found on 22 February 1990 (M. Cross, pers. comm.), successfully fledging one eaglet that year. Nest 3 may have also been used in 1989, when the eagles were in the area, but not using nest 1 or 2. As stated previously, nest 3 may have fledged young in 1986, prior to its discovery. The remains of an eaglet were found below nest 3 on 13 May 1990. The state of decomposition of bone material ruled out the possibility of the eaglet being from 1989; therefore the young would have fallen from the nest in 1986 or prior. Nest 3 is very large, measuring 2.9 × 2.4 m (9.5 × 7.8 ft), with a cave area behind the nest, offering shade most of the year. Nests 1 and 3 are still in existence.

It is worth noting that three tree nests considered to belong to an adjacent pair of eagles (Blue Point nests 2, 3, and 4) probably were nests of the Orme pair. The nests were located only 4.5 river Km from the confluence of the Salt and Verde rivers, well within the home range of the Orme eagles. In addition, local water treatment plant operators affirmed the Orme eagles had fledged young at least since the early 1970s. However, for the purpose of convention, and the integrity of early records, we reported these nests as belonging to the Blue Point pair (see Section D4.4).

In 1988, we found a parasite on the Orme eaglets which was 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.

D4.20.3 Mortalities

There has only been one documented juvenile bald eagle death at the Orme breeding area. As stated above, nest 3 was found on 22 February 1990; however the nest existed prior to its discovery. The remains of an eaglet (not from 1990) were found below nest 3 on 13 May 1990. The state of decomposition of bone material ruled out the possibility of the eaglet being from 1989, when the adults may have used nest 3. Therefore the eaglet would have fallen from the nest in 1986 or prior, since the Orme eagles fledged young from nest 1 in 1987 and 1988.

Adult mortality may be a serious problem at the Orme breeding area, as two known adult replacements have occurred since 1987. The Orme male was replaced between September and October 1987 by a very dark near-adult, likely 3.5 years old. In 1989, the Orme female was replaced by a near-adult. The female in 1990 displayed brown markings in her head, although this may have been the same female as 1989.

Shooting may be a serious problem at Orme. There is a high rate of turnover in the Orme and Blue Point adult pairs, and a person was seen shooting at one of the Orme adults in December, 1990. Although witnesses reported the adult appeared to fall from its perch, no carcass was found. Also, a juvenile eagle may have been shot at Blue Point in 1987 (see Section D4.4).

In addition, a Horseshoe eaglet banded in 1987 was found dead in 1990 near the Salt and Verde River confluence. 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 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.

D4.20.4 Known Foraging Areas and Food Habits

Although the Orme adults were not telemetered, we did observe them utilizing the Verde River from the Highway 87 bridge (Km 4.0) to the confluence (Km 0.0), and the Salt River from Km 7.0 to the Granite Reef Diversion Dam (Km 0.0). In 1987, the female regularly flew down to Maxwell Reservoir, near the diversion dam, to forage in the early morning. The male also frequented the lower Salt River, but would usually fly up the Verde first. The male had favorite cottonwood perches in Km 3 on the Verde, where he was mostly hidden from human sight, but still had a view of the river. The male then would typically make his way down to the confluence, and venture up or down the Salt River. The male also spent considerable time on the nest 2 snag in the evening, occasionally roosting there. In addition, we observed the adults foraging in a backwater area, created with a bulldozer, at the confluence of the Salt and Verde rivers.

Fawcett *et al.* (1990) observed the Orme adults flying further up the Salt, with one forage recorded at Km 14.3 near Blue Point Cliffs. In 1990, most forages were observed on the Salt River, below the Verde confluence. The eagles consistently foraged off sandbars at Km 2.9–3.1 and Km 4.1 on the Salt, often landing and then jumping on prey in the river (Fawcett *et al.* 1990). Prescott and Brashear (1987) also reported foraging more on the Salt than the Verde.

Although AGF annually stock trout on the lower Salt and Verde rivers, the Orme eagles were not observed using trout in 1987 or 1990. It is likely that trout are utilized by the Orme eagles, but use simply has not been observed. The breeding areas immediately upstream on the Salt (Blue Point) and the Verde (Fort McDowell) are reported to use the trout extensively after stocking. In fall 1987, many trout were caught by fishermen in the Maxwell Reservoir area. We found no evidence in the prey remains of significant use of trout by either the Orme, Blue Point, or Ft. McDowell pairs; however, even in a controlled feeding experiment, trout did not show up in prey remains (see Section B5.1.11).

The home range of the Orme pair is unknown since the adults have not been telemetered. However, the Orme eagles have been observed utilizing Km 0.0 to Km 14.3 on the Salt River, and Km 0.0 to Km 4.0 on the Verde River, totaling 18.3 Km. The area utilized for foraging by the Orme eagles on the Salt River overlaps with the home range of the Blue Point pair, which use the Salt down to Km 6. The Fort McDowell eagles have been visually tracked several times to a snag perch in Km 5 on the Verde River. We observed the Orme eagles in Km 4 on the Verde, but did not record them upstream of the Highway 87 bridge.

Prey items described by Fawcett *et al.* (1990) are presented in Table D4.20-2, along with prey items taken by the eagles and prey remains collected at the nest during 1986–1989. See Section B5.1.4 for a detailed analysis of prey species utilized by the Orme eagles. In addition, the eagles were observed attempting to capture mallards (Fawcett 1990). The Orme adults were also observed stealing prey from great blue herons (Prescott and Brashear 1987).

Table D4.20-2. Prey species observed taken by bald eagles or collected from the nest at the Orme breeding area.

Fish	Birds	Mammals
Carp	Waterfowl	Cottontail rabbit
Channel catfish	Anas sp.	Blacktail jackrabbit
Largemouth bass	Wading Birds	Ground squirrel
Black bass	American coot	Unidentified Sciuridae
Unidentified Centrarchidae	Raptors	
Desert sucker	Turkey Vulture	**Herptiles**
Sonora sucker	Passerines	None found
Lepomis sp.	Western meadowlark	
	Unidentified passerine	
	Other Birds	
	Gambel's quail	

D4.20.5 Human Impacts

Human disturbance is a serious problem at the Orme breeding area. Due to its close proximity to Phoenix, the lower Salt and Verde rivers receive much recreation pressure. Tubing on the Salt River extends from March to September each year, and on weekends in the summer as many as 40,000 people are on the river (Section B4.2). The tubing "start point" is immediately across the river from the Blue Point nests, and the "stop point" is upstream of the Verde confluence; however some tubers continue to the confluence area. Tubers do not pose a physical threat to the eagles, but they may interrupt foraging, and the Blue Point eagles switch to alternate foraging locations when tuber numbers increase in the summer and on weekends (Sherman 1983, Canestorp *et al.* 1984, Collie *et al.* 1985, and Section B4.2). Tubers also attempted to capture a pre-fledged Blue Point eaglet which could not yet fly well (Collie *et al.* 1985). In addition, Fawcett *et al.* (1990) observed the Orme eagles flushed from perches by tubers and rafters on the Salt and Verde rivers.

The lower Salt and Verde rivers are popular fishing spots, especially following trout stocking by AGF. We observed the adults flushed from perches by fishermen in 1987, as did Fawcett *et al.* (1990). Fishermen tend to lose and discard monofilament fishing line. Monofilament has been found in the Orme nest, as well as other bald eagle nests in Arizona, and eaglets have died from becoming entangled in monofilament at the nest (Section D4.22.3, also see Section C3.3). Two oriole nests made almost entirely of monofilament were found at the confluence of the Salt and Verde rivers. 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 an oriole nest similar to the two found at the Salt and Verde river confluence, the female oriole hung itself in a loop of the monofilament (Mather 1987).

The increasing amount of recreational disturbance on the lower Salt and Verde rivers appears to have forced the Orme and Blue Point eagles into less populated areas to nest and possibly to sub-optimum nest

sites. Nest 6 at Blue Point is located 1.6 km inland from Saguaro Reservoir on a cliff in rugged terrain. Similarly, nests 1 and 3 at the Orme breeding area are located 1.5 to 2 km inland from the Salt River, high up on Arizona Dam Butte and Mount McDowell. In both cases, the eagles have chosen to nest in areas more typical of golden eagle nesting sites, away from the river. These observations suggest that recreation is rendering nest sites along the river unsuitable for breeding. But even at the remote nest locations, hikers can disturb the eagles. Fawcett *et al.* (1990) recorded hikers flushing the eagles near the nest, and trails in the area received heavy use.

Shooting may be problem at Orme, especially when the adults are foraging along the rivers (Prescott and Brashear 1987, Fawcett *et al.* 1990). There is a high rate of turnover in the Orme and Blue Point adult pairs and a Blue Point juvenile eagle may have been shot in 1987 (see Section D4.4.3). In addition, a subadult eagle, banded in 1987 at the Horseshoe breeding area, was found dead (likely shot) in the Orme breeding area in 1990 (see the Mortality section above). Gunshots also caused the Orme adults to flush from perches in 1990 (Fawcett *et al.* 1990).

Much of the Salt River remains dry during part of the year, with isolated pools occurring from Stewart Mountain Dam to the Verde River confluence. The Arizona bald eagle breeding season, from nest building to the fledging of young, ranges from November to June at most sites. During the 1987, 1988, 1989, and 1990 breeding seasons, the Salt River flow was terminated at the dam. The USGS gaging station below the dam recorded flows of less than 9 cfs from October 1986 to 1 January 1987, and less than 11 cfs from 23 February to 9 March 1987. In the 1988 season, flows of 9–13 cfs from 4 October 1987 to 21 February 1988 were recorded, excluding five days with flows of 14, 16, 17, 18, and 26 cfs. Once again, the river was shut-off during the 1989 bald eagle breeding season, with flows of 4–7 cfs from 17 October to 2 November 1988, and 9–22 November 1988, 3–5 cfs from 29 November 1988 to 3 January 1989, 6 cfs on 10 January, 4 cfs on 11 and 12 January, and 1–3 cfs from 13–21 January. These flows are attributed to leaking at the dam; however, the dam was repaired in January 1989 and leakage ceased.

Through the 1989 season, with the Blue Point pair attempting to raise eaglets 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. The Orme territory was unoccupied at nests 1 and 2 in 1989, although the eagles may have been nesting in nest 3, which was undiscovered at the time. Increased disturbance and lack of foraging opportunities in the dry river likely contributed to the mortality of the two Blue Point eaglets in 1989 (see Section D4.4.3). The lower Salt River also remained dry during the most of the 1990 bald eagle breeding season, with no flow until 28 March.

The Salt River below Stewart Mountain Dam supports a large population of desert and Sonora suckers. 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 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. The effects on sucker populations of the complete shut-offs (0 cfs) in 1989 and 1990 are unknown to us. See Section B4.2 for details on fish populations at Blue Point and Orme.

Discussing human impacts at the Orme breeding area, Prescott and Brashear (1987), Ferrara *et al.* (1988), and Fawcett *et al.* (1990) all stated that low level military helicopters and private aircraft were abundant in the nest area. Although most aircraft were ignored or simply watched by the eagles, low level

helicopters, especially military Apache™ helicopters, flushed the adults on numerous occasions. Similar disturbances were reported at the adjacent Blue Point and Fort McDowell breeding areas.

D4.20.6 Wildlife Interactions

At Orme, interspecific interactions were numerous with prairie falcons which likely nested nearby. The eagles also interacted with red-tailed hawks, Harris' hawks, common ravens, great blue herons, turkey vultures, and ospreys. Western kingbirds harassed the eagles at certain perches along the river (Ferrara *et al.* 1988, Fawcett *et al.* 1990 and BioSystems personnel 1986–1989). In addition, Fawcett *et al.* (1990) observed the adults diving on, and vocalizing at a coyote, driving it from the nest area. Most interactions with other bald eagles at Orme simply involved escorting the intruder out of the area (Fawcett *et al.* 1990). Four adults were observed near Orme nest 3 when it was found in 1990 (M. Cross, pers. comm.).

D4.20.7 Wildlife Sightings

Prairie falcons, red-tailed hawks, and Cooper's hawks nest along the rivers, and ospreys have been sighted in almost every month of the year. Along with the usual desert raptors, golden eagles, northern harriers, sharp-shinned hawks, common black hawks, and zone-tailed hawks are sighted occasionally. Snowy egrets, great egrets, and greater and lesser yellowlegs occur with spotted sandpipers, American avocets, Wilson's phalaropes, common moorhens, and water pipits on the river. Two great blue heron rookeries are also located along the river. Maxwell Reservoir supports waterfowl in winter and spring. Some of the species observed include mallards, American wigeon, green-winged and cinnamon teal, northern shovelers, and lesser scaup. Other birds sighted include verdins, rufous-sided and Abert's towhees, red-naped sapsuckers, ruby-crowned kinglets, loggerhead shrikes, Costa's and Anna's hummingbirds, Lucy's, yellow, and Wilson's warblers, northern orioles, vermillion flycatchers, Bell's vireos, inca doves, black-headed grosbeaks, and yellow-breasted chats. Beaver also occur near the Salt and Verde River confluence. Herptiles of interest include western diamondback rattlesnakes, black-tailed rattlesnakes, checkered garter snakes, desert tortoises, and gila monsters (Fawcett *et al.* 1990, and BioSystems personnel 1986–1989).

D4.20.8 Management Recommendations

1. When the eagles nest on Mount McDowell, the trail which brings hikers close to the nest should be closed. In addition, signs should be posted informing hikers that a permit is necessary to hike the trails. Also the jeep trail leading to Mount McDowell should be closed (Fawcett *et al.* 1990).

2. Shooting may be a serious problem at Orme. There is a high rate of turnover in the Orme and Blue Point adult pairs and a person was seen shooting at one of the Orme adults in December 1990, although it is unknown whether the eagle was hit (see Mortality section above). Also, a juvenile eagle may have been shot at Blue Point in 1987 (see Section D4.4.3). In addition, a subadult eagle, banded in 1987 at the Horseshoe breeding area, was found dead (likely shot) in the Orme breeding area (see the Mortality section above). Gunshots caused the Orme adults to flush from perches in 1990 (Fawcett *et al.* 1990). The current gun restriction should be enforced on the lower Salt River.

3. Due to the high level of recreational pressure at the Orme breeding area, ABENWP personnel should begin coverage in late December, instead of the normal February start date. This would provide protection prior to egg laying, and during early incubation, when the nest is most susceptible to failure.

4. Studies are needed to determine if flow cessation from Stewart Mountain Dam affects foraging habitat for the Orme Pair.

5. Although large promontory cliffs exist on the reservoir and near the dam, perching substrate is lacking on the lower river. The existing trees are decaying and falling apart, and many were burned in the November 1987 fire. Cottonwood poles could be planted on the lower Salt and Verde rivers to provide future perch sites and maintain the riparian vegetation on the river. Due to beaver in the area, the young trees may need to be fenced in.

ORME BREEDING AREA

Date Discovered: 1986. (1970s).
Drainage: Salt and Verde River Confluence (Regulated)
Elevation (MSL): 1320 - 2600 ft
County: Maricopa
Latitude-Longitude Ten Minute Block: 333-1114
Land Management: U.S. Bureau of Indian Affairs
Salt River Indian Community (North of Salt River and south of Km 2.9 on Verde River)
Fort McDowell Indian Community (North of Km 2.9 on Verde River)
U.S. Forest Service, Tonto National Forest, Mesa Ranger District (South of Salt River)
Distance From Phoenix: Air - 38.5 km East
Distance To Nearest Breeding Area Upstream: Fort McDowell-12.6 Km
Air - 12.0 km
Distance To Nearest Breeding Area Downstream: Blue Point - 5.5 Km
Air - 5.9 km
Distance From Granite Reef Dam: 2.5 Km
Distance To Maxwell Lake: 0.5 Km
Home Range: Unknown. Known to utilize;
Km 0.0 to Km 14.3 on Salt River (Total = 14.3 Km)
Km 0.0 to Km 4.0 on Verde River (Total = 4.0 Km)
(Total = 18.3 Km)
Quadrangles: Granite Reef Dam 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Pinnacle	1970s	Existing - Built prior to 1970s.
			1980s	Young reported fledging from nest 1 at least since 1970s.
			1986?	Juvenile bald eagle perched at river confluence June 1986.
			1987-1988	Nest found 27 March 1987.
2	Cottonwood	Snag-top	1986	Nest built on great blue heron rookery in 1986, but eggs were likely laid in nest 1 or 3. Nest and branches fell between July and November 1987.

ORME BREEDING AREA (continued)

Nest Sites (cont'd.)

No.	Species	Type	Utilized	Status
3		Cliff	1990	Existing - Found 22 Feb 1990.
			1986?	
			1989?	Possibly site of 1986 and 1989 nesting seasons.
			≤1986	Remains of eaglet found below nest on 13 May 1990. Bone decomposition ruled out 1989 nestling, therefore eaglet would have been from 1986 or prior. Nest measures 2.9 × 2.4 m (9.5 × 7.8 ft).

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1970s	Successful			Yes	Young fledged from nest 1.
1980s	Successful			Yes	Young fledged from nest 1.
≤1986	Unknown	1+	1+	?	Remains of eaglet found below nest 3 on 13 May 1990. Bone decomposition ruled 1989 nestling, therefore eaglet would have been from 1986 or prior.
1986	Successful	?	?	?	Juvenile bald eagle perched at river confluence June 1986.
1987	Successful	2+	2	2	
1988	Successful	1+	1	1	New male, near-adult (ca. 3.5 years old), replaced old male Sept–Oct, 1987.
1989	Occupied				New female, near-adult (ca. 4 years old). Possibly in nest 3.
1990	Successful	2	1	1	Remains of eaglet dating to 1986 or prior found below nest. Four adults near nest on 22 February. Near-adult female in pair—possibly same bird as 1989.
Total		6+	5	4	
Years		5	5	4	
Mean		1.2	1.0	1.0	

D4.21 PERKINSVILLE BREEDING AREA

The Perkinsville breeding area is located 160 km north of Phoenix, along the free-flowing Verde River. The Verde leaves a narrow canyon, where Hell Canyon joins the river 11 km upstream of Perkinsville. The bottom opens up as the Verde continues to the Perkins Ranch, and the river is lined with cottonwoods. The river enters a deep, narrow canyon one km below the nest tree, and meanders through the Mormon Pocket area as it continues downstream.

D4.21.1 Habitat

The biotic community in the Perkinsville area is of the Upper Sonoran Life Zone. Upland habitat is characteristic of the Great Basin Conifer Woodland Biome and the Semidesert Grassland Biome. The riparian habitat is of the Sonoran Riparian Deciduous Forest and Woodlands Biome (see Section D2). Large cottonwoods line the Verde through Perkinsville, and emergent vegetation occurs along the river and springs.

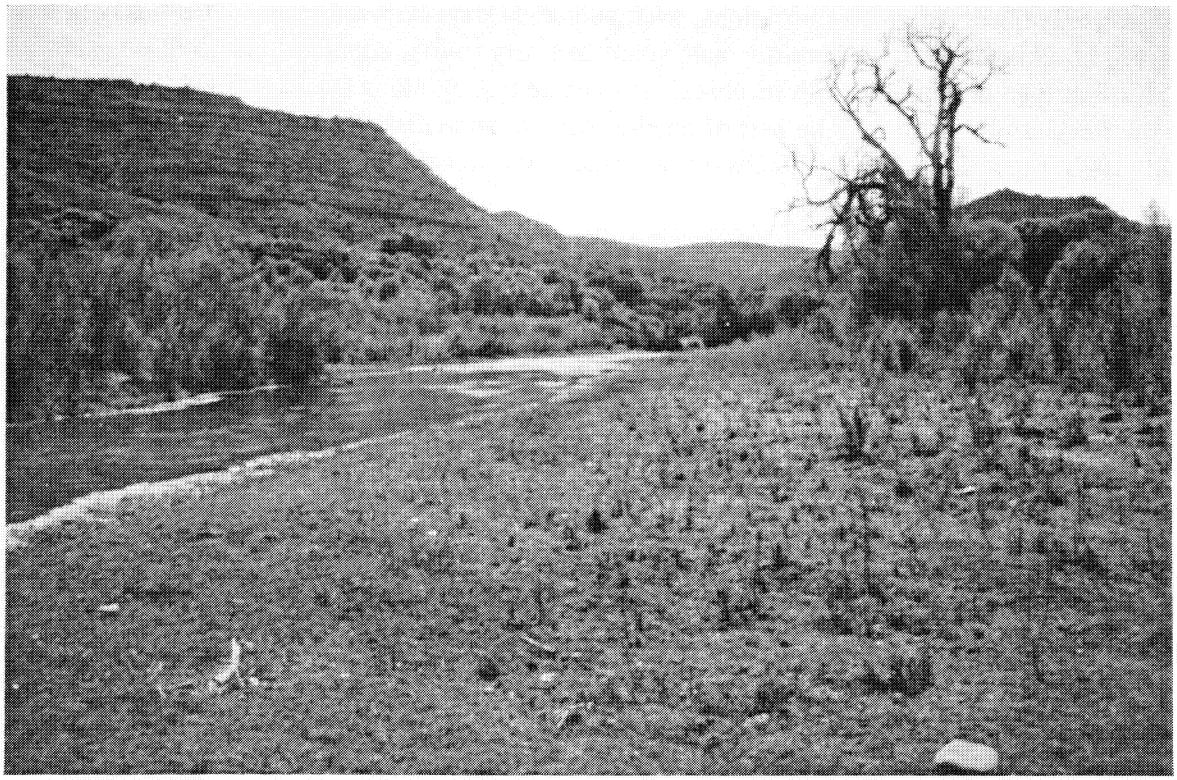

Plate D36. Perkinsville breeding area along the free-flowing Verde River, June 1989 (photo by D. Driscoll).

D4.21.2 Reproductive History

The Perkinsville breeding area was discovered by agency personnel in 1973; however, bald eagles had been known to nest in the area at least since the 1960s (Rubink and Podborny 1976). Nest 1 was built before the 1960s, fell during the 1960s, and was rebuilt prior to 1973 (Rubink and Podborny 1976, Rubink, pers. comm.). Nest 1 had fallen prior to a search of the area in June 1986. Nest 2 was built in 1989, just downstream of the nest 1 site. Nest 2 was found on 6 June 1989 adjacent to a great blue heron rookery, and is still in existence.

The Perkinsville territory was occupied in the 1960s and 1970s, although it is unknown if young hatched or fledged (Rubink, pers. comm.). No eagles or nests were found in a search of the area in 1986; however, the territory was occupied again in 1989. Near-adult feathers were found in and below the nest in 1989, but the pair apparently did not lay eggs. No eggshell fragments were recovered from the nest, and it appeared as though the nest had not been used since soft material still covered the interior portion of the nest and was not disturbed. In 1990, the site was occupied by a pair of near-adults, and the female carried a USFWS band on her right tarsus.

Incubation was not observed at Perkinsville in 1990, and apparently no eggs were laid. Fawcett and Staab (1990) noted the female remained in the nest area and defended it from other eagles; however, the male was only observed on five occasions, averaging eight days between visits. This behavior has been observed at a breeding area where the male simultaneously courts, copulates, and builds nests with two females, but then only assists with incubation at one site (see Sections D4.22 and D4.23). It is possible that the Perkinsville male may be part of another pair, at an undiscovered breeding area. Fawcett and Staab (1990) reported that the male always departed downstream into the canyon.

No known eggs have been laid at the Perkinsville breeding area since its discovery, thus no nesting chronology dates exist on this site (Table D4.21-1). Although the closest known active breeding area to Perkinsville is Ladders, 108 Km downstream, historical breeding areas occur both up- and downriver. The Hell Point nest site is located 13 Km upstream, near Hell Canyon, and the Tower site is located 25 Km downstream, near Sycamore Creek Canyon. Nests were still present at these historical sites in 1986, and each showed signs of recent activity.

D4.21.3 Mortalities

There have been no known mortalities at the Perkinsville breeding area, although this is likely due to the limited amount of data available on the territory.

D4.21.4 Known Foraging Areas and Food Habits

Data on the foraging ecology of the Perkinsville eagles are limited to prey items collected below the nest by Tom Gatz (Reclamation) on 6 June 1989, and prey remains collected in the nest by BioSystems biologists on 21 June 1989. In addition, observed forages by Fawcett and Staab (1990), most of which occurred in the river near the nest, included eight forages for fish (one was a sucker), and one capture of an American wigeon or green-winged teal. The female eagle made all the observed forages, although the male brought her a fish once. In the waterfowl capture, the female flew through a flock of ducks, driving one to the ground.

Table D4.21-1. Nesting chronology of the Perkinsville breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1973	—	—	—
1989	—	—	—
1990	—	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

Prey items described by Fawcett and Staab (1990) are presented in Table D4.21-2, along with prey items taken by the eagles and prey remains collected at the nest in 1989. See Section B5.1.6 for a detailed analysis of prey species utilized by the Perkinsville eagles. Although the Perkinsville adults were not observed stealing prey from other species, a subadult bald eagle did attempt to pirate a fish from the adult female (Fawcett and Staab 1990).

Table D4.21-2. Prey species observed taken by bald eagles or collected from the nest at the Perkinsville breeding area.

Fish	**Birds**	**Mammals**
Catfish sp.	Waterfowl	None found
Unidentified Ictaluridae	American wigeon or green-winged teal	
Sonora sucker	Gadwall	**Herptiles**
Sucker sp.		None found

D4.21.5 Human Impacts

Although data is limited on the Perkinsville eagles, hikers were observed proceeding down the river from the Perkinsville bridge camping area and walking below the nest tree. Gunshots flushed the female from perches on several occasions, and a railroad crew worked for seven days on a derailed train in the area. The female ignored activity and vehicles at the Perkinsville Ranch, and trains which passed by twice a day (Fawcett and Staab 1990).

D4.21.6 Wildlife Interactions

Interspecific interactions were recorded with red-tailed hawks, common ravens, and great blue herons (Fawcett and Staab 1990). Most interactions with other bald eagles at Perkinsville simply involved escorting the intruder out of the area (Fawcett and Staab 1990). A telemetered subadult bald eagle wearing a red band was observed at Perkinsville on 4 March 1990 (G. Beatty, pers. comm.). This subadult was one of the five eagles captured by BioSystems biologists in the winter of 1989, near the Ladders breeding area.

D4.21.7 Wildlife Sightings

Since Perkinsville is located on the upper Verde River, in grassland habitat, pronghorn antelope occur in the area, as do beaver, deer, and javelina. In addition, a small, long-tailed cat was observed in the canyon below Perkinsville in 1986. The cat likely was a small mountain lion; however, it vanished into the trees before positive identification was made. Prairie falcons, red-tailed hawks, Cooper's hawks, sharp-shinned hawks, common black hawks, ferruginous hawks, and American kestrels have been sighted along the river. In 1986, golden eagles nested in the canyon below Perkinsville, and a peregrine falcon eyrie was also found. A great blue heron rookery is located adjacent to the eagle nest, and in an interesting incident, a green-backed heron was flushed from a nest in a cottonwood tree across the river from the great blue heron rookery in 1986. Waterfowl sighted along the river include mallards, American wigeon, green-winged teal, gadwall, and Canada geese. Other birds sighted include Steller's jays, ruby-crowned kinglets, water pipits, and belted kingfishers which have been seen at apparent nest holes in the bank (Tom Gatz, pers. comm., Fawcett and Staab (1990), and Driscoll, unpublished field notes).

D4.21.8 Management Recommendations

1. If the Perkinsville eagles lay eggs in the future, a closure may be necessary to protect the birds. In 1990, hikers ventured downstream from the camping area at the Perkinsville bridge and walked below the nest tree (Fawcett and Staab 1990).

2. The Perkinsville eagles should be monitored in the future, to resolve the mysteries surrounding the male's intermittent appearance in the area. If the male continues to disappear downstream in the future, the area should be surveyed for a possible undiscovered nesting territory in the canyon below Perkinsville.

PERKINSVILLE BREEDING AREA

Date Discovered: 1973. Earliest Records 1960s.
Drainage: Verde River (Free-flowing)
Elevation (MSL): 3820 ft
County: Yavapai
Latitude-Longitude Ten Minute Block: 345-1121
Land Management: Private Land, Perkins Ranch
U.S. Forest Service, Prescott National Forest,
Chino Valley Ranger District (Surrounding Land)
Distance From Phoenix: Air - 160.0 km North
Distance To Nearest Breeding Area Upstream: None
Distance To Nearest Breeding Area Downstream: Ladders - 108.2 Km
Air - 60.0 km
Distance From Salt River Confluence: 271.1 Km
Home Range: Unknown
Quadrangles: Perkinsville 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Live	1960s	Nest built in or prior to 1960s. Nest fell in 1960s.
			1973	Nest rebuilt before 1973. Nest found 1973. Rubink No. 31. Nest fell before June 1986.
2	Cottonwood	Live	1989–1990	Existing - Built 1989. Nest found 6 June 1989.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1960s	Occupied	?	?	?	Bald eagles nesting in nest 1.
1970s	Occupied	?	?	?	Nest 1 rebuilt prior to 1973.
1973	Unknown	?	?	?	Nest 1 found.
1989	Occupied				Nest 2 built. Near-adult feathers found in and below nest.
1990	Occupied				Near-adult male and female (ca. 4–5 years old). Female banded on right tarsus.
Total		?	?	?	
Years		2	2	2	
Mean		?	?	?	

D4.22 PINAL BREEDING AREA

The Pinal breeding area is located 109 km east of Phoenix, along the free-flowing Salt River and Roosevelt Reservoir. The area upstream of Roosevelt Reservoir is characterized by steep slopes and promontory cliffs, although the land opens up downriver as the Salt flows into the reservoir. Pinal Creek is a free-flowing perennial stream which follows Highway 88 out of Globe, entering a narrow canyon after passing Hicks Crossing. The creek then turns north, flowing through a deep, narrow canyon, bounded by large promontory cliffs as it approaches the Salt River.

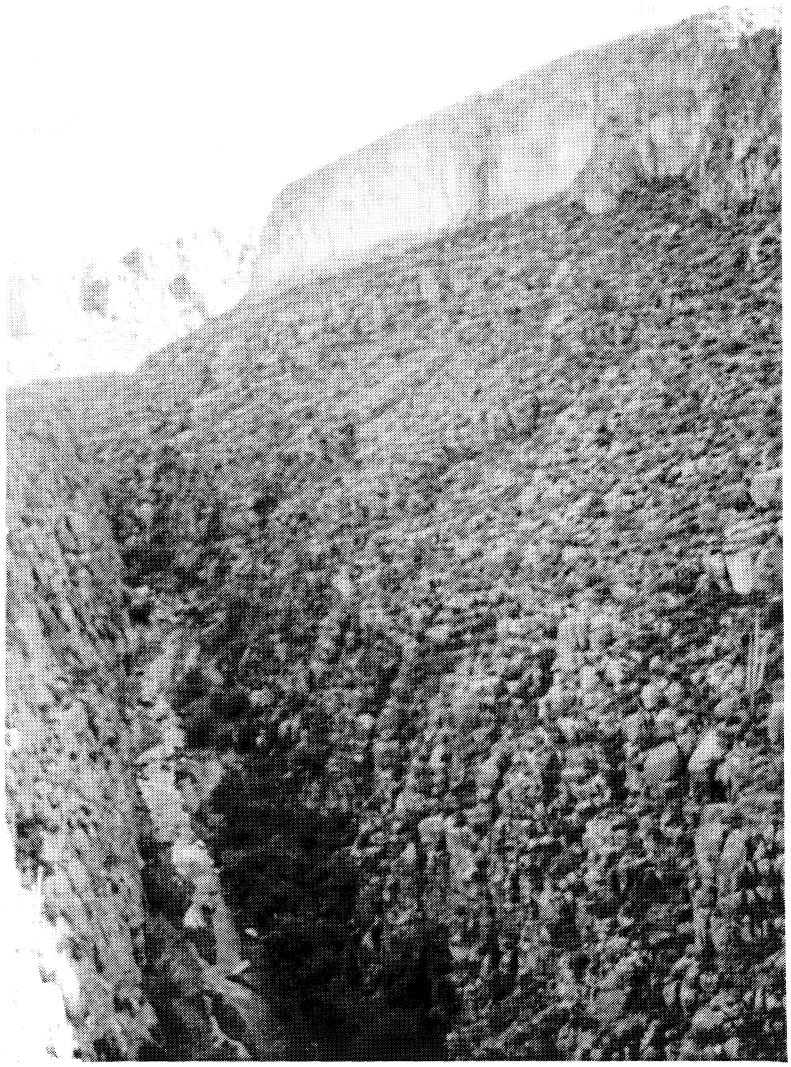

Plate D37. Pinal nest (1, 2) cliff along Pinal Creek, July 1986 (photo by D. Driscoll).

D4.22.1 Habitat

The biotic community in the Pinal area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Paloverde-Cacti-Mixed Scrub Series and the Jojoba-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).

Although the upper Salt River is a fast, white-water stream, the Salt slows down after Horseshoe Bend as the terrain opens up and the stream gradient becomes lower than in the upper canyons. The river, however, is still bounded by large promontory cliffs on one side or the other as it meanders west, often with flats opposite the cliffs. The Salt flows passed Redmond Flat (Km 124–127), where Coon and Chalk Creeks enter from the north at Km 124. The Salt River closes in as it passes Redmond Mountain to the south, and Black Mesa to the north, then flows into an "S" curve bounded by cliffs and large pinnacles at Km 113–114. Pinal Creek flows out of the Pinal Mountains and enters the Salt at Km 112.7, although the water is tainted by tailings from copper mines in the Globe area. The river opens up into Tonto Basin as it passes the Salt River Mountains and Klondike Mountain to the south. The Salt flows under the State Road 288 bridge at Km 112.2, over the Roosevelt Diversion Dam at Km 110.8, and into the Meddler Point area, lush with cottonwood groves.

River flows are variable in the Pinal area, with mean monthly flows in the Salt at the 288 bridge USGS gaging station ranging from 114–2685 cfs between November 1986 and June 1989. The river meanders over shallow sandy flats, bounded by "Red Cliffs" to the north, and marshy shallows with cottonwood groves and emergent vegetation to the south, after leaving Meddler Point. At high reservoir levels this area is inundated, but at normal levels the Salt River enters Roosevelt Reservoir around Cougar Point (Km 101).

Roosevelt Reservoir is created by Theodore Roosevelt Dam at Km 79.1, holding water from Tonto Creek (Tonto Arm) to the north and the Salt River (Salt Arm) to the east. On the Salt Arm, Pinto Creek flows into the reservoir from the south at Campaign Bay (Km 100), a large shallow basin east of School House Point. Draining the Sierra Anchas to the north, Armer Gulch enters the reservoir at Km 89.9, and Salome Creek flows into Salome Bay at Km 87.5, north of Windy Hill. Some cottonwood trees exist in Salome Bay and near Grapevine Point, although most of the shoreline is composed of desert vegetation and cockleburs. Promontory cliffs bound the water in some areas and grasses grow on the occasionally inundated flats. Preferred bald eagle perches are largely lacking on the reservoir and eagles utilize very small mesquites, low cutbanks, and saguaro cactus.

D4.22.2 Reproductive History

The Pinal breeding area was discovered in 1978 and has successfully fledged young in nine of the 12 years of known occupancy. The Pinal eagles have laid eggs from 24 January to 16 February, hatching young from 28 February to 23 March, and fledging eaglets from 20 May to 10 June (Table D4.22-1).

The Pinal eagles have built three known nests, two cliff nests (1, 2) and a pinnacle nest (3) on Pinal Creek. Nests 1 and 2 were found in 1978, 0.5 km up Pinal Creek. Nest 2 is located above and south of nest 1, on the same cliff. Since its discovery, nest 1 has only been used in 1989, while nest 2 has been used from 1978-1985 (Ohmart and Sell 1980, Haywood and Ohmart 1983, Eakle, pers. comm.) and in 1987. Nest 3 was found in 1988, 3.5 km up Pinal Creek, and was used in 1988 and 1990. Old eggshell fragments were recovered from nest 3 in 1988, indicating it was also used in 1986 or prior. One

Table D4.22-1. Nesting chronology of the Pinal breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1978	—	—	—
1979	25 January	1 March	—
1980	—	—	—
1981	24 January	28 February	—
1982	—	—	—**
1983	27 January	2–4 March	20 May
1984	30 January	5–9 March	23 May
1985	10 February	17 March	10 June
1986	—	—	—
1987	26 January	7 March	25, 29 May*
1988	—	< 16 March	—
1989	16 February	23 March	30 May*
1990	5 February	12, 13 March*	2, 3 June*

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
** One young fostered from 76 breeding area.
< Indicates "prior to"
> Indicates "later than"

adult was consistently sighted on the nest 1 and 2 cliff in 1986 (Driscoll, unpublished field notes), and the pair likely nested in nest 3 which was undiscovered at that time. All three nests are still in existence.

When the Pinal nest was found in 1978 one juvenile was in the nest vicinity, and an additional two eaglets fledged in 1979 (Ohmart and Sell 1980). The eggs failed to hatch in 1980, and two young hatched in 1981, but one died in the nest (Haywood and Ohmart 1983). In 1982, one eaglet hatched, but disappeared from the nest. In this same period, the adult female at the "76" breeding area disappeared following an aggressive interaction with a golden eagle. The eaglet was removed from the "76" nest and fostered into the Pinal nest (Forbis 1985); this eaglet jumped from the nest during a banding attempt, but was returned to the nest and later fledged (Haywood and Ohmart 1983). From 1983–1985, one young fledged each year (Grubb 1986a). The Pinal breeding area appeared to be unoccupied in 1986, but as discussed previously, the eagles probably nested in nest 3. Two young fledged in 1987, and one hatched in 1988, but died in the nest. Two eaglets hatched in 1989, although one died in the nest. Two eaglets fledged from Pinal in 1990.

When we began studying the Pinal pair in winter 1986–1987, we noticed the adult male had a white patch on the center of his back, just below the nape. A similar white patch was observed on the Chino/Alamo adult female, in the location of her transmitter, after it fell off (see Section D4.1). Mike Lockhart,

USFWS (pers. comm.), has also observed these white patches on eagles after their transmitters fall off. Telonics transmitters were placed on bald eagles in Arizona in past years, and these radios are housed in an aluminum (silver) casing. Discussing the topic with M. Lockhart (USFWS) and A. Harmata (Greater Yellowstone Ecosystem Bald Eagle Project) we entertained the possibility that the transmitter package may freeze (in cold climates) or burn (in hot climates) the feather follicles beneath, causing the white patches to persist after the transmitter has fallen off. This hypothesis gained more credibility in November, 1987, when we sighted a USFWS band on the male's right tarsus.

The only Arizona bald eagles radio-tagged prior to 1986 (BioSystems study) were six nestlings telemetered from 1977–1979; these were tagged by Master's students under Robert Ohmart, ASU. Hildebrandt (1981) telemetered two nestlings in 1977, T02 (USFWS band 629-04452) from the Fort McDowell nest, and T04 (USFWS band 629-04454) from the Bartlett breeding area. T02 drowned after breaking its left humerus in an aggressive interaction with its sibling (Hildebrandt 1981). T04 survived until 1980 when it was shot in Calgary, Alberta, Canada (Ohmart 1985). In 1978, two more nestlings were radio-tagged, one from the Bartlett breeding area (USFWS band 629-04460), and one from the Cibecue nest (USFWS band 629-04461). The Bartlett eaglet died after fledging and was eaten by a mammalian predator (Hildebrandt 1981). The Cibecue eaglet disappeared after leaving the nest, but was banded on the left leg so is ruled out as a possible source for the Pinal male, if by chance the eaglet survived.

In 1979, two additional young were telemetered, one at the Bartlett nest (USFWS band 629-04462), and another at the Fort McDowell territory (USFWS band 629-04464). The 1979 Bartlett eaglet returned to Roosevelt Reservoir the next year, although its transmitter failed in July 1980. No data are available on the 1979 Fort McDowell eaglet (Sell 1982). Therefore, if the Pinal male was telemetered, he would have been from the 1979 Bartlett or Fort McDowell nest. In addition, the Chino/Alamo female was also banded on her right tarsus and carried a backpack transmitter, and would have been from the 1979 Bartlett or Fort McDowell nest.

D4.22.3 Mortalities

There have been four documented juvenile bald eagle deaths at the Pinal breeding area. Of these, three young died in the nest, and one disappeared from the nest. One young at Pinal died in the nest in 1981 and was cannibalized by its sibling (Haywood and Ohmart 1982). In 1982, the single Pinal eaglet disappeared from the nest; however, the "76" eaglet was fostered into the Pinal nest and fledged (the "76" adult female disappeared after an aggressive interaction with a golden eagle)(Haywood and Ohmart 1983, Forbis 1985).

During a nest check at the Pinal breeding area on 13 April 1988, BioSystems biologists noticed the eaglet, which had hatched prior to 16 March, appeared to be dead and lay 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 had 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.

At the Pinal nest site in 1989, the remains of a 4–7 day old eaglet were found in the nest while banding the surviving juvenile. The young had hatched on 23 March; therefore we estimated the nestling died about 27–30 March. The remaining juvenile fledged successfully. Possible factors contributing to

nestling mortality, including monofilament fishing line, nest parasites, and heat stress are detailed in Section C3. No adult mortalities have been documented in the Pinal breeding area.

D4.22.4 Known Foraging Areas and Food Habits

Before the BioSystems study, bald eagles at the Pinal breeding area were 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, only one forage was observed on the reservoir, along the shore near School House Point (LaValley and LaValley 1983).

Although ABENWP personnel noted the eagles flying to the reservoir, they usually lost sight of the birds, so most observed foraging was located on the river. This bias resulted in small home ranges and foraging locations restricted to areas visible from nest observation points. Prior to the female's radio-tagging in December 1986, it was generally believed that the eagles rarely used the reservoir (Haywood and Ohmart 1982, Haywood and Ohmart 1983, Grubb *et al.* 1983, Grubb 1984, Grubb 1986a).

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 coincides with lower flows on the Salt, which we noted exposing riffles below the promontory cliffs and pinnacles in Km 114.

The Pinal female (AF01) was captured and radio-tagged on 13 December 1986; however, her transmitter fell off on 6 May 1987 when the cotton thread stitch in the teflon ribbon used to attach the telemetry unit apparently broke (as was intended). We recaptured AF01 on 13 June 1987 and replaced her transmitter. No signs of abrasion or wear were found from the transmitter or bands. The Pinal female provided detailed information on foraging and movements throughout 1987 and 1988. In addition, we found it exceptionally easy to visually track the Pinal male (TM01).

Much more extensive use of the reservoir was documented by telemetry, as well as seasonal shifts between the river and reservoir. The home range of the Pinal pair is now known to extend from Km 89.0 on Roosevelt Reservoir (Windy Hill) to Km 126.0 on the Salt River (Redmond Flat), totaling 37 Km. See Section B4.6 for more details on the foraging ecology and movements of the Pinal eagles.

We captured another adult female (AF03) on Roosevelt Reservoir on 17 December 1987. AF03 carried a USFWS band (629-04472) on her right tarsus, and had been banded as a nestling in 1981 at the Bartlett breeding area (Haywood and Ohmart 1983). At first we did not know if AF03 nested near Roosevelt Reservoir or if she would leave with the wintering eagles in the spring. However, the Pinal male soon began copulating and building a nest with AF03 at Km 102.5 on the Salt River, just above Roosevelt Reservoir. Bald eagles were believed to be nesting here, near the confluence of Pinto Creek, in 1986, although no nest was found in a search of the area in July 1986. The Pinto female (AF03) perched and foraged with the Pinal male, and he spent much time on "Red Cliffs" across the river from her nest.

In 1987, the Pinal male and female regularly foraged on the reservoir; however, in 1988 the Pinal female's home range changed after entering into an aggressive altercation with the Pinto female in February 1988. The Pinal female did not venture to the reservoir to forage after that point. The Pinal female did soar down to the upper reservoir occasionally, to entice the Pinal male to return his original nest area. The Pinal male proceeded to copulate and refurbish nests with both females. The Pinto female apparently did not lay eggs in 1988, and the Pinal male incubated with and foraged for the Pinal female and eaglet. As reported above, the 1988 Pinal eaglet died prior to 13 April.

During the 1988 breeding season, the Pinal female lost a large portion of her home range to the Pinto female. From January to May 1988, the Pinal female utilized the Salt River from Km 109 (below the diversion dam) to Km 126 at Redmond Flat. On 3 January 1988, she soared several km upstream of the Cherry Creek confluence (Km 138), well into the territory of the Redmond pair. The Pinto female disappeared in May, along with other radio-tagged subadults and near-adults, and apparently migrated. After the Pinto female departed, the Pinal female once again utilized the reservoir during the summer. However, the Pinto female returned after summer and once again discouraged the Pinal female from using Roosevelt Reservoir and much of the Salt River from Meddler Point to the reservoir. The Pinal male's home range was not altered by the presence or absence of the Pinto female.

The Pinal male again copulated with both females in the 1989 breeding season, and helped the Pinto female build a new nest. Both females laid eggs; however, the Pinal male did not assist the Pinto female with incubation duties. The Pinto eggs failed to hatch, as the female had to leave the eggs to forage. The Pinal nest hatched two young in 1989, fledging one eaglet.

Prey items described by Haywood and Ohmart (1981), Haywood and Ohmart (1982), Haywood and Ohmart (1983), LaValley and LaValley (1983), Browne *et al.* (1984), and Grubb (1986a), are presented in Table D4.22-2, along with prey items taken by the eagles and prey remains collected at the nest from 1986–1989. See Sections B4.6 and B5.1.5 for detailed analysis of prey species utilized by the Pinal eagles.

The Pinal adults were observed stealing a small mammal from a red-tailed hawk (Haywood and Ohmart 1982), and pirating American coots from northern harriers near Cougar Point, carrion from common ravens, and fish from great blue herons (Section B4.6).

D4.22.5 Human Impacts

Human disturbance is not a serious problem at the Pinal breeding area. Although the Highway 288 bridge is only 0.4 km below the Pinal Creek confluence, the Pinal nests are in the creek canyon, and protected from the disturbances downstream by Klondike Butte. Activities at the bridge are many, including fishing, swimming, shooting (often at the cliffs or river with automatic rifles), partying, and camping. Shooting may be a problem, since the eagles could be an easy target. Shooting from the bridge area has been reported as a disturbance by ABENWP personnel each year (LaValley and LaValley 1983, Browne *et al.* 1984, Secunda 1985, Myers 1985, Behn and VonGonten 1987, Day and Bond 1989).

The most frequent disturbance recorded each year involved low level military jets. Light planes, helicopters, sonic booms, rafters, and kayakers have also been reported, although most are ignored by the eagles (LaValley and LaValley 1983, Browne *et al.* 1984, Secunda 1985, Myers 1985, Behn and VonGonten 1987, Day and Bond 1989). The most traumatic disturbance to the eagles noted resulted from hikers above the nest cliff, which caused flights and vocalization by the adults. In each instance, the

Table D4.22-2. Prey species observed taken by bald eagles or collected from the nest at the Pinal breeding area.

Fish	Birds	Mammals
Carp	Waterfowl	Cottontail rabbit
Buffalo sp.	Ruddy duck	Blacktail jackrabbit
Channel catfish	Green-winged teal	Neotoma
Flathead catfish	Northern shoveler	Harris' ground squirrel
Largemouth bass	Anas sp.	Yuma antelope ground squirrel
Black bass	Unidentified waterfowl	Ground squirrel
Bass sp.	Grebes	Rock squirrel
Unidentified Centrarchidae	Eared grebe	Squirrel sp.
Lepomis sp.	Western grebe	Peromyscus sp.
Desert sucker	Grebe sp.	Perognathus sp. (Pocket mouse)
Sonora sucker	Wading Birds	Mouse sp.
Razorback sucker	American coot	
Black crappie	Great egret	
Crappie sp.	Raptors	**Herptiles**
	Western screech owl	Sonoran mud turtle
	Passerines	Unidentified snake
	Red-naped sapsucker	Unidentified lizard
	Other Birds	Unidentified reptile
	Gambel's quail	
	Common (gilded) flicker	
	Mourning dove	

hikers were also shooting guns, and on one occasion hikers were rolling boulders off the nest cliff (Haywood and Ohmart 1982, LaValley and LaValley 1983). See U.S. Fish and Wildlife Service (1990) for details on disturbance at the Pinal breeding area in 1989.

Fishermen congregate below the diversion dam in large numbers, catching many catfish. Carp also run from the reservoir up the river and are blocked by the diversion dam. During spring and summer carp are observed trying to jump over the diversion dam. The fishermen often fillet their catch near the river and leave the carcass behind. Often when carp are caught, the whole fish is left behind. The eagles subsequently forage on the remains when fishermen leave. Although this may seem like a benefit to the eagles, it actually can be hazardous. Catfish are notorious for swallowing the bait and hook, and many fishermen simply cut the line when this occurs. In addition large catfish often break the line, and have monofilament and hooks in their stomachs. The eagles forage on the carcasses, and often deliver them to the nest. Driscoll (1985) observed the Redmond eagles delivering large filleted catfish carcasses to the nest. We found monofilament, hooks, lures, and fishing weights in the Pinal nest each year from 1987–1990. In addition, the 1988 nestling died after becoming entangled in monofilament at the nest.

Monofilament fishing line not only kills bald eagles, but many other wildlife species as well (see Section C3.3).

Fishermen and boaters occasionally flushed the eagles from perches on Roosevelt Reservoir, but disturbance did not appear to be a problem. See Section B4.6 for details on disturbance at the Pinal breeding area from 1987–1989.

The Roosevelt Diversion Dam has been blocking the upstream migration of reservoir fishes since before Roosevelt Reservoir was created. When Theodore Roosevelt Dam modifications are complete, high water levels would allow fish access to the upper Salt River (Roosevelt Site Maps *in* U.S. Bureau of Reclamation 1983). We have sampled large flathead catfish, up to 35 pounds, in the Horseshoe Bend area, although the number of large fish would likely increase if the current fish barrier (diversion dam), was inundated by high reservoir levels. Some very large carp also exist in the reservoir, and we observed up to 30 pound carp snagged by fishermen below the diversion dam. If large fish are allowed into the upper Salt River, it may adversely impact sucker populations in the Pinal and Redmond breeding areas.

D4.22.6 Wildlife Interactions

At Pinal, interspecific interactions were numerous with red-tailed hawks which nested nearby. The eagles also interacted with common ravens, Cooper's hawks, northern harriers, great blue herons, merlins, peregrine falcons, American kestrels, osprey, turkey vultures, and golden eagles (Haywood and Ohmart 1982, LaValley and LaValley 1983, Browne *et al.* 1984, Secunda 1985, Myers 1985, Behn and VonGonten 1987, Day and Bond 1989, Armstrong 1990, and BioSystems personnel 1986–1989). Peregrines were observed chasing and attacking the eagles on several occasions in 1990 (Armstrong 1990). A group of ravens mobbed the nest in 1985, causing the adult at the nest to spread its wings and vocalize (Secunda 1985). On one occasion, the Pinal female locked talons with a red-tailed hawk and fell through the sky before separating (Myers 1985).

Intraspecific interactions usually involve pursuit, escorting the eagle out of the territory, or aggressive altercations. Many interactions with other bald eagles at Pinal simply involved escorting the intruder out of the area, although some altercations were aggressive (Haywood and Ohmart 1982, Browne *et al.* 1984, Secunda 1985, Behn and VonGonten 1987). In 1985, a third adult was observed fighting with the resident male. The two eagles locked talons and fell through the sky before separating (Secunda 1985). Numerous bald eagles utilize Roosevelt Reservoir in the winter, although the Pinal adults usually are not aggressive toward these birds.

D4.22.7 Wildlife Sightings

Roosevelt Reservoir abounds with waterfowl in the winter, especially in Campaign Bay and on the river between the Highway 288 bridge and the reservoir. Waterfowl sighted include Canada geese, snow geese, white-fronted geese, Ross' geese, mallards, pintails, American wigeon, northern shovelers, redheads, canvasbacks, common goldeneyes, ruddy ducks, buffleheads, ring-necked ducks, lesser and greater scaup, oldsquaw, wood ducks, and green-winged, blue-winged, and cinnamon teal. In addition, large rafts of eared grebes, western grebes, and American coots winter on the reservoir, along with pied-billed grebes and occasional horned grebes. In February 1988, we observed a red-necked grebe in Salome Bay, and in December 1987 we sighted tundra swans on the reservoir. Numerous gulls were observed on the reservoir, including herring, ring-billed, and Bonaparte's gulls. Forster's terns were also

a common sight, and several Caspian terns were recorded. On one occasion, we observed 13 white pelicans in Campaign Bay in April.

We observed adult peregrine falcons on the reservoir each year, and on 6 May 1987, a juvenile peregrine was sighted at Km 114, upstream of Pinal Creek. The juvenile flew up the river vocalizing, and the Pinal female pursued the falcon and drove it into a pinnacle. The falcon was still perched when we left the area an hour later. Armstrong (1990) also observed peregrines up Pinal Creek. With the numerous sightings, it is possible that peregrines nest in the Pinal area. Golden eagles nest up Pinto Creek, up Salome Creek, and on Black Mesa. At least two pairs of Harris' hawks nest on the powerline towers south of Roosevelt Reservoir. Red-tailed hawks and ravens also nest on the towers, as well as throughout the Pinal area. One redtail nest is located on Klondike Butte, near Pinal Creek. American kestrels nested in a saguaro cactus near Cougar Point in 1988 and 1989. We sighted several short-eared owls around the reservoir in February, 1988. Other raptors sighted in the area include merlins, prairie falcons, northern goshawks, Cooper's hawks, sharp-shinned hawks, ospreys, northern harriers, zone-tailed hawks, ferruginous hawks, and common black hawks. In January, 1989, we photographed a one-legged black hawk which was eating carrion near Cougar Point. Armstrong (1990) also sighted a black-shouldered kite in the Pinal area.

Snowy egrets, common egrets, white-faced ibis, American avocets, black-necked stilts, greater and lesser yellowlegs, common snipe, green-backed herons, and water pipits were sighted along the river. Two great blue heron rookeries are located along the reservoir, one near the Salt River inflow and another upstream of the Tonto Creek inflow. In June 1986, numerous black-crowned night herons were observed flying down Salome Creek, and a rookery may exist upstream of A-Cross road (Driscoll, unpublished field notes). Black-crowned night herons also utilized the Campaign Bay area, and a dozen or more were sighted there on numerous occasions. Other birds of interest at Pinal include western and mountain bluebirds, verdins, vermillion flycatchers, hooded and Scott's orioles, and loggerhead shrikes.

We observed beaver, ringtails, bobcats, mountain lions, mule deer, whitetail deer, and javelina along the river and reservoir. Herptiles of interest include western diamondback rattlesnakes, black-tailed rattlesnakes, and gila monsters. Flathead catfish grow to very large sizes in the reservoir, and 30–40 pound flatheads are commonly caught off School House Point. On 21 March 1989, we found a flathead catfish weighing about 30 pounds dead along the north shore near Griffon Wash. We cut open the fish to look for possible mortality factors and found an eared grebe in its belly.

D4.22.8 Management Recommendations

1. The Pinal eagles seem to be doing fairly well, although shooting near the nest may be a potential problem. The large amount of shooting from the Highway 288 bridge area may warrant posting "No Shooting" signs in the parking areas on both sides of the bridge.

2. As discussed previously, monofilament fishing line, hooks, and lures, are a serious problem at the Pinal breeding area. The 1988 Pinal eaglet died after becoming entangled in monofilament at the nest. In addition, monofilament, hooks, lures, and fishing weights have been found in the Pinal nest each year from 1987–1990. Fishermen congregate below the diversion dam on the river, and at School House Point on the reservoir, and trash barrels are located in these areas. Signs should be posted on both sides of the river below the diversion dam, and on School House Point, that inform fishermen of the hazards involved in the irresponsible disposal of monofilament line. Signs could

state "Monofilament fishing line can be hazardous to wildlife. Birds use it to build nests, and can die from becoming entangled in the line. Hooks in fish stomachs can also harm wildlife that feed on fish remains. Please dispose of all waste monofilament line in the trash barrels."

3. Although large promontory cliffs exist on the river, perching substrate is lacking on the reservoir where eagles perch on very small mesquites, low cutbanks, and saguaro cactus. Cottonwoods at the north end of Salome Bay, and one in Campaign Bay, are falling apart. Both Salome and Campaign Bays are heavily used by eagles in winter. Several adults of unknown territory also used Salome Bay. As an experiment, a few phone poles with cross-arms could be dropped by helicopter into the shallow areas of Campaign and Salome Bays to provide perching habitat. Cottonwood poles could also be planted along the reservoir to provide future perch sites for wintering eagles using Roosevelt Reservoir.

4. A study should be conducted to determine possible impacts reservoir fishes could have on the fish communities upstream of the Roosevelt Diversion Dam.

5. A study of the water quality of Pinal Creek should be conducted, since stream contaminants could adversely effect prey populations in the Pinal and Pinto breeding areas.

PINAL BREEDING AREA

Date Discovered: 1978
Drainage: Salt River / Pinal Creek (Free-flowing / Perennial)
Elevation (MSL): 2200 - 3000 ft
County: Gila
Latitude-Longitude Ten Minute Block: 333-1105
Land Management: U.S. Forest Service, Tonto National Forest,
Tonto Basin Ranger District (West of Pinal Creek)
Globe Ranger District (East of Pinal Creek)
Distance From Phoenix: Air - 109.0 km East
Distance To Nearest Breeding Area Upstream: Redmond -16.0 Km
Air - 9.0 km
Distance To Nearest Breeding Area Downstream: Pinto - 11.2 Km
Air - 8.0 km
Distance From Granite Reef Dam: 112.7 Km
Distance To Roosevelt Reservoir: 10.7 Km
Air - 7.3 km
Home Range: Km 89.0 on Roosevelt Reservoir to Km 126.0 on Salt River
(Total = 37.0 Km)
Quadrangles: Windy Hill 7.5 Minute
Salt River Peak 7.5 Minute
Meddler Wash 7.5 Minute
Dagger Peak 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	1989	Existing - Found 1978.
2		Cliff	1978–1985 1987	Existing - Found 1978.
3		Pinnacle	1988 1986? 1990	Existing - Found February 1988. Nest used previously, possibly 1986 season, old eggshell fragments found in nest in 1988.

PINAL BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1978	Successful	1+	1+	1+	One juvenile sighted near nest.
1979	Successful	2+	2	2	
1980	Failed	2+	0	0	
1981	Successful	2+	2	1	One young died in nest and was cannibalized by sibling.
1982	Failed/Foster	1+	1	0(1)	Eaglet disappeared from nest. One young from "76" breeding area fostered into nest and fledged. Eaglet jumped during banding attempt and was returned to nest.
1983	Successful	1+	1	1	
1984	Successful	1+	1	1	
1985	Successful	1+	1	1	Mexican chicken bugs in nest after young fledged.
1986	Unoccupied				Possibly in nest 3, old eggshell fragments found in 1988. Only one adult sighted at any one time near nest 1 and 2. Adult female banded on left tarsus and black VID band placed on right tarsus, Dec 1986.
1987	Successful	2+	2	2	Adult male banded on right tarsus. Band sighted Nov 1987.
1988	Failed	2	1	0	Young died prior to 13 April. Eaglet became entangled in monofilament which cut off its circulation.
1989	Successful	2+	2	1	One young died in nest at 4–7 days of age.
1990	Successful	2+	2	2	
Total		19+	16	12	
Years		12	12	12	
Mean		1.6	1.3	1.0	

D4.23 PINTO BREEDING AREA

The Pinto breeding area is located 102 km east of Phoenix, along the free-flowing Salt River and Roosevelt Reservoir. The area upstream of Roosevelt Reservoir is characterized by steep slopes and promontory cliffs, although the land opens up downriver as the Salt flows into the reservoir. Pinto Creek is a small, free-flowing intermittent stream which enters Roosevelt Reservoir from the south at Campaign Bay.

Plate D38. Pinto cottonwood tree nest (2, arrow), built on top of a great blue heron nest, in secondary branches, June 1989 (photo by D. Driscoll).

D4.23.1 Habitat

The biotic community in the Pinto area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Paloverde-Cacti-Mixed Scrub Series and the Jojoba-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).

The Salt River opens up into Tonto Basin as it passes the Salt River Mountains and Klondike Mountain to the south. The Salt flows under the State Road 288 bridge at Km 112.2, over the Roosevelt Diversion Dam at Km 110.8, and into the Meddler Point area, lush with cottonwood groves. River flows are variable in the Pinto area, with mean monthly flows in the Salt at the 288 bridge USGS gaging station ranging from 114–2685 cfs between November 1986 and June 1989. The river meanders over shallow sandy flats, bounded by "Red Cliffs" to the north, and marshy shallows with cottonwood groves and emergent vegetation to the south, after leaving Meddler Point. At high reservoir levels this area is inundated, but at normal levels the Salt River enters Roosevelt Reservoir around Cougar Point (Km 101).

Roosevelt Reservoir is created by Theodore Roosevelt Dam at Km 79.1, holding water from Tonto Creek (Tonto Arm) to the north and the Salt River (Salt Arm) to the east. On the Salt Arm, Pinto Creek flows into the reservoir from the south at Campaign Bay (Km 100), a large shallow basin east of School House Point. Draining the Sierra Anchas to the north, Armer Gulch enters the reservoir at Km 89.9, and Salome Creek flows into Salome Bay at Km 87.5, north of Windy Hill. Some cottonwood trees exist in Salome Bay and near Grapevine Point, although most of the shoreline is composed of desert vegetation and cockleburs. Promontory cliffs bound the water in some areas and grasses grow on the occasionally inundated flats. Bald eagle perches are largely lacking on the reservoir, and eagles have been observed perching on very small mesquites, low cutbanks, and saguaro cactus.

D4.23.2 Reproductive History

The Pinto breeding area was discovered in December, 1987, although bald eagles were reported nesting in the area in 1986. Bent (1937) described bald eagles nesting on the Salt River Bird Reservation, which was inundated by Roosevelt Reservoir in 1911. Three known nests have been built at the Pinto breeding area, all located in live cottonwood trees near the Pinto Creek confluence. Nest 1 was found in 1986 by an employee of Tonto National Monument, who reported adult bald eagles feeding young in the nest. We searched the area in July, 1986, although the nest could not be distinguished from the many great blue heron nests; the source stated the nest had fallen. Nest 2 was built on top of a great blue heron rookery in December 1987, and used by the eagles in 1988 and 1989. Nest 3 was built between July and December 1989, and used in 1990. Nests 2 and 3 are still in existence.

An interesting scenario has been underway at least since late 1987 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. 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 feed. In 1988, the Pinto female laid at least one egg that did not hatch. Since the Pinto female defends the breeding area against all eagles except the Pinal male, this breeding area may not be successful until the Pinal male dies. If this trio separates into two pairs in the future, the home range of the Pinal eagles will likely be reduced.

The Pinto female and Pinal male copulated and worked on nest 2 in 1988, but apparently no eggs were laid. The Pinto female and Pinal male copulated again in 1989, and egg(s) were laid in nest 2 prior to 28 February (Table D4.23-1). However, the Pinal male did not assist in incubation duties, and the eggs did not hatch since the Pinto female had to leave the nest to forage.

Table D4.23-1. Nesting chronology of the Pinto breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1986	—	—	—
1987	—	—	—
1988	—	—	—
1989	< 28 February	—	—
1990	—	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

The Pinal male and Pinto female copulated and built nest 3 in 1990, but apparently no eggs were laid. In an interesting observation, Richey (1990) reported the Pinto female sat on the nest occasionally from 12–15 February, then from 16–18 February she spent most of the day on the nest. The female was on the nest all day except for 56 minutes on 16 February, 28 minutes on 17 February, and 69 minutes on 18 February. It is possible the Pinto female laid egg(s) in 1990, although if eggs were laid, the female should have incubated longer than one week.

D4.23.3 Mortalities

The Pinto breeding area has not experienced any known adult or juvenile mortalities since 1988. However, the site was reported active in 1986, but we did not observe any adults in the area during intensive telemetry tracking of the Pinal pair during the 1987 breeding season. Obviously, Pinto was not occupied at the known nest locations in 1987, or the pair (or single adult) would have defended the area from the Pinal eagles. The fate of the 1986 Pinto eagles remains a mystery. The Pinto eagles may have nest sites up Pinto Creek, or inland from the reservoir. A large cliff nest is located along Pinto Creek, below the Highway 88 bridge, but the nest appears to be to a golden eagle eyrie.

D4.23.4 Known Foraging Areas and Food Habits

We captured the Pinto female (AF03) on Roosevelt Reservoir on 17 December 1987, and found she carried a USFWS band (629-04472) on her right tarsus. The Pinto female had been banded as a nestling in 1981 at the Bartlett breeding area (Haywood and Ohmart 1983). At first we did not know if AF03 nested in Arizona or would leave with the wintering eagles in the spring. However, the Pinal male soon began copulating and building a nest with AF03 at Km 102.5 on the Salt River, just above Roosevelt

Reservoir. The Pinto female (AF03) perched and foraged with the Pinal male, but also spent much time on "Red Cliffs" across the river from her nest, and in the Meddler Point area. We tracked the Pinto female as far west as Windy Hill, and she frequented Salome Bay in 1988. In 1990, we observed her hunting below the diversion dam on the Salt River. The home range of the Pinto female extends from Km 87.0 on Roosevelt Reservoir (including Salome Bay) to Km 110.0 on the Salt River (Diversion Dam), totaling 23 Km. On one occasion, we observed the Pinto female soaring near Black Mesa (Km 117) well into the Pinal female's territory. See Section B4.6 for more details on the foraging ecology and movements of the Pinto and Pinal eagles.

In 1987, telemetry and visual data showed that the Pinal male and female regularly foraged on the reservoir; however, in 1988 the Pinal female's home range changed. The Pinto and Pinal females entered into an aggressive altercation in February 1988, after which the Pinal female did not venture to the reservoir to forage. The Pinal female did soar down to the upper reservoir occasionally, to successfully entice the Pinal male to return his original nest area. The Pinal male copulated and refurbish nests with both females, but would not help with incubation or provision the incubating Pinto female. In summary, the Pinal female lost a large portion of her home range to the Pinto female.

The Pinto female disappeared in May, and after her departure, the Pinal female once again utilized the reservoir. However, the Pinto female returned after summer and the females' territories once again became exclusive. The Pinal male's home range was not altered by the presence or absence of the Pinto female.

Prey utilization at the Pinto breeding area is limited to observed forages while tracking the female in 1988 and 1989 (Table D4.23-2). See Section B4.6 for a detailed analysis of prey species utilized by the Pinto female. The Pinto female was also observed stealing a fish from a subadult bald eagle in 1990 (Kennedy and Richey 1990, Richey 1990).

Table D4.23-2. Prey species observed taken by bald eagles or collected from the nest at the Pinto breeding area.

Fish	**Birds**	**Mammals**
Carp	Waterfowl	None found
Largemouth bass	Green-winged teal	
Bass sp.	Wading Birds	**Herptiles**
Black crappie	American coot	None found

D4.23.5 Human Impacts

Human disturbance is a problem at the Pinto breeding area. A dirt road exits Roosevelt Lake Estates and allows vehicle access to the Campaign Bay area and the Pinto cottonwood grove. The road runs 200–250 m south of the nest 3 tree, which is visible from that point. Kennedy and Richey (1990), and Richey (1990), reported disturbances from fishing, camping, shooting, and wood cutting at Campaign

Bay. People were also observed cutting down live cottonwood trees and standing snags in the Pinto cottonwood grove, apparently for fuel-wood. Hikers also entered the cottonwood grove.

Fishermen congregate below the diversion dam in large numbers, catching many catfish. Carp also run from the reservoir up the river and are blocked by the diversion dam; we have observed carp trying to jump over the diversion dam in spring. The fishermen often fillet their catch near the river and leave the carcass behind; when carp are caught, the whole fish is often left behind. The eagles subsequently forage on the remains when fishermen leave. Although this may seem of benefit to the eagles, there are hazards. Catfish are notorious for swallowing the bait and hook, and many fishermen simply cut the line when this occurs. In addition large catfish often break the line, and thus are swimming around with monofilament and hooks in their stomachs. The eagles then forage on the carcasses, and often deliver the prey to the nest. Driscoll (1985) observed the Redmond eagles delivering large filleted catfish carcasses to the nest. We found monofilament, hooks, lures, and fishing weights in the nearby Pinal nest each year during 1987–1990. In addition, the 1988 Pinal nestling died after becoming entangled in monofilament at the nest (see Sections D4.22 and C3.3).

Fishermen and boaters occasionally flushed the eagles from perches on Roosevelt Reservoir, but did not appear to be a problem. See Section B4.6 for details on disturbance at the Pinto and Pinal breeding areas during 1987–1989.

D4.23.6 Wildlife Interactions

At Pinto, interspecific interactions were recorded with common ravens, red-tailed hawks, northern harriers, great blue herons, peregrine falcons, American kestrels, osprey, turkey vultures, and golden eagles (Kennedy and Richey 1990, Richey 1990, and BioSystems personnel 1986–1989).

Many interactions with other bald eagles at Pinto simply involved escorting the intruder out of the area, although some altercations were aggressive (Kennedy and Richey 1990, Richey 1990, and BioSystems personnel 1986–1989). Numerous bald eagles utilized Roosevelt Reservoir in the winter, although the Pinto female usually was not aggressive toward these birds, she did enter into altercations in Salome Bay and Campaign Bay.

D4.23.7 Wildlife Sightings

Roosevelt Reservoir abounds with waterfowl in the winter, especially in Campaign Bay and on the river between the Highway 288 bridge and the reservoir. Waterfowl sighted include Canada geese, snow geese, white-fronted geese, Ross' geese, mallards, pintails, American wigeon, northern shovelers, redheads, canvasbacks, common goldeneyes, ruddy ducks, buffleheads, ring-necked ducks, lesser and greater scaup, oldsquaw, wood ducks, and green-winged, blue-winged, and cinnamon teal. In addition, large rafts of eared grebes, western grebes, and American coots winter on the reservoir, along with pied-billed grebes and occasional horned grebes. In February 1988, we observed a red-necked grebe in Salome Bay, and in December 1987 we sighted tundra swans on the reservoir. Numerous gulls were observed on the reservoir, including herring, ring-billed, and Bonaparte's gulls. Forster's terns were also a common sight, and several Caspian terns were recorded. On one occasion, we observed 13 white pelicans in Campaign Bay in April.

We observed peregrine falcons on the reservoir each year, and golden eagles nest up Pinto Creek, Salome Creek, and on Black Mesa. At least two pairs of Harris' hawks nest on the powerline towers south of Roosevelt Reservoir. Red-tailed hawks and ravens also nest on the towers, as well as throughout the

Pinto and Pinal area. American kestrels nested in a saguaro cactus near Cougar Point in 1988 and 1989. We sighted several short-eared owls around the reservoir in February 1988. Other raptors sighted in the area include merlins, prairie falcons, northern goshawks, Cooper's hawks, sharp-shinned hawks, ospreys, northern harriers, zone-tailed hawks, ferruginous hawks, and common black hawks. In January 1989 we photographed a one-legged black hawk which was eating carrion near Cougar Point. Armstrong (1990) also sighted a black-shouldered kite in the area.

Snowy egrets, common egrets, white-faced ibis, American avocets, black-necked stilts, greater and lesser yellowlegs, common snipe, green-backed herons, and water pipits were sighted along the river. Two great blue heron rookeries are located along the reservoir, one near the Salt River inflow (Pinto cottonwood grove) and another upstream of the Tonto Creek inflow. In June 1986, numerous black-crowned night herons were observed flying down Salome Creek, and a rookery may exist upstream of A-Cross road (Driscoll, unpublished field notes). Black-crowned night herons also utilized the Campaign Bay area, and a dozen or more were sighted there on numerous occasions. Other birds of interest at Pinto include western and mountain bluebirds, verdins, vermillion flycatchers, hooded and Scott's orioles, and loggerhead shrikes.

Another pair of adult bald eagles have been sighted on numerous occasions throughout the year at Theodore Roosevelt Dam (SRP Dam Personnel), and likely nest in the area. The historical Rock Creek nest site is also in the dam area, off the Tonto Arm of the reservoir. We recorded a pair of adults on Windy Hill on several occasions, as well as in Salome Bay. In February 1988, we observed an adult male (which consistently perched and foraged in Salome Bay) capture a fish and carry the prey north, towards upper Armer Gulch. These observations and reports suggest the existence of an unknown breeding pair which utilize the western portion of the Salt Arm, and the Tonto Arm of the reservoir. This pair may nest off the reservoir, or in the canyon below Theodore Roosevelt Dam.

D4.23.8 Management Recommendations

1. A closure is needed at Pinto in order to protect the nest area before and during incubation. The road running south of and entering the Pinto cottonwood grove should be closed and gated. If people continue to enter the cottonwood grove, a fence may need to be constructed surrounding the area. If the residents in Roosevelt Lake Estates are aware of the eagle nest, they will likely abide by, and assist in enforcing, the closure.

2. Wood cutting should be prohibited at all times in the Pinto cottonwood grove. The undergrowth and standing snags help create a barrier that can protect the nest from some disturbances. In addition, standing snags provide nesting habitat for other species of wildlife. Signs stating "No Wood Cutting" should be posted around the cottonwood grove.

3. As discussed previously, monofilament fishing line, hooks, and lures, are a serious problem at the Pinto and Pinal breeding areas. Fishermen congregate below the diversion dam on the river, and at School House Point on the reservoir, and trash barrels are located in these areas. Signs should be posted on both sides of the river below the diversion dam, and on School House Point, that inform fishermen of the hazards involved in the irresponsible disposal of monofilament line. Signs could state "Monofilament fishing line can be hazardous to wildlife. Birds use it to build nests, and can die from becoming entangled in the line. Hooks in fish stomachs can also harm wildlife that feed on fish remains. Please dispose of all waste monofilament line in the trash barrels."

4. Although large promontory cliffs exist on the river, perching substrate is lacking on the reservoir. Eagles have been observed perching on very small mesquites, low cutbanks, and saguaro cactus. The existing "drowned cottonwood" tree in Campaign Bay is decaying and falling apart, and is the only perch in the bay. Cottonwoods at the north end of Salome Bay are also falling apart. Both Salome and Campaign Bays are heavily used by eagles in winter, as well as the Pinal and Pinto pair. Several adults of unknown territory also used Salome Bay. Phone poles could be dropped by helicopter into the shallow areas of Campaign and Salome Bays to provide perching habitat. Cottonwood poles could also be planted along the reservoir to provide future perch sites.

PINTO BREEDING AREA

Date Discovered: December 1987. First Reports 1986. (1911).
Drainage: Salt River / Roosevelt Reservoir (Free-flowing / Reservoir)
Elevation (MSL): 2100 - 2150 ft
County: Gila
Latitude-Longitude Ten Minute Block: 333-1105
Land Management: U.S. Forest Service, Tonto National Forest, Tonto Basin Ranger District
Distance From Phoenix: Air - 102.5 km East
Distance To Nearest Breeding Area Upstream: Pinal - 11.2 Km
Air - 8.0 km
Distance To Nearest Breeding Area Downstream: Horse Mesa -49.1 Km
Air - 35.0 km
Distance From Granite Reef Dam: 101.5 Km
Distance To Theodore Roosevelt Dam: 22.4 Km
Air - 18.0 km
Home Range: Km 87.0 on Roosevelt Reservoir (including Salome Bay) to Km 110.0 on Salt River (Total = 23.0 Km).
Quadrangles: Windy Hill 7.5 Minute
Meddler Wash 7.5 Minute
Salt River Peak 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Live	1986	Nest built prior to 1986. Adults reported feeding young in nest. Nest and tree fell prior to July 1986.
2	Cottonwood	Live	1988-1989	Existing - Built on top of great blue heron rookery in December 1987.
3	Cottonwood	Live	1990	Existing - Built July-Dec 1989.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
< 1911	Occupied	?	?	?	Bald eagles reported nesting at Salt River Bird Reservation (now Roosevelt Reservoir) prior to 1911.
1986	Successful	?	?	?	Adults reported feeding young in nest 1 by employee of Tonto National Monument. Site checked July 1986 with source. Nest could not be distinguished from great blue heron nests, and was reported to have fallen.

PINTO BREEDING AREA (continued)

Productivity (cont.)

Year	Status	Eggs	Young	Fledged	Comments
1987	Unknown				
1988	Occupied				Pinto female copulating and building nest with Pinal male. Pinto female banded on right tarsus as nestling in 1981 at Bartlett breeding area by Robert Ohmart. Black VID band placed on left tarsus.
1989	Failed	1+	0	0	Pinto female copulating with Pinal male. Nest failed prior to 13 March when the female left eggs to forage. Pinal male did not assist in incubation.
1990	Occupied				Pinto female copulating and building nest 3 with Pinal male. Near-adult male perching with Pinto female in February.
Total		1+	0	0	
Years		3	3	3	
Mean		0.3	0.0	0.0	

< = Prior to

D4.24 PLEASANT BREEDING AREA

The Pleasant breeding area is located 53 km northwest of Phoenix along the free-flowing intermittent Agua Fria River and Pleasant Reservoir. The area upstream of Pleasant Reservoir is characterized by steep slopes and promontory cliffs, although the land opens up as the Agua Fria flows into the reservoir. Due to the high level of recreation pressure at Pleasant Reservoir and on the river below the nest cliff during white bass spawns, a closure was created 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 enhanced to protect the nest cliff from boaters following the completion of New Waddell Dam (T. Gatz, pers. comm.).

D4.24.1 Habitat

The biotic community in the Pleasant area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Creosotebush–Crucifixion-thorn Series. The riparian habitat is a mixture of the Sonoran Riparian

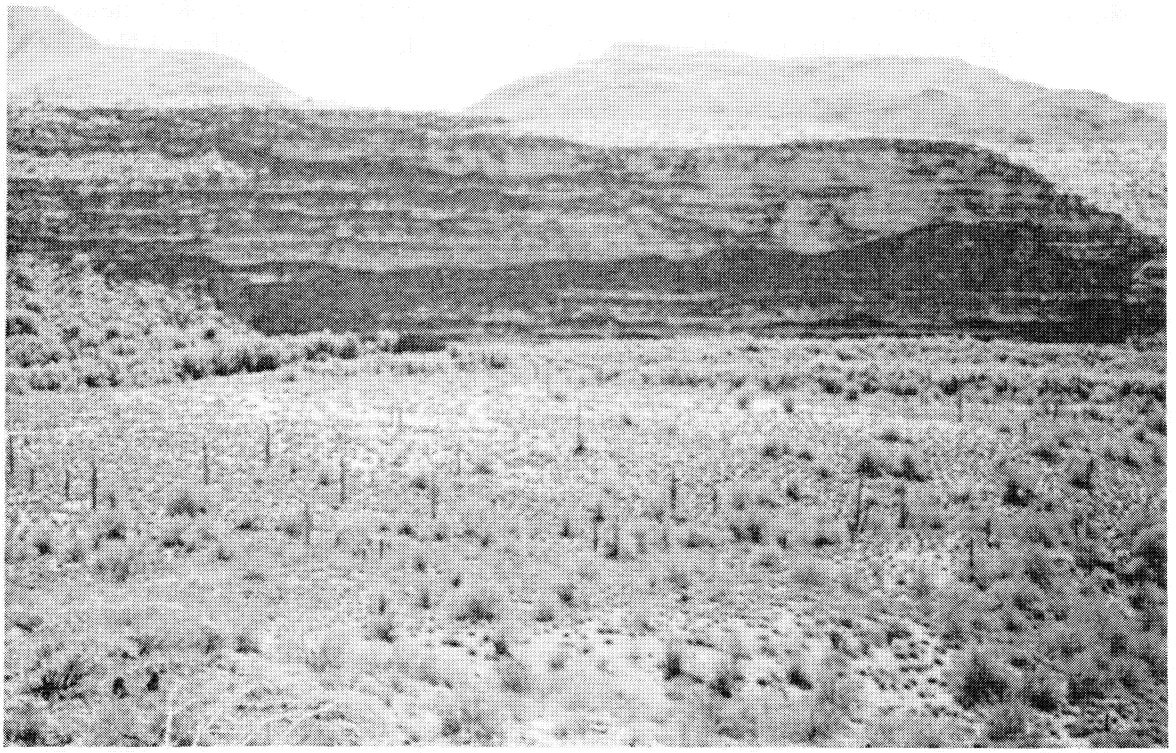

Plate D39. Pleasant nest cliff along the Agua Fria River, October 1986 (photo by D. Driscoll).

Deciduous Forest and Woodlands Biome, the Sonoran Riparian Scrubland Biome, and the Sonoran Interior Strands Biome (see Section D2).

The Agua Fria opens up into a valley as it enters Pleasant Reservoir, created by Waddell Dam at Km 57.0 on the river. The New River enters the Agua Fria below the reservoir, then the Agua Fria continues to the Gila River west of Phoenix. The Agua Fria and New rivers are intermittent streams, portions of them remaining dry during part of the year. New Waddell Dam is currently under construction 0.8 km below Waddell Dam, and when completed the reservoir will inundate the Pleasant eagle's tree nest (1) at high water levels, and raise the water level to within 116 ft of the cliff nest (2) (Reclamation 1982b).

Isolated cottonwoods and willows exist along the Agua Fria and near the reservoir inflow, and salt cedar is abundant. Most of the reservoir shoreline is composed of desert vegetation, although shallow bays (such as Humbug Bay and Coles Wash) contain emergent vegetation. These bays attract a multitude of waterfowl during winter. Promontory cliffs bound the water in some areas and grasses grow on the occasionally inundated flats.

D4.24.2 Reproductive History

The Pleasant breeding area was discovered in 1979; however, it was not known to be active until 1984. Nest 1 was found in 1979, in a live cottonwood tree along the Agua Fria River, upstream of the reservoir (Rubink, pers. comm.), although it has not been used by the eagles since its discovery. No breeding activity was recorded at Pleasant until 13 March 1984, when nest 2 was discovered (Reclamation 1984b). Nest 2 was built on an old raven or red-tailed hawk nest (R. Mesta, pers. comm.) and used by the eagles during 1984–1985 (Reclamation 1984b, Berger and Droege 1985), and again in 1990. Both nests are still in existence, although nest 1 will be inundated when the reservoir fills after completion of New Waddell Dam.

The Pleasant pair, a full adult female and a near-adult male, laid eggs in 1984 and 1985, which failed to hatch (Reclamation 1984b, Berger and Droege 1985). The two known nests were unoccupied in 1986, although one adult was in the nest area during January and 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 nest 2 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 raising young in unknown nest locations, due to their sporadic appearance in the area, but in such a case, it would seem likely they would forage regularly on the reservoir. 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. The Pleasant eagles have laid eggs during 19–21 January and prior to 13 March, although the eggs did not hatch (Table D4.24-1).

D4.24.3 Mortalities

The Pleasant breeding area has not experienced any known juvenile mortalities, since no young are known to have hatched. However, two adult mortalities have been recorded. A near-adult male and a full adult female occupied the territory in 1984, although eagles had not been documented at Pleasant prior to that year. In 1990, both adults were replaced, the male by a near-adult, and the female by an eagle with a USFWS band on its left tarsus.

Table D4.24-1. Nesting chronology of the Pleasant breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1979	—	—	—
1980	—	—	—
1981	—	—	—
1982	—	—	—
1983	—	—	—
1984	< 13 March	—	—
1985	19–21 January	—	—
1986	—	—	—
1987	—	—	—
1988	—	—	—
1989	—	—	—
1990	—	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

D4.24.4 Known Foraging Areas and Food Habits

Data on the foraging ecology of the Pleasant pair is limited, since the breeding area has only been known active in two years. However, observations indicate the eagles use the Agua Fria river, from nest 1 to the reservoir, and the northern portion of Pleasant Reservoir, especially Coles Wash and Humbug Bay (Reclamation 1984b, Berger and Droege 1985, Berger *et al.* 1986). Coles Wash and Humbug Bay are large shallow coves, with emergent vegetation. The eagles appear to forage mainly on the reservoir early in the year, then shift to the river below the nest cliffs during the white bass and carp spawns (Reclamation 1984b, Berger and Droege 1985). The white bass spawning runs begin in the Agua Fria as early as 24 February, fading out in early March when the carp begin spawning. Carp have been observed spawning in the river below the nest cliffs from 5–26 March (Berger and Droege 1985). The Pleasant eagles are known to utilize Km 63.0 on Pleasant Reservoir to Km 75.0 on the Agua Fria River, totaling 12.0 Km. In addition, the Pleasant eagles have been observed perching at Balanced Rock on numerous occasions.

Prey utilization at the Pleasant breeding area is limited to observed forages and prey remains collected from the nest in 1984 and 1985. Prey items described by Reclamation (1984b), Grubb (1984), Berger and Droege (1985), and Grubb (1986a) are provided in Table D4.24-2.

Table D4.24-2. Prey species observed taken by bald eagles or collected from the nest at the Pleasant breeding area.

Fish	Birds	Mammals
Carp	Waterfowl	Black-tailed jackrabbit
Catfish sp.	Green-winged teal	Lagomorph sp.
White bass	Wading Birds	
Crappie sp.	American coot	**Herptiles**
		None found

D4.24.5 Human Impacts

Human disturbance is not a serious problem at the Pleasant breeding area, due to the closure. However, dirt bikes, ATCs, and off-road vehicles still proceed down the Agua Fria riverbed at periods of low or no flow, gaining access to the nest area. This situation likely prevents the eagles from using nest 1, since disturbance is common near the nest tree (Berger and Droege 1985). Other disturbances recorded include light planes, helicopters, low level military jets, hikers, boats, fishermen, and shooting. Hikers, shooting, vehicles, and helicopters all caused the eagles to flush from the nest and perches, although shooting appeared the worst disturbance for the eagles (Berger and Droege 1985).

D4.24.6 Wildlife Interactions

At Pleasant, interactions were numerous with red-tailed hawks, which nest on a cliff downstream of the eagles. The eagles also interacted with common ravens, prairie falcons, and great blue herons (Berger and Droege 1985). Many wintering and subadult eagles use Pleasant Reservoir, some were ignored by the Pleasant adults, although others were chased out of the area.

D4.24.7 Wildlife Sightings

Many birds use Pleasant Reservoir in the winter. We have observed numerous waterfowl (especially in Humbug Bay and Coles Wash), including Canada geese, mallards, pintails, American wigeon, northern shovelers, redheads, canvasbacks, ruddy ducks, buffleheads, ring-necked ducks, wood ducks, and green-winged, and blue-winged teal. In addition, eared grebes and western grebes winter on the reservoir, along with pied-billed grebes and American coots. We have also observed white pelicans on the reservoir. Raptors sighted in the area include prairie falcons, Cooper's hawks, ospreys, and northern harriers. Common egrets, white-faced ibis, common snipe, purple gallinules, and green-backed herons were sighted along the river and in Humbug Bay. A great blue heron and black-crowned night heron rookery is located downstream of the eagle nest cliffs.

D4.24.8 Management Recommendations

1. The Pleasant breeding area has been unoccupied at the two known nesting locations seven of the 12 years since the breeding area was discovered in 1979. However, in some years adults are observed in the area, but not nesting in the two known nests. It is possible that the Pleasant eagles are nesting in an unknown nest location which could be found by capturing and radio-tagging one

or both of the adults. Data received from a telemetered eagle would also greatly enhance current knowledge about the foraging ecology of the Pleasant eagles and their use of the reservoir.

2. New Waddell Dam is currently under construction 0.5 mi below Waddell Dam, and when completed, the reservoir will inundate the Pleasant eagle's tree nest (1) during high water levels, and raise the water level to within 116 ft of the cliff nest (2) (Reclamation 1982b). Measures should be taken to ensure that the nest tree is not flooded if eagles are incubating eggs or raising young in nest 1. A similar situation occurs at the Horseshoe breeding area, and nest inundation has adversely effected productivity at Horseshoe in the past (see Section D4.15).

PLEASANT BREEDING AREA

Date Discovered: 1979
Drainage: Agua Fria River/Lake Pleasant (Free-flowing/Reservoir)
Elevation (MSL): 1600 - 1800 ft
County: Maricopa (East of Agua Fria River)
Yavapai (West of Agua Fria River)
Latitude-Longitude Ten Minute Block: 335-1121
Land Management: Maricopa County Parks and Recreation Department
Lake Pleasant Regional Park
Closure: Maricopa County Parks and Recreation Department Closure
Enacted 18 December 1985 (1 square mile)
Extended 25 January 1986 (2 square miles)
Closed To All Entry 15 December - 15 June
Revised 1987 - Closed To All Entry 1 December - 30 June
Distance From Phoenix: Air - 53.5 km Northwest
Distance To Nearest Breeding Area Upstream: Horseshoe
Air - 48.5 km
Distance To Nearest Breeding Area Downstream: Cliff - Air-51.0 km
Distance From Gila River Confluence: 68.9 Km
Distance To New Waddell Dam: 12.0 Km
Air - 7.5 km
Home Range: Unknown. Known to utilize Km 63.0 on Lake Pleasant (including Balanced Rock, Coles Wash, and Humbug Bay) to Km 75.0 on the Agua Fria River (Total = 12.0 Km).
Quadrangles: Governor's Peak 7.5 Minute
New River 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Live	Unknown	Existing - Found 1979.
2		Cliff	1984–1985	Existing - Found 13 March 1984.
			1990	Built on old raven or redtail hawk nest.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1979	Unoccupied				
1980	Unoccupied				
1981	Unoccupied				
1982	Unoccupied				
1983	Unoccupied				
1984	Failed	1+	0	0	Near-adult male (ca. 4 years old).
1985	Failed	1+	0	0	Near-adult male—possibly same as male 1984.

PLEASANT BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1986	Unoccupied				One adult in nest area from January-February.
1987	Occupied	?	?	?	Two adults near nest 2 on 25 Nov 1986. Two adults perched near nest 2 in June, 1987. Possibly nested in unknown location.
1988	Unoccupied				Four adults sighted during March carp spawn.
1989	Occupied				
1990	Occupied				New pair. Near-adult male (ca. 4 years old), female banded on left tarsus.
Total		2+	0	0	
Years		5	5	5	
Mean		0.4	0.0	0.0	

D4.25 REDMOND BREEDING AREA

The Redmond breeding area is located 117 km east of Phoenix in the remote rugged terrain along the free-flowing Salt River. The area is characterized by steep slopes and promontory cliffs. Cherry Creek is a free-flowing perennial stream which drains the Sierra Anchas and flows into the Salt River upstream of Horseshoe Bend. 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.

D4.25.1 Habitat

The biotic community in the Redmond area is of the Upper Sonoran and Lower Sonoran Life Zones. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Paloverde-Cacti–Mixed Scrub Series and the Jojoba–Mixed Scrub Series. On the high mesas, habitat is of the Interior Chaparral Biome. 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).

Plate D40. Redmond breeding area on free-flowing Salt River, February 1985 (photo by D. Driscoll).

The Salt River is a fast white-water stream as it flows out of the White Mountains. In the Redmond area, the Salt enters Jump-Off Canyon at Km 147, flows past McGee Mountain (to the north), then opens up at the Cherry Creek confluence (Km 137.9). Cherry Creek drains the Mogollon Rim and the Sierra Anchas, flowing into the Salt from the north. The river immediately enters another canyon, which opens up at Horseshoe Bend (Km 132–135). Horseshoe Bend supported a large mesquite bosque as late as 1985; however, the land has now been cleared for cattle grazing.

The Salt River slows down after Horseshoe Bend as the terrain opens up and the stream gradient becomes lower than in the upper canyons. The river, however, is still bounded by large promontory cliffs on one side or the other as it meanders west, often with flats opposite the cliffs. The Salt flows past Redmond Flat (Km 124–127), where Coon, Dry, and Chalk Creeks enter from the north at Km 124. The Salt River closes in as it passes Redmond Mountain to the south, and Black Mesa to the north, then flows into an "S" curve bounded by cliffs and large pinnacles at Km 113–114. Pinal Creek flows out of the Pinal Mountains and enters the Salt at Km 112.7, although the water is tainted by tailings from copper mines in the Globe area. The river opens up into Tonto Basin as it passes the Salt River Mountains and Klondike Mountain to the south (in the Pinal breeding area) and flows into Roosevelt Reservoir.

The free-flowing Salt River contains variable flows, and due to the narrow canyon, heavy rains (especially in spring, when snow is on the mountains) can cause violent floods. During heavy rains in mid-March 1985, a 12-foot-wall of water passed Cibecue Creek, which thinned to 4–6 ft as it passed Horseshoe Bend in the Redmond territory. Such a volume of water sent large boulders smashing against one another, with a sound resembling gunshots echoing off the cliffs for several days as the water remained at high levels.

Dry Creek flows into Chalk Creek west of Redmond Flat, then Chalk continues east, with a waterfall dropping off a large cliff near the Salt River confluence. Both are intermittent streams. Coon Creek also flows into the Salt from the west, although it is a perennial stream which contained many pools 2–4 ft in depth in June 1985. The creeks support isolated cottonwoods as they flow to the Salt, with small groves of large cottonwoods and sycamores at their confluences. Cherry Creek is a perennial stream with isolated large cottonwoods and sycamores along the banks, and mesquite bosques in some areas. Portions of the creek are open, while others are bounded by promontory cliffs. Water levels in Cherry Creek ranged from 2–6 ft in depth at the end of May 1985, with a variety of pools, runs, and riffles over rock, sand, and gravel substrates (Driscoll 1985).

D4.25.2 Reproductive History

The Redmond breeding area was discovered in 1974, and the eagles have laid eggs in 15 of the 17 years of known occupancy. The Redmond eagles are among the latest nesters of all the Arizona bald eagle breeding areas. However, they are not always the last pair to lay eggs in any given year (see Section C2.1). The Redmond eagles have laid eggs from 31 January to 17 March, hatching young from 5 March to 20 April, and fledging eaglets from 12–18 May to 19 June (Table D4.25-1). In 1978, the Redmond pair laid eggs (17 March), hatched eaglets (20 April), and fledged young (19 June)(Hildebrandt 1981), the latest dates on record, excluding a 6 July fledge date at Lone Pine. Interestingly, even though 19 June is the second latest fledging date, that eaglet left the nest at 60 days of age (only 8.5 weeks), the earliest fledging age on record; however, this eaglet died 1–2 days after fledging (Grubb 1986a). In the same year, a Fort McDowell eaglet fledged at 60 days of age and survived (Hildebrandt 1981).

Table D4.25-1. Nesting chronology of the Redmond breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1974	—	—	—
1975	—	< 23 April	—
1976	—	—	—
1977	—	—	—
1978	17 March	20 April	19 June*
1979	6 March	10 April	—
1980	—	—	—
1981	3 February	10 March	28 May, 5 June
1982	6 February	13 March	2 June
1983	10 February	16 March	6, 9 June
1984	4 March	8, 11 April*	—
1985	9, 12 February*	18, 19 March*	6–8 June*
1986	16 February	23 March*	> 7 June
1987	< 13 February	—	—
	13 February	18 March	> 6 May**
1988	31 January	5 March	12–18 May*
1989	20 February	27 March	—
1990	21 February	28–29 March*	6 June*

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
** Indicates second clutch data.
< Indicates "prior to"
> Indicates "later than"

The Redmond eagles have built six known nests, four cliff nests (1, 2, 3, 6) and two pinnacle nests (4, 5) on the Salt River surrounding Redmond Flat. In addition, a possible historical nest may have been built on the cliffs northeast of Redmond Flat (Forbis, pers. comm.), although no nest was found at the site in 1985. Nest 1 was found in 1974 (Rubink and Podborny 1976) and is now merely a remnant. The eagles have not used nest 1 since its discovery, although the birds perch at the site frequently. Nest 2 was found in 1976 near the Coon Creek confluence (Rubink, pers. comm.), but had fallen prior to 1985, and was not known to be used by the eagles. Nest 3 was found in 1988 upstream of the Redmond pinnacles, and has not been used by the eagles since its discovery.

Nest 4 was found in July 1986, while retrieving prey remains from a ledge on the north face of the nest 5 pinnacle. Nest 5 is located on top of a free standing pinnacle, and due to the curvature of the pinnacle, nest 4 is located nearly below nest 5. Nest 4 is surrounded by rock, cradled between a small pinnacle and the north face of the large nest 5 pinnacle. Nest 4 is difficult to see from the air or ground, and

while sitting in the nest, the eagle has a limited view upstream, with a more expansive view downstream to Redmond Flat. The nest 5 pinnacle basically forms a roof over nest 4, precluding any aerial view. In addition, it appears nest 4 would be shaded most, if not all, of the day, receiving direct sun only in the first few hours of daylight.

We collected old eggshell fragments from nest 4 in 1986, indicating the eagles had used the nest prior to that year. The Redmond pair has been accounted for in all years except 1974 and before, so unless the eagles double-clutched during 1975–1986, the fragments would have been from 1974 or prior. All eggshell fragments and prey remains were removed from nest 4 in 1986. We rappelled to nest 4 again after the 1987 breeding season to obtain nest measurements. When we reached the nest, we found eggshell fragments on top of the nest. The eggshells were from 1987, since they still retained their bluish tint and all eggshell fragments and prey remains had been removed from deep in nest 4 in 1986. However, in 1987 the adults laid at least two eggs and raised two young in nest 5. Therefore, the Redmond eagles must have double-clutched in 1987, laying at least one egg in nest 4, then subsequently laying eggs and raising young in nest 5. The fragments were sent to Lloyd Kiff, Western Foundation of Vertebrate Zoology, and confirmed as bald eagle eggshells. This represents the first documented incidence of double-clutching in Arizona bald eagles.

Nest 5, located on top of a free standing pinnacle east of Redmond Flat, was found in 1974 (Rubink and Podborny 1976). Nest 5 has been used by the eagles during 1975–1976 (Rubink and Podborny 1976, Rubink, pers. comm.), 1978–1987 (Hildebrandt 1981, Ohmart and Sell 1980, Haywood and Ohmart 1983, Grubb 1986a, this report), and 1988–1990, appearing to be the most preferred nest in the territory. Nest 6 was built and used by the Redmond pair in 1988, on a cliff east of Redmond Flat. Nests 1, 3, 4, 5, and 6 are still in existence.

Prey remains and nest sticks commonly fall from nest 5 to ledges on the north and east face of the pinnacle. These sticks have been reported as nests in the past (Hildebrandt 1981, Ohmart and Sell 1980, Haywood and Ohmart 1980, Haywood and Ohmart 1983); however, we examined them in 1986 and found they are only piles of fallen sticks from nest 5, with no form or arrangement.

When the Redmond nest was found in 1974 the adults were in the area, but it was unknown if eggs were laid (Rubink and Podborny 1976). It is possible the eagles laid eggs that year in nest 4 which is not visible from the air or ground. In 1975, one eaglet hatched, but died in the nest (Rubink and Podborny 1976). Productivity data in 1976 vary between sources. Ohmart and Sell (1980) and Haywood and Ohmart (1983) state that one young fledged; however, Forbis (1985), Forbis (1986), Forbis (pers. comm.) and Rubink (pers. comm.) all indicated that two young fledged. In 1977, the site was occupied by a new pair, a subadult male and near-adult female, and apparently no eggs were laid (Hildebrandt 1981).

Similarly, productivity data for 1978 vary between sources. Ohmart and Sell (1980) and Haywood and Ohmart (1983) state that both young died when they fell from the nest, resulting in nest failure; however, Hildebrandt (1981), Forbis (1985), Forbis (1986), Forbis (pers. comm.) and Grubb (1986a) all indicated that one young fledged to a ledge below the nest, but died 1–2 days later. Two eaglets hatched in 1979, but one fell from the nest, and the eggs did not hatch in 1980 (Ohmart and Sell 1980, Haywood and Ohmart 1983). Two young fledged each year during 1981–1983 (Haywood and Ohmart 1983, Grubb *et al.* 1983). Two eaglets hatched in 1984, but died in the nest (Weber 1984, Kohlsdorf and Boyce 1984). Two young fledged in 1985 (Driscoll 1985), and one fledged in 1986 (Prescott *et al.* 1986).

As discussed above, at least one egg was laid in nest 4 in 1987 which did not hatch. The adults then laid a second clutch of eggs in nest 5, fledging two young. Two eaglets hatched in 1988, but one died in the nest, and both young died in the nest in 1989. One nestling hatched and fledged in 1990.

The Redmond nest site is interesting for ABENWP personnel, since observations can be made from a mountain to the south, providing an unobstructed view into the nest. In 1985, Driscoll (1985) actually witnessed the eggs being laid and also observed hatching. The first egg was laid at 1501 hours on 9 February. The female exhibited normal behavior through the morning, and returned to the nest at 1254 hours. She assumed a sitting posture and remained in that position until 1411 hours, when she stood up. The male returned to the nest at 1437 hours, and both birds rearranged nest material until 1441 hours. At 1500 hours the female crouched over and held her wings down to her side, but remained standing above the nest. At 1501 hours she laid the first egg, and began incubating at 1503 hours. The second egg was laid at night, between 1800 hours on 12 February and 0700 hours on 13 February (Driscoll 1985).

The first observation of pipping occurred at 1152 hours on 18 March. The female rose from an incubation posture, exposing a small egg chip laying in the nest. Examination of the eggs revealed a hole in the end of one egg and a longitudinal crack on the top. The female rose again at 1212 hours, and the hole had been pipit open slightly larger, but she resumed incubation. The female assumed a brooding posture at 1242, partially exposing the pipit open egg. The female remained at the nest until 1529 hours, when the male returned to the nest. At this time, the eaglet had worked itself half-way out of the eggshell. The male began brooding at 1532 hours, sitting higher on the eggs than the female had been. The male rose up from the eggs at 1647 hours, and at 1648 hours he pulled the remainder of the shell off the eaglet. The male then took the shell to the east rim of the nest, crumbled it, and scattered the fragments. The male pushed the other egg into the nest cup, while the eaglet stood at his breast. The eaglet lifted its head to the male's throat, then laid down on the nest. At 1649 hours, the male began brooding again (Driscoll 1985).

The first observation of pipping in the second egg occurred at 1603 hours on 19 March, when a hole had been pipping in one end of the egg. The hole had been pipping open slightly larger at 1754 hours. The egg had not hatched by 1801 hours on 19 March. At 0700 hours on 20 March, eggshell fragments were observed in the nest, indicating possible hatching of the second egg. The female rose from a brooding posture at 0802 hours, revealing the second eaglet in the nest (Driscoll 1985).

Assuming that the first egg laid hatched first, incubation time for the first egg, from 1501 hours on 9 February to 1648 hours on 18 March, 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).

D4.25.3 Mortalities

The Redmond breeding area has experienced ten juvenile mortalities since 1975, making it one of the highest nestling mortality sites in Arizona, second only to the Cibecue breeding which has had 13 recorded deaths. Of the ten deaths at Redmond, six young died in the nest, two fell from the nest, and two died post-fledging.

In 1975, the single eaglet died in the nest of unknown causes (Rubink and Podborny 1976). Ohmart and Sell (1980) and Haywood and Ohmart (1983) state that both young died when they fell from the nest,

resulting in nest failure; however, Hildebrandt (1981), Forbis (1985), Forbis (1986), Forbis (pers. comm.) and Grubb (1986a) all indicated that one young fledged to a ledge below the nest, but died 1–2 days later. This eaglet was 60 days (8.5 weeks) old. In 1979, one of the eaglets fell from the nest again (Hildebrandt 1981). 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).

In 1984, a photographer was stationed in a blind south of the nest pinnacles, with camera boxes near the nest. The cameras were controlled from the blind. The Redmond eagles laid eggs on 4 March in 1984, and two eaglets hatched on 8 and 11 April, but one died in the nest on 18 April and the other on 12–16 May. It was thought that the photographer's blind and activities caused the eagles to lay late and contributed to the nest failure (Grubb 1984, Forbis 1985, Forbis 1986, Grubb 1986a); however, a severe infestation of Mexican chicken bugs was found in the nest on 16 May (Grubb 1984, Grubb 1986a, Eakle, pers. comm.).

Camera boxes had been camouflaged and placed 60 ft from the nest prior to 11 January 1984, so this likely would not disturb the birds, although the blind and photographers activities may have caused the eagles to lay late (4 March). However, the Redmond eagles laid eggs on 6 March in 1979, and 17 March in 1978. In addition, the Cibecue eagles laid eggs on 5 March in 1980, and the Lone Pine pair laid eggs on 8 March in 1988. We have documented Mexican chicken bugs as a contributing factor in nestling mortalities at Redmond and other breeding areas during 1987–1989, and this likely contributed to the mortality of the Redmond juveniles in 1984. See Section C3.4 for details on Mexican chicken bugs in Arizona bald eagle nests.

The Redmond eagles raised two young in a new nest (6) 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 tanned skin. Upon entering the nest, Mexican chicken bugs dashed up the climbers 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 1988 nestlings. Similarly, two eaglets died at the Redmond breeding area on 6–7 April 1989, at 1.5 weeks of age, during a period of unusually high temperatures. A low density of Mexican chicken bugs was found in the nest when climbed on 13 April. The above average heat and the nest parasites likely contributed to the death of both 1989 juveniles. See Section C3 for details on nest parasites and heat stress at Arizona bald eagle breeding areas.

The Redmond breeding area has experienced four known adult mortalities since 1974. Both adults were replaced in 1977, the male by a subadult (ca. 3 years old) and the female by a near-adult (ca. 4 years old) (Hildebrandt and Ohmart 1977, Hildebrandt 1981). The male had developed near-adult plumage by 1978, although the female had been replaced by another near-adult (Hildebrandt 1981). 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 (ca. 4–5 years old) in 1988.

Mexican Chicken Bugs. There is a reoccurring problem of nest infestation with Mexican chicken bugs at the Redmond breeding area. The parasite has been found in nest 5 in 1984, 1987, and 1989, and in nest 6 in 1988, and has probably caused or contributed to the mortality of six eaglets at Redmond.

The Mexican chicken bug is a bloodsucking ectoparasite of the Cimicidae family, similar to a bed bug. The bugs live in the nest lining, emerge to feed on the young, then drop back into the nest material (Usinger 1966). This parasite was first found at the Redmond breeding area in 1984 (nest 5) (Grubb 1984), and likely caused or contributed to the death of both eaglets that year.

We observed chicken bugs in low density at the Redmond breeding area in 1987 when two young fledged (nest 5). In 1988, the parasite occurred in high density in a new nest (6), 1.5 km north of the pinnacle nest (5). When approached for banding, both eaglets were perched on a ledge away from the nest, and we noted the bugs crossing the rock to reach the young eagles. 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, and noticed only a few of the parasites. In 1989, a low density of chicken bugs was found in nest 5, where two eaglets had died at 1.5 weeks of age.

Heat Stress. Heat stress has been debated as a possible mortality factor at the Redmond breeding area 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 feed (Ohmart and Sell 1980). The structure was still in place in 1981, when two young fledged (Haywood and Ohmart 1982), but 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 feed and exercise, until 6 May. After 6 May, only one eaglet could fit in the shade of the structure 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 structure 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 section on Mexican Chicken Bug above). An artificial shade structure was constructed of sticks prior to the 1985 breeding season, although the adults dismantled the structure 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°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.

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. The angle of the sun on the pinnacles above (and west of) the nest, as well as those on the south rim, created shade around the south and west portions of the nest during part of the day. 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).

A number of factors contribute to potential high temperatures in Arizona bald eagle nests. 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. During 1989–1990, BioSystems 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 nests. 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). In all samples the area of highest heat was the nest surface, excluding Redmond, where exposed cliff surface was 9° hotter than ambient, and 7° hotter than the nest surface (nest 5).

Even the best protected nests are subject to the high ambient temperatures noted in recent nesting seasons (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. A number of proteins denature at approximately 106–108°F, and can become permanently inactive even if only slightly denatured (Dr. L. J. Calciano, pers. comm.).

D4.25.4 Known Foraging Areas and Food Habits

Bald eagles at the Redmond breeding area have been known to forage on the Salt River, from the east side of Redmond Flat (Km 124) to the bend in the river below the nest (Km 128) (Hildebrandt 1981, Firchow 1982, Haywood and Ohmart 1983, Grubb *et al.* 1983, Kohlsdorf and Boyce 1984, Grubb 1984, Driscoll 1985, Grubb 1986a, Prescott 1986, Kime and Upton 1990). In addition, Driscoll (1985) reported possible foraging at Redmond Well Wash (Km 123), and M. Cross (pers. comm.) observed the eagles feeding on carrion at Horseshoe Bend (Km 133).

The eagles were reported making flights up a canyon north of Redmond Flat on numerous occasions (Firchow 1982, Driscoll 1985), often resulting in lengthy soaring over the Cherry Creek area (Driscoll 1985). This canyon leads directly to Km 3 on Cherry Creek (near Dagger Ranch), so the eagles likely use the creek more extensively than has been documented. Driscoll (1985) observed numerous carp in schools of up to 30 fish (up to 2.5 ft in length) in the creek in late May 1985, when spawning may have been occurring. Driscoll (1985) also reported skeletal remains of flathead and channel catfish up to 2 ft in length along sandbars in the creek. A sighting of the Redmond male, and two subadult eagles, at the Cherry Creek and Salt River confluence (on 27 April) by Driscoll (1985) lends credibility to this hypothesis. In addition, adult bald eagles have been sighted foraging at the Cherry Creek confluence during sucker spawns in April 1985 and 1986 (M. Cross, pers. comm.).

The Redmond eagles also made flights up Coon and Chalk Creeks (Firchow 1982, Kohlsdorf and Boyce 1984, Driscoll 1985) and soared over a vast area. Driscoll (1985) observed the eagles soaring as far upstream as the Km 148 area on the Salt River, and downstream to the Km 120 area. To the northwest, the eagles were observed soaring over the Cougar Canyon area. The adults appeared to travel farthest to the north, soaring to the upper Coon Creek area (above Bill Lee Springs) and the upper Cherry Creek area near Montague Springs. The eagles did not venture far into the desert area south of the nest, and were only observed as far east as Storm Canyon (Driscoll 1985).

We captured and radio-tagged the Redmond male at the end of the 1988 breeding season (21 May); however, his transmitter failed prior to the 1989 nesting season. This early failure of transmitter batteries prevented us from obtaining data on the home range of the Redmond eagles. The extensive soaring observed by Driscoll (1985), and the similarity of the Redmond and East Verde habitats and tributaries may indicate long-range foraging as BioSystems documented at the East Verde breeding area (see Section B4.4 for details on the foraging ecology and movements of the East Verde eagles). The full extent of the home range of the Redmond pair is unknown, although the eagles have been observed on Cherry Creek, as well as the Salt River from Km 122.0 to Km 139.0, totaling 17 Km (Driscoll 1985).

The home range of the adjacent Pinal eagles (see Section D4.22) overlapped with that of the Redmond pair. From January to May 1988, the Pinal female utilized the Salt River from Km 109 (below the diversion dam) to Km 126 at Redmond Flat. On 3 January 1988, she soared several km upstream of the Cherry Creek confluence (Km 138), well into the territory of the Redmond pair. See Section B4.6 for details on the foraging ecology and movements of the Pinal eagles.

Large Colorado River squawfish were still taken from the Salt River at the turn of the century, as evidenced by the photo on the first page of Minckley (1973). Although the squawfish (up to 30 pounds) described by Davis (1982) are now gone, catfish of similar size still inhabit the Salt and Verde rivers. At the location of the photo in Minckley (1973), between Redmond Flat and Cherry Creek on the Salt River, during 1985–1989 we sampled flathead catfish ranging from 3–35 pounds, many in the 8–15-pound

size, and several weighing 25, 27, 28 and 35 pounds. We have also sampled channel catfish weighing between 1 and 15 pounds in the Salt River near the Redmond nest, as well as one weighing 25 pounds from the Verde River.

Razorback suckers have been reintroduced to the Salt River in the Horseshoe Bend area by AGF. These releases have apparently been somewhat successful, since razorback suckers were taken as prey by the Redmond and Pinal eagles during 1986–1989. One razorback release was conducted in mid-March 1985, just prior to the flood that year, which likely washed all the fry down to Roosevelt Reservoir.

Prey items described by Hildebrandt (1981), Haywood and Ohmart (1981), Firchow (1982), Haywood and Ohmart (1982), Haywood and Ohmart (1983), Grubb *et al.* (1983), Weber (1984), Kohlsdorf and Boyce (1984), Grubb (1984), Driscoll (1985), and Grubb (1986a), are presented in Table D4.25-2, along with prey items taken by the eagles and prey remains collected at the nest during 1986–1989. See Section B5.1.7 for a detailed analysis of prey species utilized by the Redmond eagles.

Table D4.25-2. Prey species observed taken by bald eagles or collected from the nest at the Redmond breeding area.

Fish	**Birds**	**Mammals**
Carp	Waterfowl	Cottontail rabbit
Buffalo sp.	None found	Blacktail jackrabbit
Channel catfish	Grebes	Neotoma
Flathead catfish	Grebe sp.	Rock squirrel
Blue catfish	Wading Birds	Unidentified Sciuridae
Largemouth bass	American coot	Ringtail
Smallmouth bass	Great blue heron	Hognose skunk
Black bass	Passerines	Beaver
Unidentified Centrarchidae	None found	Javelina
Desert sucker	Other Birds	Deer sp.
Sonora sucker	Gila woodpecker	Mountain lion
Razorback sucker	Greater roadrunner	Hereford cow
Crappie sp.	Mourning dove	Cow sp.
	Unidentified Caprimulgidae	Domestic sheep
		Herptiles
		Sonoran mud turtle
		Unidentified snake
		Unidentified lizard
		Unidentified reptile
		Other
		Flies

We collected the lower jaw of a domestic sheep from the Redmond nest in 1986, along with three trash bags full of flathead catfish and channel catfish skulls and other prey parts. Some of these catfish skulls were of immense size, and the fish would be much too heavy for the eagles to carry to the nest whole. Driscoll (1985) observed the Redmond eagles feeding on filleted catfish carcasses which washed up onto a sandbar near nest 5, and delivering these carcasses to the young in the nest. The Redmond adults were also observed capturing catfish, carp, and suckers so large the eagles had to swim (using their wings) out of the river and drag the fish to shore. The adults then fed on the head, and usually tore the fish in half, before delivering the prey to the nest (Driscoll 1985, Driscoll, unpublished field notes). In addition, the eagles fed on a hereford calf carcass which washed up near the nest following a flood in mid-March 1985, and a female mountain lion shot at Horseshoe Bend by a local rancher in 1986 (Driscoll 1985, M. Cross, pers. comm.).

In some interesting observations, both adults began capturing flies as prey items accumulated in the nest after hatching. 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 succeeded in capturing flies in many instances, and swallowed them following several movements of the beak (Driscoll 1985). In a possibly related behavioral observation, the male and female were seen removing old prey items from the nest and embarking on short flights, dropping the remains over the river or surrounding desert area (Driscoll 1985).

Riffles become exposed near the Redmond nest (5) and surrounding Redmond Flat, as flows in the Salt decrease in late spring and summer. The eagles used these riffles extensively to capture carp and suckers in 1985, often foraging right off the nest (Driscoll 1985, Driscoll, unpublished field notes). On 9 May 1982, the adults delivered five fish to the nest within a 2.5 hour period from the river near the nest 5 pinnacle (Firchow 1982). When flows decrease in late spring and summer, the Horseshoe Bend area becomes braided, with rock bars separating the stream sections, which may create similar foraging habitat. The Redmond adults also were observed stealing carrion from turkey vultures (Firchow 1982, Driscoll, unpublished field notes).

D4.25.5 Human Impacts

Due to its remote location, human disturbance is not a serious problem at the Redmond breeding area. Fishermen can access the area at Horseshoe Bend, and Redmond Well Wash, although the promontory cliffs hamper access to the nest area. However, Kime and Upton (1990) did observe a fisherman flush the adult female from a perch. A photographer changing film in camera boxes near the nest caused the adults to circle and vocalize (Weber 1984). Other disturbances recorded involved low flying military jets, light planes, and helicopters, sonic booms, gunshots, rafts, kayaks, and canoes (Firchow 1982, Weber 1984, Kohlsdorf and Boyce 1984, Driscoll 1985, Prescott *et al.* 1986). Helicopters caused the eagles to flush from perches on several occasions, sometimes approaching within 20 m of the nest (Firchow 1982, Driscoll 1985, Prescott *et al.* 1986). During flood conditions in mid-March 1985, Department of Public Safety helicopters were rescuing rafters from the river. On 12 and 13 March, 15 helicopters flew at low levels through the nest area, some approaching within 50 m of the nest. In one incident, the adult female (soaring in the Redmond Well Wash area) was nearly struck by a helicopter, and resorted to evasive tactics (erratic flight) to avoid the aircraft, which passed within 10 m of her (Driscoll 1985).

Gunshots caused the eagles to flush from the nest and perches on several occasions, especially when the guns were fired from rafts and canoes passing below the nest pinnacles (Weber 1984, Kohlsdorf and Boyce 1984). The most serious disturbances at Redmond resulted from rafters, kayakers, and canoers

stopping on the beach across from the nest pinnacles to picnic or camp, especially during incubation (Firchow 1982, Kohlsdorf and Boyce 1984, Driscoll 1985). In one instance, the incubating female left the eggs, and both adults left the area when rafters and kayakers stopped to camp on the beach (Driscoll 1985). In a severe disturbance, Firchow (1982) witnessed a kayaker climbing the nest pinnacle on 3 May 1982. Firchow (1982) recorded 30 rafts passing below the nest on 11 April 1982, and Driscoll (1985) observed 65 rivercraft floating passed the nest from 20–24 April 1985. The rafting season extends from February to July in most years; however, the peak seems to be from March to June. A total of 300 rivercraft passed the Redmond nest on 36 sample days from February to June in 1985, with weekend traffic being the heaviest (Driscoll 1985).

Fishermen access the Redmond area at Horseshoe Bend and Redmond Well Wash, commonly filleting their catch and leaving the carcass behind or throwing it in the river. The eagles subsequently forage on the remains when fishermen leave (Driscoll 1985). This practice may be hazardous to the eagles if hooks and line remain in the fish (see the Pinal section). Driscoll (1985) observed the Redmond eagles delivering large filleted catfish carcasses to the nest, and we have found monofilament and fishing stringers in the Redmond nest. In addition, at the adjacent Pinal breeding area, the 1988 nestling died after becoming entangled in monofilament at the nest (see Section C3.3).

The Roosevelt Diversion Dam (downstream near Roosevelt Reservoir) has been blocking the upstream migration of reservoir fishes since Roosevelt Reservoir was created. When Theodore Roosevelt Dam modifications are complete, high water levels will allow fish access to the upper Salt River (Roosevelt Site Maps *in* U.S. Bureau of Reclamation 1983). We have sampled large flathead catfish, up to 35 pounds, in the Horseshoe Bend area, although the number of large fish would likely increase if the current fish barrier (diversion dam) was inundated by high reservoir levels. Some very large carp also exist in the reservoir, and we observed up to 30 pound carp snagged by fishermen below the diversion dam. If the large reservoir fish are allowed into the upper Salt River, it may adversely impact prey species (suckers) in the Pinal and Redmond breeding areas.

D4.25.6 Wildlife Interactions

At Redmond, interspecific interactions were numerous with red-tailed hawks which nested nearby, and turkey vultures which roosted in large numbers on a cliff south of the eagle nest (5) (Driscoll 1985). The eagles also interacted with common ravens, great blue herons, and golden eagles (Firchow 1982, Kohlsdorf and Boyce 1984, Driscoll 1985, Prescott *et al.* 1986, Kime and Upton 1990). In one instance, the adults chased a zone-tailed hawk out of the nest area (Firchow 1982). In an interesting observation, Driscoll (1985) witnessed a red-tailed hawk land on the nest pinnacle and attempt to enter the nest while the adult male was brooding. The male allowed the hawk to approach within two ft of the nest before spreading his wings and flushing the intruder. In addition, white-throated swifts often whizzed by the nest, causing the adults to duck their heads. Hummingbirds also buzzed around the adults and young at the nest, and Say's phoebes and western kingbirds were observed flycatching over the nest (Driscoll 1985). The adults soared non-aggressively with golden eagles on several occasions in 1985, and adult and subadult golden eagles were observed perching on the butte southeast of nest 5 on many occasions (Driscoll 1985, Driscoll, unpublished field notes).

Interactions with other bald eagles were often aggressive. Driscoll (1985) noted stooping, locking talons, cartwheeling, and vocalizations until the birds flew out of sight. In one instance, the male and female drove a subadult into the ground, where it scurried under a paloverde tree to escape the wrath of the Redmond adults (Driscoll, unpublished field notes).

D4.25.7 Wildlife Sightings

Waterfowl sighted in the Redmond area include Canada geese, mallards, buffleheads, and common mergansers. In addition, pied-billed grebes, American coots, double-crested cormorants, killdeer, spotted, solitary, western, and least sandpipers, Wilson's phalaropes, black-necked stilts, greater and lesser yellowlegs, green-backed herons, and great blue herons occur along the river. Raptors sighted in the area include great horned owls, elf owls, western screech owls, merlins, prairie falcons, American kestrels, Cooper's hawks, sharp-shinned hawks, osprey, zone-tailed hawks, Swainson's hawks, Harris' hawks, common black hawks, and golden eagles (Driscoll 1985, Driscoll, unpublished field notes). One osprey was sighted at Redmond in June 1987, although we commonly saw osprey in all seasons along the Salt and Verde rivers during 1987–1990.

Other birds of interest at Redmond include band-tailed pigeons, rock doves, mourning and white-winged doves, poor-wills, whip-poor-wills, common and lesser nighthawks, Anna's, black-chinned, Costa's, and broad-tailed hummingbirds, belted kingfishers, common (gilded and red-shafted) flickers, Gila, acorn, Lewis', and ladder-backed woodpeckers, scrub, Steller's, and pinyon jays, American crows, western and Cassin's kingbirds, Say's and black phoebes, Weid's crested, ash-throated, western, olivaceous, willow and vermillion flycatchers, and western wood peewees. Bank, barn, cliff, rough-winged, tree, and violet-green swallows were observed, but barn swallows only on several occasions.

In addition, Bewick's, cactus, canyon, and rock wrens were recorded, along with curve-billed and Crissal thrashers, American robins, Townsend's solitaires, western and mountain bluebirds, verdins, hooded, northern, and Scott's orioles, loggerhead shrikes, blue-gray and black-tailed gnatcatchers, phainopeplas, cardinals, pyrrhuloxias, gray vireos, Virginia's, Lucy's, yellow, and yellow-rumped warblers, brown-headed cowbirds, western meadowlarks, hepatic, summer, and western tanagers, yellow-billed cuckoos, house, Cassin's, and purple finches, American and lesser goldfinches, rufous-sided, brown, green-tailed, and Abert's towhees, lazuli buntings, black-headed grosbeaks, black-throated, chipping, and white-crowned sparrows, and dark-eyed juncos (Driscoll 1985, Driscoll, unpublished field notes).

Mammals sighted in the Redmond area include beaver, ringtails, bobcats, mountain lions, mule deer, whitetail deer, javelina, coyotes, grey fox, cliff chipmunks, and Yuma antelope squirrels. On several occasions very large bats (the size of a dove or robin) of a species unknown to us, which the local ranchers called "cow bats", were observed along the river. Scorpions, tarantulas, and giant centipedes were also recorded. Herptiles of interest include western diamondback rattlesnakes, black-tailed rattlesnakes, mojave rattlesnakes, Arizona coral snakes, kingsnakes, Mexican garter snakes, western black-necked garter snakes, Sonora gopher snakes, and western ground snakes, chuckwallas, gila monsters, and collared, desert spiny, mountain short-horned, and regal horned lizards, toads, and Sonoran mud turtles. On one occasion, a western diamondback rattlesnake was observed swimming across the river (Driscoll 1985, Driscoll, unpublished field notes).

D4.25.8 Management Recommendations

1. The Redmond breeding area suffers a high rate of juvenile mortality to which Mexican chicken bugs are a contributing factor. The eagles have five nests to choose from, although they appear to prefer the pinnacle nest (nest 5), using it in 14 of the 15 known years when eggs have been laid. Nestling mortality may be reduced by dusting that nest (No. 5) with pyrethrins, naturally-occurring plant-derived insecticides which are non-toxic to vertebrates. Pyrethrin applications might also wipe out beneficial invertebrates, thus allowing populations of harmful parasites a chance to rapidly infest the

nest. A study of the invertebrate communities within Arizona bald eagle nests should be conducted to properly address this issue. If pyrethrin applications are warranted, nest 5 (the most commonly used site) should be dusted prior to incubation (November) and during banding climbs, since the parasite seems to be able to infest the nests over a short period of time.

2. In addition to nest parasites, heat stress also appears to be a contributing factor to the high rate of juvenile mortality at Redmond. As stated above, the eagles appear to prefer the pinnacle nest (5), even though nest 4 provides more shade. Shade structures have been erected at Redmond in the past, and the eaglets have used the artificial shade in each case. However, installing a permanent shade may prevent the eagles from using this favored nest site. Artificial shade is an issue of much debate in Arizona, and, in the end, the Southwestern Bald Eagle Management Committee should decide if a shade structure is warranted at Redmond. If artificial shade is erected, care should be taken to use a natural color so as not to call attention to the nest. Possibly a natural-colored adobe could be used to create a shade wall on the southeast section of the nest pinnacle.

3. 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. This closure should be printed on the commercially available river maps, which the rafters use as a guide to hazards on the white-water stream. In addition, commercial rafting operators should be informed of the closure and part of their permit conditions should include not stopping in the closure area.

4. Activities such a photographers in blinds near Arizona bald eagle nests should be prohibited, unless there is some scientific basis for the human presence.

5. A study should be conducted to determine possible impacts reservoir fishes could have on the fish communities upstream of the Roosevelt Diversion Dam.

REDMOND BREEDING AREA

Date Discovered: 1974
Drainage: Salt River (Free-flowing)
Elevation (MSL): 2320 - 2800 ft
County: Gila
Latitude-Longitude Ten Minute Block: 333-1104
Land Management: U.S. Forest Service, Tonto National Forest, Globe Ranger District
Closure: Tonto National Forest Closure
Recommended "No Stop" Zone
Enacted 1986
Closed To Stopping River Craft 1 December - 30 June
Closed from Km 126.7 to Km 129.8 on Salt River
Distance From Phoenix: Air - 117.5 km East
Distance To Nearest Breeding Area Upstream: Cibecue - 49.5 Km
Air - 32.5 km
Distance To Nearest Breeding Area Downstream: Pinal - 16.0 Km
Air - 9.0 km
Distance From Granite Reef Dam: 128.7 Km
Distance To Roosevelt Reservoir: 26.7 Km
Air - 15.0 km
Home Range: Unknown. Known to utilize Km 122.0 to Km 139.0 on the Salt River, and Cherry Creek.
(Total = 17.0 Km)
Quadrangles: Dagger Peak 7.5 Minute
Meddler Wash 7.5 Minute
Salt River Peak 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
H		Cliff	Unknown	Possible historical nest site. No nest found in 1985.
1		Cliff	Unknown	Existing - Remnant. Found 1974. Rubink No. 12.
2		Cliff	Unknown	Found 1976. Fell prior to 1985.
3		Cliff	Unknown	Existing - Found 1988.

REDMOND BREEDING AREA (continued)

Nest Sites (cont'd.)

No.	Species	Type	Utilized	Status
4		Pinnacle	< 1986 1987 1974 ?	Existing - Found 1986. Nest immediately below nest 5, on north face of pinnacle. All prey remains and old eggshell fragments collected in July 1986. Egg(s) laid in nest in 1987, but adults later laid eggs and raised young in nest 5.*
5		Pinnacle	1975–1976 1978–1987 1989–1990	Existing - Found 1974. Rubink No. 11. Nest on top of pinnacle.
6		Cliff	1988	Existing - Built 1988.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1974	Occupied	?	?	?	Unknown if eggs were laid.
1975	Failed	1+	1	0	Young died in nest.
1976	Successful	2+	2	2	
1977	Occupied				New pair, subadult male (ca. 3 yr old) and near-adult female (ca. 4 yr old).
1978	Successful	2+	2	1	New female, near-adult (ca. 4 yr old). Male now near-adult (ca. 4 yr old). One young fell from nest. One nestling fledged to a ledge below nest, but died 1–2 days later. Adult skull found below nest pinnacle, possibly from 1976 or 1977 adult.
1979	Successful	2+	2	1	One young fell from nest. Shade structure erected at nest in first week of May by Robert Ohmart. Shade used by nestlings.
1980	Failed	1+	0	0	Shade structure in place.
1981	Successful	2+	2	2	Shade fell after 1981 season.
1982	Successful	2+	2	2	Shade structure erected at nest on 23 April by Robert Ohmart. Shade used by nestlings. Shade fell after 1982 season.

REDMOND BREEDING AREA (continued)

Productivity (cont'd.)

Year	Status	Eggs	Young	Fledged	Comments
1983	Successful	2+	2	2	
1984	Failed	2+	2	0	Photographer in blind near nest may have induced late laying. Two young died in nest, one on 18 April (1 week old) and one on 12–16 May (4 weeks old). Mexican chicken bugs in nest.
1985	Successful	2	2	2	Artificial shade constructed of sticks by Teryl Grubb prior to nesting season. Adults dismantled shade while refurbishing nest. Hatching at 37 days, 1 hour, and 47 minutes for first egg. Second egg laid and hatched at night, at 35 days.
1986	Successful	1+	1	1	
1987	Successful	3+	2	2	Eggs (1+) laid in nest 4, but adults later laid eggs (2+) and raised young in nest 5.* Mexican chicken bugs in nest 5.
1988	Successful	2+	2	1	New male, near-adult (ca. 4–5 yr old. Both young died 12–19 May. 1 eaglet died in nest. 1 young died post-fledging. Severe Mexican chicken bug infestation in nest. Adult male banded on left tarsus and black VID band placed on right tarsus.
1989	Failed	2	2	0	Two young died in nest 6–7 April, at 7–10 days of age. Mexican chicken bugs in nest.
1990	Successful	1+	1	1	
Total		27+	25	17	
Years		16	16	16	
Mean		1.7	1.6	1.1	

< = Prior to

* First documented incidence of double-clutching in Arizona bald eagles. Eggshell fragments confirmed as bald eagle by Lloyd Kiff, Western Foundation of Vertebrate Zoology.

D4.26 "76" BREEDING AREA

The "76" breeding area is located 99 km northeast of Phoenix along the free-flowing Tonto Creek. Tonto Creek flows out of a narrow canyon ("The Narrows") at Km 65 and enters an open basin. The creek flows passed the town of Gisela and enters a small narrow canyon ("The Box") at Km 58.2. The stream exits The Box at Km 57.8, 3 km above the "76" nests. The area surrounding the nests is fairly open, with isolated cottonwoods and sycamores scattered along the creek. Rye Creek, an intermittent stream, enters Tonto Creek near "76" Ranch. Tonto Creek enters another canyon at Km 50, below "76" Ranch. The stream is bounded by steep slopes and promontory cliffs as it meanders to the canyons exit at Km 44 and opens up into Tonto Basin. Due to the large amount of recreation centered around the nest trees, a closure was enacted at the "76" breeding area on 15 October 1987. Tonto National Forest Order 12-65-R, closed the area to all entry from 1 December to 30 June.

D4.26.1 Habitat

The biotic community in the "76" area is of the Upper Sonoran and Lower Sonoran Life Zones. Upland habitat is characteristic of the Semidesert Grassland Biome and the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Paloverde-Cacti-Mixed Scrub Series and the Jojoba-Mixed Scrub Series. The riparian habitat is a mixture of the Sonoran Riparian Deciduous Forest

Plate D41. "76" cottonwood tree nest (3) containing two seven-week-old eaglets, May 1988 (photo by D. Driscoll).

and Woodlands Biome, the Sonoran Riparian Scrubland Biome, and the Sonoran Interior Strands Biome (see Section D2).

Tonto Creek is perennial, with deep pools scattered amongst runs over a rocky substrate. Portions of the creek are bounded by promontory cliffs, but most of the area is open, with scattered cottonwoods and sycamores along the banks, and a small grove in the nest vicinity. However, the area is intensively grazed, and there is a noticeable lack of young trees in the area.

D4.26.2 Reproductive History

The "76" breeding area was discovered by agency personnel in 1981, although local ranchers knew the eagles had been breeding in the area since the 1970s. The "76" breeding area has been successful in eight of the ten years since its discovery by management agencies, fledging 11 young. The "76" eagles have laid eggs from 16 January to 15 February, hatching young from 20–22 February to 21 March, and fledging eaglets from 19 May to 18 June (Table D4.26-1).

Table D4.26-1. Nesting chronology of the 76 breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1981	—	—	—
1982	—	—	—**
1983	8 February	14 March	31 May
1984	1 February	8 March	29 May, 1–4 June*
1985	16 January	20–22 February	19 May
1986	25 January	28 February	20 May*
1987	< 23 February	—	—
1988	10 February*	17 March*	10–13 June*
1989	—	—	—
1990	15 February*	21 March*	18 June

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.

** One young fostered into Pinal breeding area.

< Indicates "prior to"

> Indicates "later than"

The "76" eagles have built three known nests along Tonto Creek, one cliff nest (1) below "76" Ranch, and a two nests in live cottonwood trees (2, 3) near Bee Canyon. Nest 1 was built prior to the 1970s, and used by the eagles up to 1974. Nest 1 fell, along with a section of the cliff, prior to January 1977. Nest 2 was built prior to 1975, and used by the eagles during 1975–1984 (Haywood and Ohmart 1983, Forbis, pers. comm.). Nest 3 was built 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 during 1985–1990, fledging young from the artificial nest in 1990. Nests 2 and 3 are still in existence.

Although the "76" breeding area was discovered by agency personnel in 1981, the site has been occupied by adults since the 1970s. The "76" eagles fledged two young in 1981. The 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). A new adult female occupied the site in 1983, and two young hatched, but one was killed by its sibling on 13 April (Grubb *et al.* 1983). Two eaglets hatched in 1984. One fell from the nest on 24 April, but was returned and later fledged (LaValley and LaValley 1984). One eaglet fledged each year in 1985 and 1986 (Grubb 1986a, Forbis 1986).

Three eggs were laid 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. The adults abandoned the nest on 13 March and there is little doubt that the photographers activities caused the failure. After the adults abandoned the nest, we recovered two eggs with the tops crushed and a separate set of eggshell fragments (3 eggs). It is likely that the disturbance from the photographers presence caused the adults to move excessively on the nest. In addition, the photographers flushed the adults off the nest daily throughout incubation, which may have resulted in egg breakage. See the Mortality Section below for details on the 1987 nest failure.

The "76" male was replaced in 1988 by a male with a USFWS band on its left tarsus. The eagles fledged two young in 1988, but not without incident. One young was blown out of the nest on 21 May. The adults did not appear to be feeding the eaglet on the ground, so we returned the eaglet to the nest on 25 May. The same eaglet fell again on 28 May, when the northeast portion of the nest collapsed. We returned the eaglet to the nest on 29 May, and both siblings later fledged.

The "76" breeding area was occupied in 1989, but apparently no eggs were laid. One young was hatched and fledged in 1990. It is interesting that a third adult was often seen soaring (non-aggressively) with the "76" pair in 1989 (Moller and Phillips 1989). This same behavior was observed in 1984 (LaValley and LaValley 1984). It is possible that an undiscovered territory exists upstream of "76," and the eagles home range overlaps. The adult may have also been one of the eagles from the Sheep breeding area, which was occupied in 1984 and 1989, but apparently the birds did not lay eggs. The Sheep nest is located 21 km downstream of the "76" nests; however, it is likely that the home range of the "76" and Sheep eagles overlaps. Beatty and Housser (1988) observed the "76" eagles as far south as the canyon entrance at Km 51, and the adults likely range farther south than was observed. We observed the Sheep eagles as far north as Km 43, where the canyon (which begins at Km 50), opens up into Tonto Basin. We observed large pools (over six ft deep), as well as shallow runs, in the canyon on 18 March 1990. In addition, there is a large free standing pinnacle at Km 45, which appears to be an ideal bald eagle nest site, and is painted white with mute on the top. We have found overlapping home ranges at many adjacent Arizona breeding areas studied with the aid of telemetry (Orme and Blue Point; Horseshoe, Cliff, and Bartlett; Pinto, Pinal, and Redmond).

D4.26.3 Mortalities

There has only been one documented juvenile bald eagle mortality at the "76" breeding area. In 1983, one eaglet was killed by its sibling at four weeks of age. The larger chick was more aggressive and frequently attacked and bit the younger eaglet.

"76" Breeding Area—1987. 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. 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. The following is an excerpt from Nahstoll and Prescott (1987):

> Of particular interest was a visit on 03-04 to the nest area by a wildlife photographer, Bill Barcus. He approached us on a Dawn to Dusk survey day where we were at the scope, immediately showing interest in the nesting birds activity. He seemed familiar with the site saying that he had been there the year before shooting photographs of the "76" pair. He had met the nest watchers in the area at that time. He told us this year he had built himself a blind near the nest, as close to the edge of the mesa approaching the nest tree as one could get; so close you could see the bird's pupils. He and a friend had devised a system of approaching the blind, regularly flushing the birds, which allowed one of the photographers to remain in the blind. As the two would approach the nest and flush the birds, one person would leave the area and "because the birds can't count", would return to the tree. Barcus said that he had hung a tin can lid from a branch near the blind to create a constant movement in the area so the birds would get used to his movement in the area. He felt that by this time the female was used to his presence. 150 photographs had already been taken so it can be assumed that he had spent a good deal of time in the area. He expressed interest in the chicks and said he would be back to get photographs of them. We warned him of how sensitive the birds were during this part of the nesting period and that flushing was not good for the security of the nest. He asked if there was any law against the type of thing he was doing. We informed him of the Endangered Species Act and our job in conjunction with it. He asked what our supervisors might think of his activities. When warned of the general concern he said he was nevertheless going to continue as he had planned, saying that he would return at the end of the month. We thought we had made it clear that we were in the area to prevent occurrences of this nature but he claimed that this was "the year of the eagle" in which he would collect as many photographs as possible. After we discovered that the adults had abandoned the nest we found what we believed to be the area where he had erected his blind approximately 50′ from the nest tree.

The photographer returned to the nest area on 12 or 13 March, although the nest had been abandoned by this time.

The adult on the nest, in photos confiscated by USFWS, 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). The disturbance from the photographers caused the adults to flush off the nest, and, at other times, to move

excessively and suddenly. Daily flushing of the adults by the photographers very likely resulted in the egg breakage.

The "76" breeding area has experienced two known adult mortalities. In 1982, the adult female disappeared following an aggressive altercation with a golden eagle, and she was replaced by a new female prior to the 1983 season. A male with a USFWS band on his left tarsus replaced the original male prior to the 1988 breeding season.

D4.26.4 Known Foraging Areas and Food Habits

Bald eagles at the "76" breeding area have been known to forage on Tonto Creek, from "The Box" upstream of the nest (Km 58) to the canyon downstream of the nest (Km 51) (Beatty and Housser 1988). However, most observed foraging has been recorded in the nest vicinity (Grubb *et al.* 1983, LaValley and LaValley 1984, Grubb 1984, Marion and Devaul 1985, Grubb 1986a, Oehler and Vana 1986, Nahstoll and Prescott 1987, Beatty and Housser 1988, Pierson and Galvin 1990). Although the eagles were observed flying upstream and downstream, and returning with prey, no foraging has been documented away from the nest area (Grubb *et al.* 1983, LaValley and LaValley 1984, Grubb 1984, Marion and Devaul 1985, Grubb 1986a, Oehler and Vana 1986, Nahstoll and Prescott 1987, Beatty and Housser 1988, Pierson and Galvin 1990).

Foraging information at "76" is limited to areas observed by ABENWP and other research personnel watching creek sections near the nest and other areas visible from nest observation points (Grubb 1984, Grubb 1986a). Although we did not radio-tag the "76" eagles, based on data we collected at breeding areas with telemetered adults, the "76" pair likely forage over a much more extensive range than has been documented. See Sections A3 and B4 for details on the foraging ecology and movements of Arizona bald eagles.

Prey items described by Haywood and Ohmart (1983), Grubb *et al.* (1983), LaValley and LaValley (1984), Kohlsdorf *et al.* (1984), Grubb (1984), Marion and Devaul (1985), Grubb (1986a), Oehler and Vana (1986), and Beatty and Housser (1988) are presented in Table D4.26-2, along with prey items taken by the eagles and prey remains collected at the nest during 1986–1989. See Section B5.1.8 for a detailed analysis of prey species utilized by the "76" eagles. In addition, R. Mesta (pers. comm.) collected an osprey foot and feathers from the nest in 1990, along with a frog. In contrast to other breeding areas in Arizona, the "76" eagles utilize a large amount of mammalian prey, up to 30 percent of the observed prey deliveries (Grubb 1984, Marion and Devaul 1985, Grubb 1986a, Oehler and Vana 1986, Beatty and Housser 1988). A "76" adult was observed stealing a small mammal from a red-tailed hawk (LaValley and LaValley 1984) and carried the prey in its beak to the nest. It is interesting that the adult carried the prey in its beak, as raptors usually carry prey in their feet.

D4.26.5 Human Impacts

Human disturbance is a serious problem at the "76" breeding area. The "76" nests are located 5 km south of the town of Gisela, and hiking, hunting, ATCs, tubing, rafting, kayaking, and camping near and under the nests have caused problems over the years. Other disturbances include vehicles, low level military jets, light planes, helicopters, sonic booms, gunshots, photographers, and ranching activities associated with the nearby "76" Ranch. (LaValley and LaValley 1984, Kohlsdorf *et al.* 1984, Marion and Devaul 1985, Oehler and Vana 1986, Nahstoll and Prescott 1987, Beatty and Housser 1988, Moller and Phillips 1989, Pierson and Galvin 1990).

Table D4.26-2. Prey species observed taken by bald eagles or collected from the nest at the "76" breeding area.

Fish	Birds	Mammals
Carp	Waterfowl	Cottontail rabbit
Channel catfish	Teal sp.	Blacktail jackrabbit
Bullhead (catfish)	Anas sp.	Neotoma
Unidentified Ictaluridae	Grebes	Rock squirrel
Black bass	Grebe sp.	Squirrel sp.
Desert sucker	Wading Birds	Striped skunk
Sonora sucker	Great blue heron	Javelina
	Raptors	Hereford calf
	Osprey	
	Passerines	**Herptiles**
	Western meadowlark	Sonoran mud turtle
	Northern mockingbird	Soft shelled turtle
	Common raven	Frog sp.
	Other Birds	Unidentified reptile
	Gambel's quail	
	Northern flicker	
	Greater roadrunner	

The javelina hunting season occurs during the bald eagle nesting season, and the "76" area is popular for hunting peccaries. Gunshots and hunters associated with the javelina season caused the adults to flush from the nest and perches during incubation (LaValley and LaValley 1984, Beatty and Housser 1988). On 4 March 1984, a javelina hunter on an ATC stopped below the nest, flushing the adult off the eggs for 65 minutes. ATCs were recorded under the nest again on 31 April 1984. In addition, two fishermen camped below the nest tree on 8 April 1984, which kept the adults from returning to the nest (LaValley and LaValley 1984). Moller and Phillips (1989) also reported campers below the nest tree. On 27 April 1987, two off-road vehicles drove down Bee Canyon, and below the nest tree. The trucks got stuck and kept the adults away from the nest for three hours (Marion and Devaul 1985).

Rafters, kayakers, and tubers floating passed the nest area caused the eagles to flush from the nest and perches on almost all recorded instances (Marion and Devaul 1985, Oehler and Vana 1986). Helicopters also flushed the eagles from the nest and perches (Marion and Devaul 1985, Beatty and Housser 1988). Hikers were reported as the most numerous disturbance in 1985 (Marion and Devaul 1985).

Activities at the nearby "76" Ranch, and the associated cattle operation, have been recorded as disturbances in several years (Kohlsdorf *et al.* 1984, Beatty and Housser 1988, Pierson and Galvin 1990). Beatty and Housser (1988) reported that activities associated with the "76" Ranch were the biggest disturbances of the season. In one instance, on 21 February 1988, the ranch crew was gathered 250 m

from the nest to fix a windmill in full view of the eagles and nest. Beatty and Housser (1988) stated of the incident, "The work party consisted of two trucks, one ATV, two horses, five dogs, and ten people. They worked, played, picnicked, and rode the ATV and horses around all afternoon. The eagles were restless and distressed while the area was occupied, but neither bird showed intentions of leaving the area." The ranchers were also recorded riding horses under the nest tree (Kohlsdorf *et al.* 1984, Beatty and Housser 1988). Pierson and Galvin (1990) noted that gunshots, heavy machinery, and dynamiting in the "76" Ranch area disturbed the eagles. In addition, Oehler and Vana (1986) reported a rancher was planning to bulldoze a dam in the creek near the nest; however, he changed his plans when they told him about the eagles.

ABENWP personnel entering and leaving blinds near the nest caused the eagles to flush from the nest and perches in 1984 and 1985 (LaValley and LaValley 1984, Marion and Devual 1985). Although the blinds were not used during incubation, when the nest is most susceptible to failure, erecting, entering, and leaving the blinds in daylight hours disturbed the eagles.

The worst disturbance recorded at the "76" breeding area involved two photographers who built a blind within 30 m of the nest, at nest level. Three eggs were laid in 1987, but the adults were flushed off the eggs daily by the two photographers, and the adults abandoned the nest on 13 March. There is little doubt that the photographers activities caused nest failure. See the Mortality Section above for details on the 1987 nest failure.

In addition to human activities directly impacting the eagles, cattle grazing is preventing the regeneration of cottonwoods and sycamores along Tonto Creek. The trees along the creek are all older large trees, and there is an obvious lack of young growth. When the old trees begin decaying and falling apart, there will be no perching or nesting substrate in the area.

D4.26.6 Wildlife Interactions

At "76," interspecific interactions were numerous with red-tailed hawks, American kestrels, and common ravens which nested nearby. The eagles also interacted with American crows, Cooper's hawks, great blue herons, merlins, osprey, and golden eagles (LaValley and LaValley 1984, Kohlsdorf *et al.* 1984, Marion and Devaul 1985, Oehler and Vana 1986, Beatty and Housser 1988, Moller and Phillips 1989, Pierson and Galvin 1990).

Many interactions with other bald eagles at "76" simply involved escorting the intruder out of the area, although some altercations were aggressive (LaValley and LaValley 1984, Marion and Devaul 1985, Oehler and Vana 1986, Beatty and Housser 1988, Moller and Phillips 1989, Pierson and Galvin 1990). The "76" adults were often observed soaring (non-aggressively) with a third adult in 1989 (Moller and Phillips 1989) and in 1984 (LaValley and LaValley 1984). As mentioned, this adult may be from an undiscovered territory upstream of "76," or may be one of the Sheep adults. The Sheep eagles apparently did not lay eggs in 1984 and 1989, and their home range may overlap with that of the "76" eagles.

D4.26.7 Wildlife Sightings

Waterfowl sighted in the "76" area include Canada geese, mallards, redheads, cinnamon teal, and common mergansers. In addition, killdeer, spotted sandpipers, green-backed herons, and great blue herons occur along the river. Raptors sighted in the area include great horned owls, elf owls, western screech owls, barn owls, spotted owls, merlins, American kestrels, Cooper's hawks, sharp-shinned

hawks, osprey, zone-tailed hawks, Harris' hawks, common black hawks, and golden eagles (Beatty and Housser 1988, Moller and Phillips 89, Pierson and Galvin 1990). A pair of osprey were sighted at "76" in 1984 (Kohlsdorf *et al.* 1984).

Other birds of interest at "76" include poor-wills, whip-poor-wills, lesser nighthawks, Anna's, black-chinned, and Costa's hummingbirds, belted kingfishers, northern flickers, Gila and ladderbacked woodpeckers, scrub and Stellar's jays, American crows, Say's and black phoebes, ash-throated and vermillion flycatchers. In addition, curve-billed and Bendire's thrashers, American robins, Townsend's solitaires, western bluebirds, verdins, hooded, northern, and Scott's orioles, black-tailed gnatcatchers, phainopeplas, cardinals, pyrrhuloxias, Virginia's, Lucy's, yellow, hermit, MacGillivray's, Wilson's, and yellow-rumped warblers, brown-headed cowbirds, western meadowlarks, summer tanagers, brown towhees, black-throated, vesper, lark, and rufous-crowned sparrows, and ruby-crowned kinglets (Beatty and Housser 1988, Moller and Phillips 89, Pierson and Galvin 1990).

Mammals sighted in the "76" area include beaver, raccoons, bobcats, mountain lions, mule deer, whitetail deer, javelina, coyotes, bannertail kangaroo rats, and Yuma antelope squirrels. Herptiles of interest include western diamondback rattlesnakes, Sonoran whipsnake, gopher snakes, roundtailed horned lizards, regal horned lizards, canyon tree frogs, soft shelled turtles, and Sonoran mud turtles (Beatty and Housser 1988, Moller and Phillips 89, Pierson and Galvin 1990).

D4.26.8 Management Recommendations

1. Each of the available sources stated that the "76" breeding area needs to be closed to javelina hunting, hiking, and tubers, rafters, and kayaks (LaValley and LaValley 1984, Kohlsdorf *et al.* 1984, Marion and Devaul 1985, Oehler and Vana 1986, Beatty and Housser 1988, Moller and Phillips 1989, Pierson and Galvin 1990). The closure enacted by Tonto National Forest in 1987 has greatly reduced disturbance in the "76" area; however, Beatty and Housser (1988), Moller and Phillips (1989), and Pierson and Galvin (1990) all maintain that more signs need to be placed on the fences and at the closure boundaries. Pierson and Galvin (1990) also noted the closure fences were in disrepair.

2. Cattle grazing in the riparian area of Tonto Creek is preventing the regeneration of cottonwoods and sycamores along the creek. The trees along the creek are all older large trees, and there is an obvious lack of young growth. When the old trees begin decaying and falling apart, there will be no perching or nesting substrate in the area. Cottonwood poles could be planted along the creek to provide future perch and nesting sites, although in the long run, cattle need to be removed from (or fenced out of) the riparian habitat.

3. The "76" Ranch personnel are aware of the nest site, but continue to cause disturbances to the eagles. The personnel should be encouraged to stay away from the nest area during incubation and the early nestling period and should not be allowed to adversely impact the riparian habitat along Tonto Creek.

"76" BREEDING AREA

Date Discovered: 1981. (1970s).
Drainage: Tonto Creek (Free-flowing - Perennial)
Elevation (MSL): 2760 - 2880 ft
County: Gila
Latitude-Longitude Ten Minute Block: 340-1111
Land Management: U.S. Forest Service, Tonto National Forest, Tonto Basin Ranger District
Closure: Tonto National Forest Closure
Order #12-65-R
Enacted 15 October 1987
Closed To All Entry 1 December - 30 June
Distance From Phoenix: Air - 99.0 km Northeast
Distance To Nearest Breeding Area Upstream: None
Distance To Nearest Breeding Area Downstream: Sheep - 21.4 Km
Air - 17.0 km
Distance From Salt River Confluence: 55.2 Km
Home Range: Unknown. Known to utilize Km 51.0 to Km 58.0 on Tonto Creek.
Quadrangles: Gisela 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cliff		1970s < 1974	Nest built prior to 1970s. Eagles reported nesting on cliff up to 1974. Cliff gave way and nest fell prior to January 1977.
2	Cottonwood	Live	1975–1984	Existing - Built prior to 1975 Eagles reported nesting in nest 2 beginning in 1975.
3	Cottonwood	Live	1985–1990	Existing - Built 1985. Nest fell 15–25 June 1988. Artificial nest built in same location of same tree, with original nest sticks, on 8 October 1988 by Robert Mesta, U.S. Fish and Wildlife Service. Nest built up by eagles in 1989.

"76" BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1970s	Occupied	?	?	?	Eagles reported nesting in nest 1 up to 1974.
< 1974	Occupied	?	?	?	
1975–1980	Occupied	?	?	?	Eagles reported nesting in nest 2 beginning in 1975.
1981	Successful	2+	2	2	
1982	Successful/Foster	1+	1	1	Adult female disappeared following aggressive interaction with golden eagle. Young fostered into Pinal breeding area and fledged.
1983	Successful	2+	2	1	New adult female. One young killed by sibling 13 April (4 weeks old).
1984	Successful	2+	2	2	One young fell from nest 24 April, but was returned to nest and fledged.
1985	Successful	1+	1	1	
1986	Successful	1+	1	1	
1987	Failed	3	0	0	Photographers in blind near nest may have caused egg breakage. Eggs crushed from top.
1988	Successful	2+	2	2	New adult male—banded on left tarsus. One young fell from nest 21 May. Returned eaglet to nest 25 May. Same young fell from nest 28 May, with northeast portion of nest. Returned eaglet to nest 29 May.
1989	Occupied				Three adults in area.
1990	Successful	1+	1	1	
Total		15+	12	11	
Years		10	10	10	
Mean		1.5	1.2	1.1	

< = Prior to

D4.27 SHEEP BREEDING AREA

The Sheep breeding area is located 87 km northeast of Phoenix, along the free-flowing Tonto Creek. Tonto Creek enters a canyon at Km 50, below "76" Ranch, and is bounded by steep slopes and promontory cliffs as it meanders to the canyons exit at Km 44, opening up into Tonto Basin. Tonto Creek meanders through the open bottomland as it passes Punkin Center at Km 29, and enters Roosevelt Reservoir at Km 16, when the reservoir is at high levels.

D4.27.1 Habitat

The biotic community in the Sheep area is of the Lower Sonoran Life Zone. Upland habitat is characteristic of the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Paloverde-Cacti–Mixed Scrub Series and the Jojoba–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).

Tonto Creek is a free-flowing perennial stream, with deep pools scattered amongst runs over a rocky substrate. From the Sheep area to Roosevelt Reservoir the creek flows through open bottomland, with isolated cottonwoods and sycamores along the banks and small groves in some areas. A large cottonwood grove exists at the Tonto Creek estuary, where the stream enters Roosevelt Reservoir.

Plate D42. Sheep nest (1) in dying cottonwood along Tonto Creek, November 1987 (photo by D. Driscoll).

However, the cottonwoods along Tonto Creek are old and in various stages of decay, especially near the Sheep nest, and there are few young trees in the area. Three other large trees exist in the nest vicinity; however, these (along with the nest tree) are rapidly falling apart. The only available cliff nesting substrate occurs, along with other suitable trees, in the Gun Creek area (10 Km north). To the south, scattered trees exist near the growing residential areas at, and downstream of, Punkin Center. There are many large trees at the Roosevelt Reservoir confluence (17 Km south); however, no known eagle nests occur there.

This bottomland habitat is in no way lush with vegetation, excluding the estuary at Roosevelt Reservoir. Cattle are intensively grazed along the creek, as well as in the uplands, and have successfully raped the riparian area of any cottonwood, willow, or sycamore regeneration. The bottomland is mainly rock, sand, and salt cedar. Each year during 1986–1990, more branches had fallen off the few isolated cottonwoods in the Sheep area, including the nest tree. In contrast to other Arizona bald eagle breeding areas, Sheep has no known alternate nests. The current nest tree is rapidly falling apart, and appears to lack suitable future support. When the nest branch broke and the nest fell (for the second time) in 1988, the only location stable enough to reconstruct the nest was much lower in the tree. The Sheep eagles have not laid eggs since their nest fell in 1988, and this breeding area is in serious jeopardy of loss, as there appears to be a lack of suitable nesting habitat for the future. In short, the riparian habitat along Tonto Creek is dying.

D4.27.2 Reproductive History

The Sheep breeding area was discovered in May 1982, when a pair of adults was 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 that year, and have used the nest during 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 enough location in the upper branches; thus the nest had to be placed lower in the tree.

The Sheep breeding area has not been successful since its discovery. The territory was occupied in 1982, but apparently no eggs were laid. In 1983, two eggs were laid, but failed to hatch. Adults perched in the nest tree in 1984 and 1985, but did not lay any known eggs (Forbis 1985, Forbis, pers. comm.). Two young hatched in 1986, but died at 1–2 days of age, in a heavy rain storm. The pair laid at least three eggs from 1987–1988, but the eggs did not hatch. Adults were sighted in the nest tree and surrounding area in 1989 and 1990, but apparently did not lay eggs in the known nest location. The Sheep eagles have laid eggs from 1 or 2 February to 28 February, but hatched young only one year, on 8–9 March (Table D4.27-1). No eaglets have fledged from the known nest at Sheep since its discovery.

A USFWS band was sighted on the adult female in November 1987. The female was not known to be banded previously, but observations have been limited due to productivity problems. The female laid two eggs, and incubation progressed normally until 26 March, when the adult male disappeared. The female continued to incubate the eggs alone, leaving the nest only to drink (Krueger *et al.* 1988). By April 2, the female had not fed for the seven days since the male disappeared. Concerned that she might become malnourished, we supplied ABENWP personnel with fish and jackrabbits to place out for the female. The first food was placed near the nest tree on 2 April. The female did not feed until the next day when a subadult eagle took one of the supplied fish, carried it to a downstream perch and began feeding. The

Table D4.27-1. Nesting chronology of the Sheep breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1982	—	—	—
1983	25 February	—	—
1984	—	—	—
1985	—	—	—
1986	1-2 February	8-9 March*	—
1987	< 17 March	—	—
1988	28 February	—	—
1989	—	—	—
1990	—	—	—

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

female left the nest and pirated the fish from the subadult. The female continued to utilize the supplied food until 7 April when she abandoned the nest (Krueger *et al.* 1988).

On 4 April, a near-adult male eagle which carried a USFWS band (G. Beatty, pers. comm.) entered the nest area and fed on one of the supplied fish. The male remained near the nest, and the female did not act aggressively toward the eagle. On 6 April, the Sheep female and the near-adult male were flying together upstream. The near-adult male remained in the area for the extent of observations (Krueger *et al.* 1988).

The Sheep eagles appear to have a productivity problem. The 1986 eaglets that died are the only young known to hatch, out of at least seven eggs laid in four years at Sheep. In addition, the eagles apparently did not lay eggs in five other years. There are six possible hypotheses that might explain the productivity problems at Sheep: (1) The adults used another nest in an unknown location in years when no eggs were thought to have been 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 (see Pinal/Pinto); (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 (hypothesis 1), but this does not appear to be the case, since both adults are observed in the known nest tree during the breeding season. Fertility in the adults (hypothesis 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 (hypothesis 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 (hypothesis 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 (hypothesis 5); however, the eggshell thickness of the Sheep eggs in 1988 was within the range of other Arizona bald eagle nests (Section E5). Human disturbance during incubation could also cause nest failure (hypothesis 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 is needed on the foraging ecology of the Sheep eagles, prey availability, habitat quality, and relationships, if any, with other pairs.

D4.27.3 Mortalities

There have been two documented juvenile bald eagle mortalities at the Sheep breeding area. Two young hatched in 1986, but died at 1-2 days of age in a heavy rainstorm. The 1986 eaglets are the only young known to hatch, out of at least seven eggs laid in four years at Sheep. In addition, the eagles apparently did not lay eggs in five other years.

The Sheep breeding area has experienced one known adult mortality. In 1988, the adult male disappeared on 26 March during incubation. A near-adult banded male entered the nest area on 4 April and was observed interacting with the adult female. The female showed no aggression toward the young male and he remained in the area through the extent of observations (Krueger *et al.* 1988). A USFWS band was sighted on the adult female's right tarsus in November 1987, although observations in previous years were limited due to nest failure, so it is not known if the female was banded prior to 1987.

D4.27.4 Known Foraging Areas and Food Habits

Bald eagles at the Sheep breeding area have only been recorded foraging on Tonto Creek and the upland habitat in the immediate nest vicinity (Chadbourne 1983, Nahstoll and Webster 1986, Krueger *et al.* 1988). Foraging information at Sheep is limited to areas observed by ABENWP personnel watching the nest, resulting in a bias toward the creek sections near the nest. Although we did not radio-tag the Sheep eagles, we did observe them as far south as Km 30 (near Punkin Center) and as far north as Km 43 (Gun Creek). Based on data we collected at breeding areas with telemetered adults, the Sheep pair most likely forage over a much more extensive range than has been documented. See Sections A3 and B4 for details on the foraging ecology and movements of other Arizona bald eagles.

The adjacent "76" breeding area was occupied in 1989, but apparently no eggs were laid. It is interesting that a third adult was often seen soaring (non-aggressively) with the "76" pair in 1989 (Moller and Phillips 1989). This same behavior was observed at "76" in 1984 (LaValley and LaValley 1984). It is possible that an undiscovered territory exists upstream of "76," and the eagles home range overlaps. The adult may have also been one of the eagles from the Sheep breeding area, which was occupied in 1984 and 1989, but apparently no eggs were laid. The Sheep nest is located 21 km downstream of the "76" nests; however, it is likely that the home ranges of the "76" and Sheep eagles overlap. Beatty and Housser (1988) observed the "76" eagles as far south as the canyon entrance at Km 51, and the adults

likely range farther south than was observed. We observed the Sheep eagles as far north as Km 43 (near Gun Creek), where the canyon (which begins at Km 50) opens up into Tonto Basin. We observed large pools (over six ft deep), as well as shallow runs, in the canyon on 18 March 1990. In addition, there is a large free-standing pinnacle at Km 45, which appears to be an ideal bald eagle nest site, and is white with mutes on the top.

As discussed above, the Sheep eagles may utilize the canyon between Km 50 and Km 44, along with the "76" eagles. The Sheep pair may also use Gun Creek, since we have observed them in this area. It is possible the Sheep eagles also utilize the Tonto Arm of Roosevelt Reservoir; the reservoir is 17 Km (16 km by air) from the Sheep nest.

It is also possible that the Sheep eagles are prevented from using the reservoir by a pair of adults at an unknown breeding area nearer the reservoir. A pair of adult bald eagles have been sighted on numerous occasions throughout the year at Theodore Roosevelt Dam (SRP Dam Personnel) and possibly nest in the canyon downstream. The historical Rock Creek nest site was also in the dam area, off the Tonto Arm of the reservoir. We recorded a pair of adults on Windy Hill on several occasions, as well as in Salome Bay. In February 1988, we observed an adult male (which consistently perched and foraged in Salome Bay) capture a fish and carry the prey north, towards upper Armer Gulch. These observations and reports suggest the existence of an unknown breeding pair which utilizes the western portion of the Salt Arm and the Tonto Arm of the reservoir.

Data on prey utilization at Sheep is virtually non-existent. Krueger *et al.* (1988) observed the adult female capture a ringtail, but the only other information available is from prey remains we collected at the nest during 1986–1988 (Table D4.27-2). See Section B5.1.8 for a detailed analysis of prey species utilized by the Sheep eagles. The Sheep female pirated a fish from a subadult bald eagle in 1988; however, this fish was one supplied by ABENWP personnel after the adult male's disappearance (see Mortality Section above).

Table D4.27-2. Prey species observed taken by bald eagles or collected from the nest at the Sheep breeding area.

Fish		**Mammals**
Sucker sp.	Passerines	Cottontail rabbit
	American robin	Blacktail jackrabbit
Birds	Unidentified passerine	Ringtail
Waterfowl	Other Birds	Unidentified Sciuridae
Canada goose	Gila woodpecker	Javelina
American wigeon	Mourning dove	Cow
Unidentified waterfowl	Gull sp.	
Wading Birds		**Herptiles**
Great blue heron		None found

D4.27.5 Human Impacts

Human disturbance does not appear to be a problem at the Sheep breeding area. The Sheep nest is located 4 km north of Punkin Center, and easily accessible by Highway 188, which runs along the creek. ABENWP personnel have recorded a virtual lack of human activity near the nest (Chadbourne 1983, Nahstoll and Webster 1986, Tocco and Brashear 1987, Krueger *et al.* 1988). Nahstoll and Webster (1986) recorded one ATC driving under the nest tree, and a group of kayakers floating down the creek, but the eagles apparently ignored the disturbances. Since the Sheep breeding area has not been successful, data on human disturbance is limited, and many disturbances likely go unobserved. We annually collected beer cans and spent shotgun shells below the Sheep nest, and one year we found a Budweiser beer can in the nest.

In addition to human activities directly impacting the eagles, cattle grazing is preventing the regeneration of cottonwoods and sycamores along Tonto Creek. The cottonwoods along Tonto Creek are old and in various stages of decay, especially near the Sheep nest, and there are no young trees in the area. This bottomland habitat is in no way lush with vegetation. Cattle are intensively grazed along the creek, as well as in the uplands, and are obviously preventing cottonwoods, willows, and sycamores from regenerating. The bottomland is mainly rock, sand, and salt cedar. Each year during 1986–1990 we observed that more branches had fallen off the few isolated cottonwoods in the Sheep area, including the nest tree.

In contrast to other Arizona bald eagle breeding areas, Sheep has no known alternate nests. The current nest tree is rapidly falling apart, and few other suitable nest trees exist in the area. When the nest branch broke and the nest fell (for the second time) in 1988, the only location stable enough to reconstruct the nest was much lower in the tree. The Sheep eagles have not laid eggs since then, and this breeding area is in serious jeopardy of loss, as there appears to be a lack of suitable nesting habitat for the future. In short, the riparian habitat along Tonto Creek is dying.

D4.27.6 Wildlife Interactions

Interspecific interactions were recorded with common ravens and golden eagles at Sheep (Nahstoll and Webster 1986). Some of the interactions with other bald eagles at Sheep were aggressive, but most were not (Chadbourne 1983, Nahstoll and Webster 1986, Krueger *et al.* 1988), The adjacent "76" adults were often observed soaring non-aggressively with a third adult in 1989 (Moller and Phillips 1989) and in 1984 (LaValley and LaValley 1984). As previously mentioned, this adult may be from an undiscovered territory, or may be one of the Sheep adults. The Sheep eagles apparently did not lay eggs in 1984 and 1989, and their home range may overlap with that of the "76" eagles.

D4.27.7 Wildlife Sightings

Waterfowl sighted in the Sheep area include mallards, redheads, cinnamon teal, buffleheads, and wood ducks. In addition, spotted and least sandpipers, greater and lesser yellowlegs, white-faced ibis, snowy egrets, green-backed herons, black-crowned night herons, and great blue herons occur along the river. A great blue heron rookery is located at the Tonto Estuary near Roosevelt Reservoir. We sighted short-eared owls in the Sheep area in February 1988. Other raptors sighted in the area include great horned owls, elf owls, western screech owls, barn owls, American kestrels, Cooper's hawks, sharp-shinned hawks, osprey, common black hawks, and golden eagles (Chadbourne 1983, BioSystems personnel 1986–1990). In addition, a Cooper's hawk nest is located upstream of the Sheep nest.

Other birds of interest at Sheep include lesser nighthawks, Anna's, black-chinned, and Costa's hummingbirds, belted kingfishers, northern flickers, Gila, Lewis', and ladder-backed woodpeckers, American crows, Say's and black phoebes, vermillion flycatchers, verdins, red-winged blackbirds, and ruby-crowned kinglets. Mammals sighted in the area include beaver, raccoons, bobcats, javelina, and coyotes. Herptiles of interest include western diamondback rattlesnakes, and Sonoran mud turtles (Chadbourne 1983, BioSystems personnel 1986–1990).

D4.27.8 Management Recommendations

1. To understand the productivity problem in the Sheep breeding area, more data are needed on the foraging ecology of the Sheep eagles, prey availability, and the possible existence of neighboring pairs.

2. The Sheep breeding area in danger of being lost due to habitat degradation. Cattle grazing in the riparian area of Tonto Creek is preventing the regeneration of cottonwoods and sycamores along the creek. The trees along the creek are dilapidated older large trees which are falling apart, and there is an obvious lack of younger growth. When the old trees are gone, there will be no perching or nesting substrate in the area. The current nest tree is falling apart at a rapid rate, as are the few other suitable trees in the area. Cottonwood poles could be planted along the creek to provide future perch and nesting sites, although in the long run, cattle need to be removed from (or fenced out of) the riparian habitat.

SHEEP BREEDING AREA

Date Discovered: May 1982
Drainage: Tonto Creek (Free-flowing / Perennial)
Elevation (MSL): 2360 ft
County: Gila
Latitude-Longitude Ten Minute Block: 335-1111
Land Management: U.S. Forest Service, Tonto National Forest, Tonto Basin Ranger District
Distance From Phoenix: Air - 87.5 km Northeast
Distance To Nearest Breeding Area Upstream: "76" - 21.4 Km
Air - 17.0 km
Distance To Nearest Breeding Area Downstream: None
Distance From Salt River Confluence: 33.8 Km
Distance To Roosevelt Reservoir: 17.0 Km
Air - 16.0 km
Home Range: Unknown. Known to utilize Km 30 to Km 43 on Tonto Creek
Quadrangles: Kayler Butte 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Snag-Top	1982-1990	Existing - Built 1982 on top of buteo nest. Branch broke and nest fell July-August 1983. Eagles rebuilt nest in same tree in 1984. Branch broke and nest fell October 1988. Artificial nest constructed in same tree, with original nest sticks, on 12 November 1988 by Robert Mesta, U.S. Fish and Wildlife Service, and Daniel Driscoll, BioSystems Analysis, Inc.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1982	Occupied				
1983	Failed	2+	0	0	Nest failed 19 April.
1984	Occupied				
1985	Occupied				
1986	Failed	2+	2	0	Young died at 1 and 2 days old, on 12 March.
1987	Failed	1+	0	0	Nest failed 21 March.

SHEEP BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1988	Failed	2+	0	0	Adult female banded on right tarsus. Band sighted November 1987. Adult male disappeared 26 March. Near-adult male (ca. 4 years old), with band, in nest area after 4 April. Female incubated alone until 7 April.
1989	Occupied				
1990	Occupied				
Total		7+	2	0	
Years		9	9	9	
Mean		0.8	0.2	0.0	

D4.28 TABLE MOUNTAIN BREEDING AREA

The Table Mountain breeding area is located 88.5 km north of Phoenix along the free-flowing Verde River in the remote country near Mule Shoe Bend between the East Verde River and Horseshoe Reservoir. The Verde River is somewhat open south of the East Verde River confluence, but closes in to a narrow meandering canyon at Mule Shoe Bend, then opens up again downstream. In this area the Verde River is mainly bounded by promontory cliffs on one side or the other as it flows south to Horseshoe Reservoir.

D4.28.1 Habitat

The biotic community in the Table Mountain area is of the Upper Sonoran and Lower Sonoran Life Zones. The upland habitat is characteristic of the Semidesert Grassland Biome and the Sonoran Desertscrub Biome, Arizona Upland Subdivision, with species representing the Paloverde-Cacti-Mixed Scrub Series. The riparian habitat is of the Sonoran Riparian Deciduous Forest and Woodlands Biome, the Sonoran Riparian Scrubland Biome, and the Sonoran Interior Strands Biome (see Section D2). Portions of the river are bounded by cliff walls, although more open areas support cottonwoods, sycamores, and willows.

Plate D43. Table Mountain cliff nest (4) containing one eight-week-old eaglet, May 1991. Note prickly pear cactus and jojoba bush growing out of nest (photo by D. Driscoll).

D4.28.2 Reproductive History

The Table Mountain breeding area was discovered by agency personnel on 9 April 1987, during an ORA helicopter flight; however, adults had been reported in the Mule Shoe Bend area in 1985 and 1986 by river rafters. Due to its remote location in rugged terrain, data on the Table Mountain territory is limited to nest checks during ORA helicopter flights. Although the pair has laid at least three eggs in the four years of known occupancy, only one young has hatched and fledged. The Table Mountain eagles normally have not laid eggs prior to the first ORA flights in early February; however, they are usually incubating by the second flight in mid-March. The eagles have laid eggs from mid-February to mid-March. The only known eaglet(s) hatched in 1990 around mid-March, and likely fledged prior to 1 June (Table D4.28-1).

Table D4.28-1. Nesting chronology of the Table Mountain breeding area.

Year	Incubation Date	Hatching Date	Fledging Date
1985	—	—	—
1986	—	—	—
1987	—	—	—
1988	< 18 March	—	—
1989	< 28 February	—	—
1990	< 20 March	< 20 March	< 1 June

* Indicates known date. Other dates include first observations of incubating adults, or estimations based on 35 day incubation period or the aging of nestlings.
< Indicates "prior to"
> Indicates "later than"

Four nests have been found in the Table Mountain breeding area, two on cliffs (1, 4), and two in live willow trees (2, 3). Nest 1 was found on 9 April 1987 in Mule Shoe Bend, and was used by the eagles in 1987. Nest 2, found on 12 February 1988 upstream of Mule Shoe Bend, was used by the Table Mountain pair in 1988. Nest 3, found on 7 March 1989 near nest 2, was used by the eagles in 1989. We climbed the nest after the eggs failed to hatch and found old eggshell fragments, indicating the nest was used previously. The eagles were accounted for in 1988, so the fragments would have been from 1987 or prior. Nest 4 was found on 28 March 1990 downstream of nest 1, and was used by the eagles in 1990. All four nests are still in existence.

Adult bald eagles were reported at Wet Bottom Creek, near Mule Shoe Bend, in 1985 and 1986, indicating the Table Mountain breeding area was likely occupied at that time. Nest 1 was found in 1987, but apparently no eggs were laid. However, nest 3 contained old eggshell fragments when found in 1989, indicating the eagles laid eggs in or prior to 1987. The Table Mountain pair laid at least one egg each year from 1988–1989, but the eggs failed to hatch. The adults were found incubating, or brooding young chicks, on 20 March 1990. The nest was not checked again until 1 June, when a large amount of mute

was observed on the nest ledge, suggesting that at least one young survived to an advanced stage of development and likely fledged.

D4.28.3 Mortalities

No incidents of mortality have been recorded at the Table Mountain breeding area, although this is likely due to the limited amount of data on the site.

D4.28.4 Known Foraging Areas and Food Habits

Virtually nothing is known about the foraging ecology of the Table Mountain eagles. The only data on prey utilization is from prey remains we collected in the nest from 1988–1989 (Table D4.28-2). See Section B5.1.6 for a detailed analysis of prey remains collected from 1988–1989.

Table D4.28-2. Prey species observed taken by bald eagles or collected from the nest at the Table Mountain breeding area.

Fish	Birds	Herptiles
Carp	American coot	None found
Sucker sp.		
	Mammals	
	None found	

D4.28.5 Human Impacts

The remote location of the Table Mountain breeding area likely precludes much human disturbance; however, rafters do float passed the area. Since two of the known nests are in trees, the pair could be easily disturbed by human activity near the nests.

D4.28.6 Wildlife Interactions

No wildlife interactions have been recorded at this remote site.

D4.28.7 Wildlife Sightings

Common black hawks were sighted in the area, along with osprey, golden eagles, and subadult bald eagles. We observed vermillion flycatchers and hooded orioles along the river. Although we noted otters upstream at the East Verde breeding area, it is not known if they occupy the Table Mountain area.

D4.28.8 Management Recommendations

1. More data are needed on the foraging ecology and nesting activities of the Table Mountain eagles in order to determine if there are any special management requirements at this site.

2. Scheduling ORA flights on a once-per-month basis from February through June could provide more data on egg or nestling mortality at Table Mountain.

3. Although data are lacking at Table Mountain, people camping or stopping rivercraft near bald eagle nests have caused disturbances at other breeding areas in Arizona. Therefore, rafters should be prohibited from stopping or camping near the two known tree nests upstream of Mule Shoe Bend.

TABLE MOUNTAIN BREEDING AREA

Date Discovered: 9 April 1987. First Reports 1985.
Drainage: Verde River (Free-flowing)
Elevation (MSL): 2240 - 2600 ft
County: Yavapai (West of Verde River)
Gila (East of Verde River)
Latitude-Longitude Ten Minute Block: 341-1114
Land Management: U.S. Forest Service, Tonto National Forest, Cave Creek Ranger District
Distance From Phoenix: Air - 88.5 km North
Distance To Nearest Breeding Area Upstream: East Verde - 9.3 Km, Air - 7.2 km
Distance To Nearest Breeding Area Downstream: Horseshoe - 26.7 Km, Air - 16.5 km
Distance From Salt River Confluence: 110.1 Km
Home Range: Unknown
Quadrangles: Wet Bottom Mesa 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	1987	Existing - Found 9 April 1987.
2	Willow	Live	1988	Existing - Found 12 February 1988.
3	Willow	Live	1989	Existing - Found 7 March 1989.
			1985–1987 ?	Old eggshell fragments found in nest in 1989.
4		Cliff	1990	Existing - Found 20 March 1990.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1985	Unknown	?	?	?	Rafters reported adults near Wet Bottom Creek.
1986	Unknown	?	?	?	Rafters reported adults near Wet Bottom Creek.
1987	Occupied				Adults may have laid eggs in nest 3. Old eggshell fragments found in 1989.

TABLE MOUNTAIN BREEDING AREA (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1988	Failed	1+	0	0	
1989	Failed	1+	0	0	
1990	Successful	1+	1+	1+	Adults incubating/brooding on 20 March 1990. Amount of mute on nest ledge indicates at least one young survived to an advanced stage of development. Nest empty on 1 June.
Total		3+	1+	1+	
Years		4	4	4	
Mean		0.8	0.2	0.2	

D5 KNOWN AND POTENTIAL HISTORICAL NEST SITES

The Known and Potential Historical Nest Sites section includes those areas (not currently known to be occupied by bald eagles) that have or may have contained breeding pairs in the past. Using published sources, information obtained during interviews with landowners and agency personnel, and nest locations found while studying Arizona bald eagles during 1985–1990, 22 known or potential historical nest sites have been documented in Arizona. Major contributions were made by Duane Rubink, USFWS, and a list of reported adults and nests compiled by Stumph and Creighton, U.S. Bureau of Reclamation, in 1977. Site-specific sources and contacts are listed on the summary sheet for each nest site. Reproductive terminology follows that of Postupalsky (1974), and is summarized in Section D1 to benefit those unfamiliar with such terms.

The history of each nest site is provided on a summary sheet, including any reported productivity data. The following notations are presented to clarify terms used on summary sheets.

1. Unoccupied status indicates unoccupied at known nest locations. Sometimes a site is classified as unoccupied, then later the eagles are found nesting in a previously unknown location.

2. Elevation (above Mean Sea Level) was measured from the river, stream or reservoir to the highest nest. Sites with only tree nests may have one elevation reading instead of two.

3. All distances are in River Kilometers (Km) unless indicated as air kilometers (km).

4. Distances from Phoenix to each breeding area were measured from South Mountain on aeronautical charts.

5. Each nest is numbered chronologically based on its use.

6. Species of nest trees are as follows:
   a. Cottonwood = Fremont Cottonwood (*Populus fremontii*)
   b. Willow = Goodding Willow (*Salix gooddingii*)
   c. Sycamore = Arizona Sycamore (*Platanus wrightii*)
   d. Ponderosa = Ponderosa Pine (*Pinus ponderosa*)
   e. Pinyon = Pinyon Pine (*Pinus cembroides*)
   f. Juniper = Juniper (*Juniperus* sp.)

7. Eagles are identified by plumage in some cases, which correlates with age (McCollough and Krohn 1986).
   a. Adult—Eagle with full white head and tail, usually 5+ years of age.
   b. Near-adult—Eagle with brown mottling in predominately white head and tail, ca. four years old.
   c. Subadult—One to three-year-old eagle in various plumages of brown and white mottling. One-year-old bald eagles are typically dark, and two to three-year-old birds have white bellies with an inverted white triangle on their back. However, we observed a ten-month old telemetered nestling in the white belly phase, so variation does exist.
   d. Juvenile—A first year eagle, from fledging (when it leaves the nest) through migration.
   e. Nestling—A baby eagle, from hatching to fledging.

As mentioned, 22 known or potential historical nest sites have been documented in Arizona, each with varying degrees of evidence concerning nesting and adults. The nest sites are presented in alphabetical order (by name) on summary sheets, with details on each nest. The exact locations of these nests are plotted on maps in the Arizona Bald Eagle Nest Map Atlas (Volume F). Most nest sites occur on five major drainages, the Salt, Verde, Gila, Colorado, and Little Colorado rivers. In addition, nests are located on Stoneman Lake, Upper and Lower Lake Mary, East Clear Creek, and near Prescott (Figure 5.0-1).

Verde River Drainage

Eight historical breeding areas are located on the Verde River drainage, seven on the Verde River and one on the East Verde River. The Box Bar and Needle Rock sites were found in 1937, between the Fort McDowell Indian Reservation and Bartlett Dam on the Verde River. Both nests were built in saguaro cacti (Stumph and Creighton 1977). The Cold Water breeding area occurs near the confluence of Cold Water Creek on the Verde, between West Clear Creek and the East Verde River. Adults were first reported at Cold Water in 1986 (D. MacPhee, pers. comm.), and a cliff nest was found on 12 February 1989, but the site has apparently not been occupied in recent years.

The Tower territory was found on 28 June 1986, near the confluence of Sycamore Creek Canyon on the Verde River. Five cliff nests exist in the area, one of which forms an approximately 3 m high column, and had a white tail feather stuck in the top of it when found. Adults have been sighted in the area, but breeding has not been recorded in recent years (Driscoll, unpublished field notes). However, Floyd Thompson (USFWS) reported a nest was active and produced young in 1965, 1966, and 1968, in this same location (Forbis 1984). Hell Point, discovered in 1975 just below the confluence of Hell Canyon on the Verde (Rubink and Podborny 1976, Rubink, pers. comm.), contains five cliff nests. Adults were sighted on the cliffs in 1975, and the caretaker at Rio Verde Ranch documented bald eagles nesting here in the 1970s. He said he reported the nests to AGF in the early 1970s, but was told that bald eagles "... don't nest on cliffs," a reasonable belief at the time. The amount of mute near one nest on 26 June 1986 lead to the assumption that the nest may have been used that year. In addition, a juvenile bald eagle was sighted 6 km (by air) upstream (Driscoll, unpublished field notes). The Muldoon site was also found on 26 June 1986, 16 Km upstream of Hell Point. The Muldoon nest is more typical of a golden eagle nest, although we flushed a juvenile bald eagle from the cliff. Suckers were abundant in the Verde River in this area (Driscoll, unpublished field notes). The Sullivan nest, in a live cottonwood tree, was found in 1973 on Sullivan Lake (Verde River). The site was not occupied by bald eagles from 1973–1975; however, golden eagles used the nest in 1974 (Rubink and Podborny 1976, Rubink, pers. comm.). The LF site was located on the East Verde River, near the LF ranch, but the nest tree blew down in 1983 or 1984 (C. Swaboda, pers. comm.).

Salt River Drainage

Five historical breeding areas are located on the Salt River drainage, one off the Tonto Arm of Roosevelt Lake, two on the Black River, and two along the White River. The Rock Creek breeding area was found in 1951 inland of the Tonto Arm of Roosevelt Reservoir. The site was occupied from 1951–1952, but a University of Arizona graduate student shot one or both the adults. No adults were sighted in 1953; however, in 1954 the adults and nest were photographed. Adults were observed at the nest again in 1955, but the breeding area was not checked from 1956–1958. The nest tree burned in a fire in 1959 (C. McCollough, unpublished field notes).

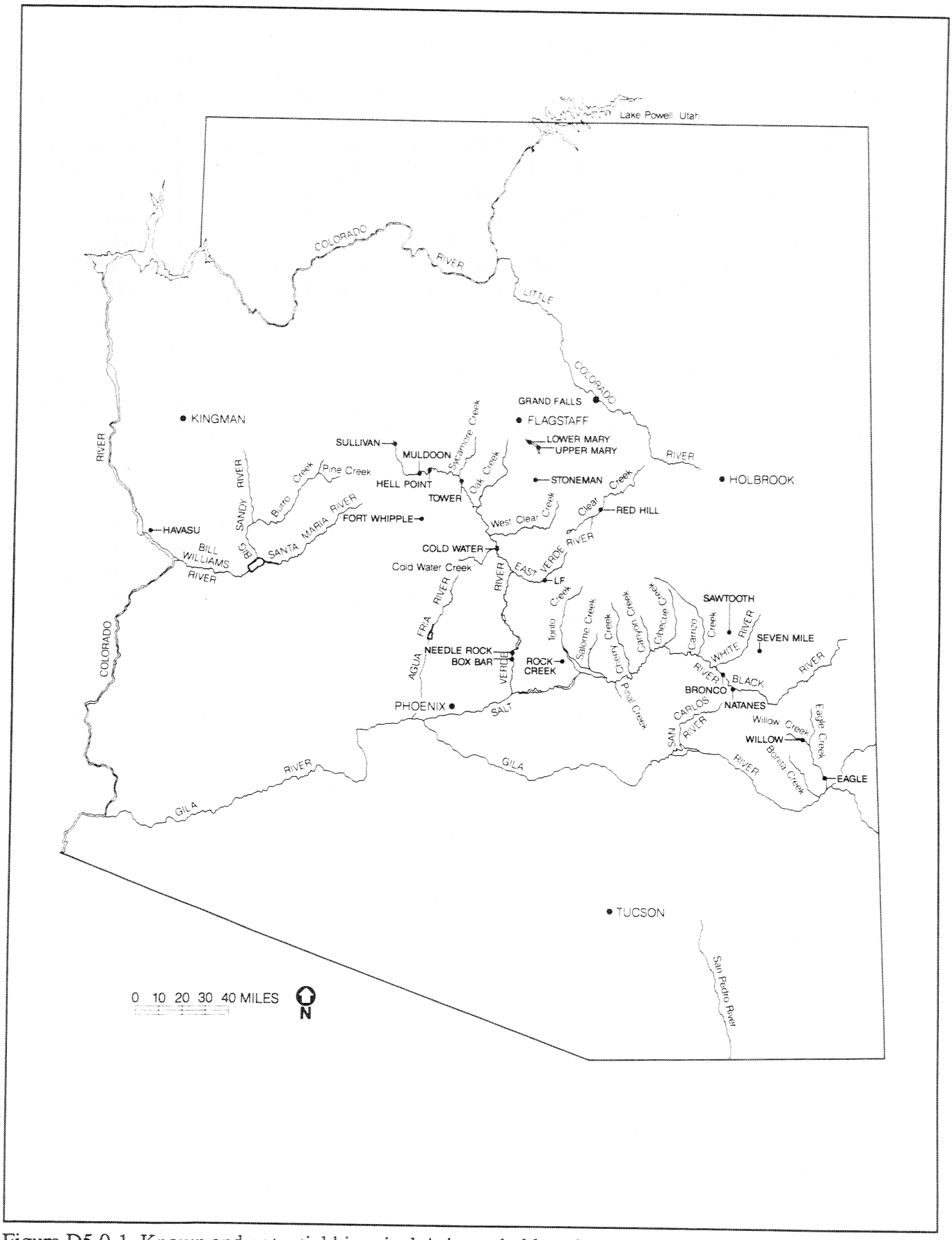

Figure D5.0-1. Known and potential historical Arizona bald eagle nest sites.

The Bronco and Natanes nests were found in 1975, along the Black River, in live ponderosa pine trees. Bronco is 5.6 km (by air) from the White and Black River confluence, and Natanes is 17.5 km (by air) from the confluence (Rubink, pers. comm.). Natanes has shown recent signs of occupancy (May 1990), as a pair of adults were observed taking 20 smallmouth bass (during a fish-stocking operation) and flying off in the same direction on each foray, as if feeding young in a nest (Bob Barnes, pers. comm.). The Seven Mile site is located in Seven Mile Wash off the White River. The nest tree was checked in 1974, and bald eagles were in the area, but golden eagles were using the nest. Sawtooth was reported in 1974, in a juniper snag near Sawtooth Tank, off the White River. The site was visited, but someone had cut the snag down. One young was reported to have fledged in 1974 (Rubink and Podborny 1976, Rubink, pers. comm.).

Gila River Drainage

Two possible historical sites are located along Eagle Creek, a tributary of the Gila River. The cliff nests at Eagle and Willow were found in 1977, but were unoccupied that year (Rubink, pers. comm.).

Little Colorado River Drainage

The historical Grand Falls nest site was first reported in 1939, when bald eagle bones dating between 700 and 1300 A.D. were found in the Wupatki Pueblo (Hargrave 1939). However, these bones may have been a product of Indian trading with other regions. In 1951, two young were reported to have fledged from the cliff nest, 20–22 mi upstream of Leupp. The young were raised to adult plumage by Charles Foster (Stumph and Creighton 1977).

Colorado River Drainage

Havasu is a historical breeding area on Topock Marsh within the Havasu National Wildlife Refuge. Adults built a nest in January 1975, in a cottonwood snag, but the tree fell in a storm in September 1976. Refuge personnel constructed an artificial nest in a live cottonwood tree 100 m away, using the original nest sticks. The breeding area was occupied from 1975–1979, but apparently no eggs were laid. The site was unoccupied from 1980–1981, and was dropped from the nest survey in 1982 (Rubink and Podborny 1976, Rubink, pers. comm., Delaney and Berry, pers. comm.). Two cliff nests were also reported in this area (2-5 mi downstream of railroad bridge) by Floyd Thompson (USFWS), in Forbis (1984).

Other Areas

Five other historical nest sites are located off the main river systems. Adults were first reported in the Fort Whipple area (near Prescott) prior to 1866, and the eagles were recorded nesting prior to 1937 (Coues 1866, Bent 1937). Mearns (1890) noted bald eagles nesting for many years in a pine tree near Stoneman Lake. The Red Hill site was found in a snag on East Clear Creek in 1968 (Stumph and Creighton 1977). The nest still existed as of 1976, but fell prior to 1986 (T. Grubb, pers. comm.). The Lower Mary breeding area was found on Lower Lake Mary in 1970. The tree nest was used from 1970–1972 (Stumph and Creighton 1977). The Upper Mary site was found in 1971, and was reported to have fledged young that year (Stumph and Creighton 1977).

Summary

Of the 22 potential historical breeding areas, six are known (have records of nesting) bald eagle breeding areas (Fort Whipple, Grand Falls, Havasu, Hell Point, Rock Creek, Stoneman), three are most likely bald eagle breeding areas (Cold Water, Natanes, Tower), three are possible bald eagle breeding areas (LF, Sawtooth, Tower, Upper Mary), three are possible bald or golden eagle breeding areas (Muldoon, Seven Mile, Sullivan), and seven remain unknown (Box Bar, Bronco, Eagle, Lower Mary, Needle Rock, Red Hill, Willow). Although some of these sites will likely remain historical (unoccupied), others may become occupied in the future. The now occupied Perkinsville breeding area (see Section D4.21) was on the historical roster prior to 1989. Adults have been sighted in the vicinity of the Rock Creek and Cold Water breeding areas since 1986, and these territories may be occupied at unknown nest locations. The Hell Point site has also shown signs of occupancy recently (1986), and adults are consistently sighted near the Tower breeding area. Other historical nest sites are within the home range of currently active breeding areas, Box Bar (Fort McDowell), Needle Rock (Bartlett), LF (East Verde). In addition, the riparian habitat and stream flows in Arizona have changed over the years, and some historical breeding areas may no longer contain all of the necessary components of a serviceable breeding location (see Section C2.2).

D5.1 BOX BAR NEST SITE

Information Source: Kermit Lee, Lee's Indian Trading Post, in Stumph and Creighton 1977.
Date Discovered: 1937
Drainage: Verde River (Regulated)
Elevation (MSL): 1500 - 1620 ft
County: Maricopa
Latitude-Longitude Ten Minute Block: 334-1114
Land Management: U.S. Forest Service, Tonto National Forest, Cave Creek Ranger District
Distance From Phoenix: Air - 50.0 km Northeast
Distance From Salt River Confluence: 24.6 Km
Quadrangles: Fort McDowell 7.5 Minute
Bartlett Dam 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Saguaro Cactus	Live	1937	Unknown

D5.2 BRONCO NEST SITE

Information Source: Duane Rubink, U.S. Fish and Wildlife Service
Date Discovered: 1975
Drainage: Black River
Elevation (MSL): 4400 - 4600 ft
County: Gila
Latitude-Longitude Ten Minute Block: 334-1101
Land Management: U.S. Bureau of Indian Affairs
Fort Apache Indian Community (North of Black River)
San Carlos Indian Community (South of Black River)
Distance From Phoenix: Air - 175.0 km East
Distance From Black and White River Confluence: 14.2 Km
Air - 5.6 km
Quadrangles: Forks Butte 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Ponderosa	Live	Unknown	Unknown - Rubink No. 4.

D5.3 COLD WATER NEST SITE

Date Discovered: 12 February 1989. First Reports October 1986.
Drainage: Verde River (Free-flowing)
Elevation (MSL): 2760 - 3000 ft
County: Yavapai
Latitude-Longitude Ten Minute Block: 342-1114
Land Management: U.S. Forest Service, Coconino National Forest, Beaver Creek Ranger District (East of River)
U.S. Forest Service, Prescott National Forest, Verde Ranger District (West of Verde River)
U.S. Forest Service, Tonto National Forest, Cave Creek Ranger District (South of Km 147.9)
Distance From Phoenix: Air - 107.5 Km North
Distance From Salt River Confluence: 151.0 Km

Quadrangles:		
	Verde Hot Springs	7.5 Minute
	Hackberry Mountain	7.5 Minute
	Horner Mountain	7.5 Minute
	Tule Mesa	7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	Unknown	Existing - Found 12 February 1989.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1986	Unknown				Adults sighted in area by Doug MacPhee, U.S. Forest Service, Verde Ranger District.
1987	Unknown				Adults sighted in area.
1988	Unknown				Adults sighted in area.
1989	Unoccupied				Nest 1 found.
1990	Unoccupied				

D5.4 EAGLE NEST SITE

Information Source: Duane Rubink, U.S. Fish and Wildlife Service
Date Discovered: 1975
Drainage: Eagle Creek (Free-flowing / Perennial)
Elevation (MSL): 3500 - 3800 ft
County: Greenlee
Latitude-Longitude Ten Minute Block: 330-1092
Land Management: Private Land
Distance From Phoenix: Air - 250.0 km East
Quadrangles: Clifton 15 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	Unknown	Unknown - Rubink No. 2. Floyd Thompson (USFWS) also reported a nest in this area (Forbis 1984).

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1977	Unoccupied				Nest checked 2 March 1977.

D5.5 FORT WHIPPLE NEST SITE

Information Source: Elliott Coues 1866.
Arthur Cleveland Bent 1937.
Date Discovered: Prior to 1937. (1866).
Drainage: Unknown
Elevation (MSL): 5300 ft
County: Yavapai
Latitude-Longitude Ten Minute Block: 343-1122
Land Management: Unknown
Distance From Phoenix: Air - 130.0 km North
Quadrangles: Prescott 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Unknown		< 1937	Unknown.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
< 1866					Bald eagles sighted in area.
< 1937					Bald eagles nesting in area.

< = Prior to

D5.6 GRAND FALLS NEST SITE

Information Source: Lyndon L. Hargrave 1939.
Jack Foster, U.S. National Park Service, in Stumph and Creighton 1977.
Date Discovered: 1951. (1939).
Drainage: Little Colorado River
Elevation (MSL): 4600 - 4700 ft
County: Coconino
Latitude-Longitude Ten Minute Block: 352-1110
Land Management: U.S. Bureau of Indian Affairs
Navajo Indian Community
Distance From Phoenix: Air - 232.0 km Northeast
Quadrangles: Grand Falls 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	1951	Unknown - Approximate nest location. Nest is 20-22 mi upstream of Leupp, on the south cliffs of the Little Colorado River.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1939					Bald eagle bones dating between 700 and 1300 A.D. found in the Wupatki Pueblo (Wupatki National Monument).
1951	Successful	2+	2	2	Two young raised to adult plumage by Charles Foster, Leupp, Arizona.

D5.7 HAVASU NEST SITE

Information Source: Robert L. Delaney and Ty Berry,
U.S. Fish and Wildlife Service,
Havasu National Wildlife Refuge
Date Discovered: 15 January 1975
Drainage: Colorado River (Regulated)
Elevation (MSL): 460 ft
County: Mohave
Latitude-Longitude Ten Minute Block: 344-1143
Land Management: U.S. Fish and Wildlife Service, Havasu National Wildlife Refuge
Closure: U.S. Fish and Wildlife Service Closure
Enacted 1976
Closed To All Entry 440 m Surrounding Nest Tree
Distance From Phoenix: Air - 270.0 km Northwest
Quadrangles: Needles 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Snag	1975-1976	Nest built January 1975. Rubink No. 36. Tree destroyed in wind storm September 1976.
2	Cottonwood	Live	1977-1979	Existing - Artificial nest constructed November 1976 in cottonwood tree 100 m east of original nest snag, using sticks from nest 1, by U.S. Fish and Wildlife Service personnel at refuge.
3		Cliff	Unknown	Unknown location. Nest is 2-5 mi downstream of railroad bridge, just inside mouth of canyon. Nest reported by Floyd Thompson, in Forbis (1984). Nest status is unknown.
4		Cliff	Unknown	Unknown location. Nest is downstream of nest 3. Nest reported by Floyd Thompson, in Forbis (1984). Nest status is unknown.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1975	Occupied				New pair, both near-adults (ca 4 years old). Eagles in area 15 January - 2 March. Nest 1 built. Apparently no eggs were laid.
1976	Occupied				Eagles in area December 1975 to February 1976. Adults copulating and working on nest 1. Apparently no eggs were laid.

HAVASU NEST SITE (continued)

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1977	Occupied				Eagles in area 1 December 1976 to April 1977. Adults worked on nest 2. Male disappeared 17 March. Female left area in April. Apparently no eggs were laid.
1978	Occupied				
1979	Occupied				
1980	Unoccupied				
1981	Unoccupied				
1982	Unknown				Breeding area dropped from nest surveys.

D5.8 HELL POINT NEST SITE

Information Source: Duane Rubink, U.S. Fish and Wildlife Service
Daniel Driscoll, BioSystems Analysis, Inc.
Date Discovered: 1975. (1970s).
Drainage: Verde River (Free-flowing)
Elevation (MSL): 4000 - 4300 ft
County: Yavapai
Latitude-Longitude Ten Minute Block: 345-1121
Land Management: U.S. Forest Service, Prescott National Forest, Chino Valley Ranger District
Distance From Phoenix: Air - 163.0 km North
Distance From Salt River Confluence: 284.1 Km
Quadrangles: Hell Point 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	Unknown	Nest found 1975 - Rubink No. 32. Not found on 1986 survey.
2		Cliff	1970s	Existing - Found 1975. Rubink No. 33.
3		Cliff	1970s	Existing - Found 1975. Rubink No. 34.
4		Cliff	Unknown	Existing - Found June 1986.
5		Cliff	1986	Existing - Found June 1986.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1970s	Occupied				Caretaker at Rio Verde Ranch (via Michael Cross, Arizona Game and Fish Department, 1990) reported bald eagles nesting on these cliffs in the 1970s.
1975	Occupied ?				Adults sighted on cliffs during nest surveys.
1986	Occupied ?				Fresh mute on cliff and nest in June. Juvenile bald eagle sighted 6 km (by air) upriver in June.

D5.9 LF NEST SITE

Information Source: Charlie Swaboda, LF Ranch
Date Discovered: 1970s
Drainage: East Verde River (Free-flowing)
(30 cfs pumped in from East Clear Creek)
Elevation (MSL): 3240 ft
County: Gila
Latitude-Longitude Ten Minute Block: 341-1113
Land Management: U.S. Forest Service, Tonto National Forest, Payson Ranger District
Distance From Phoenix: Air - 102.0 km Northeast
Distance From Verde River Confluence: 18.8 Km
Quadrangles: Cypress Butte 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Live	Unknown	Nest tree blew down in 1983 or 1984.

D5.10 LOWER MARY NEST SITE

Information Source: James R. Sweeney, U.S. Forest Service, Mormon Lake Ranger District, in Stumph and Creighton 1977.
Date Discovered: 1970
Drainage: Walnut Creek / Lower Lake Mary (Regulated / Reservoir)
Elevation (MSL): 6790 - 6880 ft
County: Coconino
Latitude-Longitude Ten Minute Block: 350-1113
Land Management: U.S. Forest Service, Coconino National Forest, Mormon Lake Ranger District
Distance From Phoenix: Air - 186.0 km North
Quadrangles: Lower Lake Mary 7.5 Minute
Ashurst Lake 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Unknown	Live	1970-1972	Unknown.

D5.11 MULDOON NEST SITE

Information Source: Daniel Driscoll, BioSystems Analysis, Inc.
Date Discovered: 26 June 1986
Drainage: Verde River (Free-flowing)
Elevation (MSL): 4200 - 4300 ft
County: Yavapai
Latitude-Longitude Ten Minute Block: 345-1122
Land Management: U.S. Forest Service, Prescott National Forest, Chino Valley Ranger District
Distance From Phoenix: Air - 163.0 km North
Distance From Salt River Confluence: 299.8 Km
Quadrangles: Hell Point 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	Unknown	Existing - Found 26 June 1986. Nest more closely resembles a golden eagle nest, although a juvenile bald eagle was flushed from this site on 26 June 1986.

D5.12 NATANES NEST SITE

Information Source: Duane Rubink, U.S. Fish and Wildlife Service
Date Discovered: 1975
Drainage: Black River (Free-flowing)
Elevation (MSL): 4680 - 4900 ft
County: Gila
Latitude-Longitude Ten Minute Block: 333-1100
Land Management: U.S. Bureau of Indian Affairs
San Carlos Indian Community (South of Black River)
Fort Apache Indian Community (North of Black River)
Distance From Phoenix: Air - 182.5 km East
Distance From Black and White River Confluence: Air - 17.5 km
Quadrangles: Georges Butte 7.5 Minute
Velasquez Butte 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Ponderosa	Live	Unknown	Unknown - Found 1975. Rubink No. 3.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1990	Occupied?	?	?	?	Pair of adults sighted in area in May 1990 by Bob Barnes, Reclamation. Adults took 20 smallmouth bass (during fish-stocking operation) from a mesa near George's Basin, and flew off in same direction on each foray, as if feeding young in a nest.

D5.13 NEEDLE ROCK NEST SITE

Information Source: Kermit Lee, Lee's Indian Trading Post, in Stumph and Creighton 1977.
Date Discovered: 1937
Drainage: Verde River (Regulated)
Elevation (MSL): 1550 - 1640 ft
County: Maricopa
Latitude-Longitude Ten Minute Block: 334-1114
Land Management: U.S. Forest Service, Tonto National Forest, Cave Creek Ranger District
Distance From Phoenix: Air - 48.5 km Northeast
Distance From Salt River Confluence: 29.5 Km
Quadrangles: Bartlett Dam 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Saguaro Cactus	Live	1937	Unknown.

D5.14 RED HILL NEST SITE

Information Source: Louis Erlich, U.S. Bureau of Reclamation, in Stumph and Creighton 1977.
Date Discovered: 1968
Drainage: East Clear Creek (Regulated / Perennial)
Elevation (MSL): 6000 - 6400 ft
County: Coconino
Latitude-Longitude Ten Minute Block: 344-1105
Land Management: U.S. Forest Service, Coconino National Forest, Blue Ridge Ranger District (West of Creek). U.S. Forest Service, Sitgreaves National Forest, Chevelon Ranger District (East of Creek).
Distance From Phoenix: Air - 175.0 km Northeast
Quadrangles: Quayle Hill 7.5 Minute
Hamilton Crossing 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Unknown	Snag	Unknown	Nest found in large snag on west rim of canyon, above gaging station in 1968. Nest still there in 1976. Snag fell prior to 1986 (Teryl Grubb, U.S. Forest Service).

D5.15 ROCK CREEK NEST SITE

Information Source: Clay McCollough's Field Notes, Arizona Game and Fish Department.
Date Discovered: 1951
Drainage: Rock Creek
Elevation (MSL): 2800 ft
County: Gila
Latitude-Longitude Ten Minute Block: 334-1111
Land Management: U.S. Forest Service, Tonto National Forest, Tonto Basin Ranger District
Distance From Phoenix: Air - 80.0 km Northeast
Distance From Roosevelt Reservoir: Air - 5.5 km
Quadrangles: Four Peaks 7.5 Minute
Theodore Roosevelt Dam 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Live	1951-1952	Nest found 1951
			1954-1955	Nest tree destroyed by fire in 1959.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1951	Occupied	?	?	?	One or both adults shot in 1951 or 1952.
1952	Occupied	?	?	?	
1953	Unoccupied				
1954	Occupied	?	?	?	Adults and nest photographed. Adults defending site in February and March, but no adults in area in April.
1955	Occupied	?	?	?	Adults defending nest site in May.
1956	Unknown				
1957	Unknown				
1958	Unknown				
1959					Nest tree destroyed by fire. No eagles seen in area.

D5.16 SAWTOOTH NEST SITE

Information Source: Duane Rubink, U.S. Fish and Wildlife Service
Date Discovered: 1974
Drainage: Yellow Jacket Spring (Free-flowing / Intermittent)
Elevation (MSL): 5600 ft
County: Gila
Latitude-Longitude Ten Minute Block: 334-1100
Land Management: U.S. Bureau of Indian Affairs
Fort Apache Indian Community
Distance From Phoenix: Air - 201.0 km East
Distance From White River: Air - 8.1 km
Quadrangles: Canyon Day 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Juniper	Snag	1974	Nest reported 1974. Rubink No. 5. Nest snag cut down 1974.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1974	Successful	1+	1	1	One young reported fledged.

D5.17 SEVEN MILE NEST SITE

Information Source: Duane Rubink, U.S. Fish and Wildlife Service
Date Discovered: 1974
Drainage: Seven Mile Wash (Free-flowing / Intermittent)
Elevation (MSL): 5400 ft
County: Navajo
Latitude-Longitude Ten Minute Block: 334-1095
Land Management: U.S. Bureau of Indian Affairs
Fort Apache Indian Community
Distance From Phoenix: Air - 200.0 km East
Distance From White River: Air - 2.5 km
Quadrangles: White River 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Unknown	Live	Unknown	Unknown - Found 1974. Approximate nest location.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1974					Bald eagles in area, but golden eagles in nest.

D5.18 STONEMAN NEST SITE

Information Source: Edgar Alexander Mearns 1890
Date Discovered: 1890
Drainage: Stoneman Lake (Natural Lake)
Elevation (MSL): 6800 ft
County: Coconino
Latitude-Longitude Ten Minute Block: 344-1113
Land Management: U.S. Forest Service, Coconino National Forest,
Beaver Creek Ranger District (West half of Lake)
Long Valley Ranger District (East half of Lake)
Distance From Phoenix: Air - 155.0 km North
Quadrangles: Stoneman Lake 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Pine	Live	< 1890	Unknown.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
< 1890	Occupied				Bald eagles reported nesting many years prior to 1890. Approximate nest location.

< = Prior to

D5.19 SULLIVAN NEST SITE

Information Source: Duane Rubink, U.S. Fish and Wildlife Service
Date Discovered: 1973
Drainage: Verde River / Sullivan Lake (Free-flowing)
Elevation (MSL): 4380 ft
County: Yavapai
Latitude-Longitude Ten Minute Block: 345-1122
Land Management: Private Land
Distance From Phoenix: Air - 161.5 km North
Distance From Salt River Confluence: 316.0 Km
Quadrangles: Chino Valley North 7.5 Minute
Paulden 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Cottonwood	Live	Unknown	Unknown - Found 1973. Rubink No. 35.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1973	Unoccupied				
1974	Unoccupied				Nest used by golden eagles.
1975	Unoccupied				

D5.20 TOWER NEST SITE

Information Source: Daniel Driscoll, BioSystems Analysis, Inc.
Date Discovered: 28 June 1986. Productivity data from a nest in the same location in the 1960s (possibly nest 2) reported by Floyd Thompson (USFWS) in Forbis (1984).
Drainage: Verde River (Free-flowing)
Elevation (MSL): 3500 - 3600 ft
County: Yavapai
Latitude-Longitude Ten Minute Block: 345-1120
Land Management: U.S. Forest Service, Coconino National Forest, Sedona Ranger District (East of Verde River and Sycamore Creek)
U.S. Forest Service, Prescott National Forest, Chino Valley Ranger District (West of Verde River and Sycamore Creek)
Distance From Phoenix: Air - 154.0 km North
Distance From Salt River Confluence: 242.6 Km
Quadrangles: Clarkdale 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	Unknown	Existing - Found 28 June 1986.
2		Cliff	Unknown	Existing - Found 28 June 1986. Nest ca. 3 m in depth.
3		Cliff	Unknown	Existing - Found 28 June 1986.
4		Cliff	Unknown	Existing - Found 28 June 1986.
5		Cliff	Unknown	Existing - Found 28 June 1986.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1965	Successful	1+	1+	1+	Nest site active and produced young.
1966	Successful	1+	1+	1+	Nest site active and produced young.
1967	Unknown				
1968	Successful	1+	1+	1+	Nest site active and produced young.
1986					White tail feather stuck in top of nest 2.
Annually					Adults reported at Pecks Lake. Adults present along Verde River during breeding season.

D5.21 UPPER MARY NEST SITE

Information Source: John Elam, Flagstaff, in Stumph and Creighton 1977.
Date Discovered: 1971
Drainage: Newman Creek / Walnut Creek / Upper Lake Mary
(Free-flowing / Regulated / Reservoir)
Elevation (MSL): 6800 - 6900 ft
County: Coconino
Latitude-Longitude Ten Minute Block: 350-1113
Land Management: U.S. Forest Service, Coconino National Forest, Mormon Lake Ranger District
Distance From Phoenix: Air - 184.0 km North
Quadrangles: Ashurst Lake 7.5 Minute
Lower Lake Mary 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1	Unknown	Live	1971	Unknown.

Productivity

Year	Status	Eggs	Young	Fledged	Comments
1971	Successful	1+	1+	1+	Young reported fledged.

D5.22 WILLOW NEST SITE

Information Source: Duane Rubink, U.S. Fish and Wildlife Service
Date Discovered: 1975
Drainage: Willow Creek (Free-flowing / Perennial)
Elevation (MSL): 4830 - 5120 ft
County: Graham
Latitude-Longitude Ten Minute Block: 332-1093
Land Management: U.S. Bureau of Indian Affairs
San Carlos Indian Community (West of Eagle Creek)
U.S. Forest Service, Apache National Forest,
(East of Eagle Creek)
Distance From Phoenix: Air - 238.0 km East
Distance From Eagle Creek Confluence: Air - 3.5 km
Quadrangles: Willow Mountain SE 7.5 Minute
Bee Canyon 7.5 Minute

Nest Sites

No.	Species	Type	Utilized	Status
1		Cliff	Unknown	Unknown - Found 1975. Rubink No. 1.

D6 POSSIBLE NEST SITES AND UNVERIFIED REPORTS

This section contains locations where adults have been sighted during the breeding season, although a nest has not been found to date, and areas where nests or eagles have been reported by the public. The 60 possible nest sites and unverified reports are presented to archive past reports of nests or breeding activity, and to aid in future nest search efforts. Data to create Section D6 stemmed from many sources and personal contacts. Major contributions were made by Duane Rubink, U.S. Fish and Wildlife Service, and by Stumph and Creighton (Reclamation) who in 1977 compiled a list of reported adults and nests. Site specific sources and contacts are listed under each site.

The 60 possible nest sites and unverified reports are located throughout Arizona. Most sites occur on seven major drainages, the Salt, Verde, Gila, San Pedro, Bill Williams, Colorado, and Little Colorado rivers. In addition, sites are located on Mormon Lake, creeks in the Mogollon Rim area, and lakes in the White Mountains (Figure D6.0-1).

Details on each of the 60 possible nest sites and unverified reports are provided under each site. Eight sites are located on the Verde River drainage. Three are on the Verde River; one near Peck's Lake (35), and two near Childs (5, 9). In addition, two sites are on Sycamore Creek (19, 20), one on Oak Creek (15), and two on the East Verde River (4, 6).

Thirteen of the sites are located on the Salt River drainage. Six are on the Salt River; one above the Highway 60 bridge (51), two near Gleason Flat (13, 18), one on Roosevelt Reservoir at Windy Hill (8), one on Apache Reservoir (1), and one on Canyon Reservoir (2). In addition, one site is off the White River (12), one off Ash Creek (11), two on Cherry Creek (16, 17), one on Coon Creek (3), one on Salome Creek (7), and one on Rock Creek (10).

Five sites are on the Gila River drainage. Two are on the Gila River; one near Safford Valley (33), and one near the confluence of the San Carlos River (43). An additional site is located on a high mountain lake off the San Carlos River (26), and two north of Highway 70 (59, 60).

Four sites are located on the Bill Williams River drainage. One is on Trout Creek (44), one on Pine Creek (29), and two are on Burro Creek (27, 28).

Thirteen sites are on the Colorado River drainage. Five are on Powell Reservoir (38, 39, 40, 41, 42), two are on the Colorado River below Glenn Canyon Dam (36, 37), two are on the Little Colorado River (56, 57), three are on the Colorado River within the Grand Canyon (53, 54, 55), and one is on Mohave Reservoir (52).

One site is on Cholla Lake (22), near the Little Colorado River. An additional site is on the San Pedro River, down near the Mexican border (47).

Ten sites are located on the Mogollon Plateau area. One is on Mormon Lake (25), two on Clear Creek (48, 49), one on Leonard Creek (31), and one on Chevelon Creek (32). In addition, one site is on a small lake near Star Valley (14), and three are on Christopher Creek (23, 24, 50). One site is located on Foxborough Lake (30); however, the location of this lake is unknown to us.

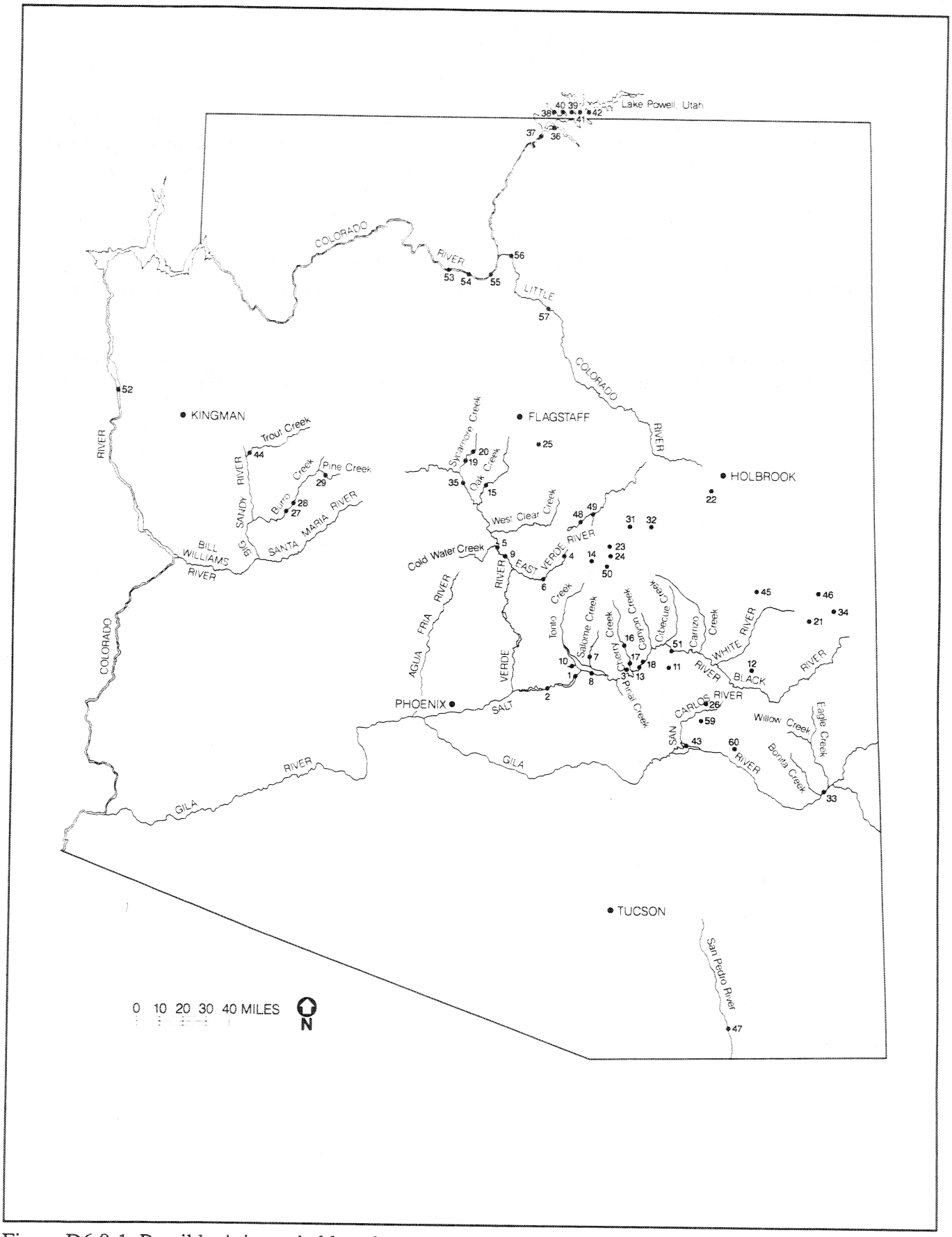

Figure D6.0-1. Possible Arizona bald eagle nest sites and unverified reports.

Five other sites are located in the White Mountains. One is on Scott Reservoir (45), one between Scott Reservoir and Springerville (46), one on Sunrise Lake (21), and one on Mexican Hay Lake (34). Another site is located on Christmas Tree Lake (58); however the location of this lake is unknown to us.

Of the 60 possible nest sites and unverified reports, 11 may support nesting bald eagles (1, 2, 5, 7, 8, 10, 18, 43, 45, 46, 51). Site 18 may be the Canyon or Ash eagles (see Sections D4.2 and D4.5) which possibly forage near Gleason Flat on the Salt River. In addition, sites 7 and 8 may be the same eagles, in Salome Bay and on Windy Hill at Roosevelt Reservoir. Nests and adults have been documented at sites 5, 10, 45, and 46 in the past.

Four sites are within active breeding areas (see Section D4), and may be defended by those pairs (3—Redmond, 6—East Verde, 11—Ash, 17—Redmond). Bald eagles could possibly occupy 28 sites (4, 9, 13, 15, 16, 19, 20, 25, 26, 27, 28, 29, 33, 35, 36, 37, 38, 39, 40, 41, 42, 44, 52, 53, 54, 55, 56, 57), based on habitat conditions and reports of adults. The possibility of eagles occurring at the 17 remaining sites (12, 14, 21, 22, 23, 24, 30, 31, 32, 34, 47, 48, 49, 50, 58, 59, 60) is unknown.

1. APACHE RESERVOIR
   Pine Cove: 1 cove east of Waterdog USAF Camp. Adults consistently sighted in 1974. Burnt Corral to Theodore Roosevelt Dam: Adults foraging in 1984. Adults sighted at T.R. dam all summer 1986. Many reports of adults at T.R. Dam area in spring and summer, 1986–1990.
   Sources: Ruesch and Browne (1984). Theodore Roosevelt Dam personnel, Salt River Project, Phoenix, Arizona, 1986.

2. CANYON RESERVOIR
   Cliffs north of boat ramp: Adults foraging in 1987. Adults feeding fledged (screaming) young on cliffs at Km 38.8 "every summer from 1977–1987."
   Source: Fisherman on Canyon Reservoir, 1987.

3. SALT RIVER
   Coon Creek (T4N, R15E, Sec 8): Bill Lee Springs. Active nest in crack on cliff in 1987.
   Source: Anonymous Report, 1987.

4. EAST VERDE RIVER
   Diamond S Bend (near Diamond Rim): Adults in area.
   Source: Anonymous Report, 1987.

5. VERDE RIVER
   Cold Water Creek: Adults often seen in area. Empty nest found in 1989.
   Source: Doug MacPhee, U.S. Forest Service, Verde Ranger District, Camp Verde, Arizona, 1986, 1987.

6. EAST VERDE RIVER
   LF Ranch: Nest in top of pine tree on Pine Creek or Rock Creek
   Source: Charlie Swaboda, LF Ranch, 1987.

7. ROOSEVELT RESERVOIR
Salome Creek: Adult male consistently perched in Salome Bay in 1988. Male observed carrying prey north up creek.
Source: BioSystems Analysis, Inc., Tempe, Arizona.

8. ROOSEVELT RESERVOIR
Windy Hill Adult pair perched on cliff in winter 1986–1988.
Source: BioSystems Analysis, Inc., Tempe, Arizona.

9. VERDE RIVER
Childs: Cliffs north of Childs. Adult in area in 1986.
Source: Anonymous Report, 1986.

10. ROOSEVELT RESERVOIR
Rock Creek: Arizona Game and Fish Cabin to confluence.
Source: Clay McCollough's field notes, Arizona Game and Fish Department, Phoenix, Arizona, 1951–1959.

11. ASH CREEK
Highway Tanks: Adults sighted from 1986–1988. Two young sighted in May 1986.
Source: Dugger Hughes, U.S. Forest Service, Globe Ranger District, Globe, Arizona, 1986–1988.

12. WHITE RIVER
Chino Springs Tank (T4N, R23E, Sec 11): Nest in area.
Source: Anonymous Report, 1986.

13. SALT RIVER
Hackberry Springs: Adults seen in area.
Source: River Runner, 1986.

14. STAR VALLEY
Small lake: Adults foraging throughout year.
Source: Rick and Val Doudna, Mesa, Arizona, 1987.

15. OAK CREEK
Page Springs Hatchery: Adults sighted annually downstream of hatchery.
Source: Many anonymous reports.

16. CHERRY CREEK
Ellis Ranch (east of Aztec Peak): Adults sighted throughout year.
Source: Dallas Reigal, Salt River Project, Hydrology Department, Phoenix, Arizona, 1986.

17. CHERRY CREEK
South of creek ford, near powerlines, Nest on cliff. Pellets collected below nest in 1985 contained fur and fish scales. Possibly a black, zonetail, or redtail hawk.
Sources: Nest reported by backpacker, 1985. Pellets collected by Daniel E. Driscoll, 1985.

18. SALT RIVER
Gleason Flat: Adult foraged and flew to cottonwood with prey, May 1986.
Source: Michael Cross, Kayak Ranger, U.S. Forest Service, Globe Ranger District, Globe, Arizona, 1986.

19. VERDE RIVER
Sycamore Creek: Cliff nest approximately 5 mi upstream of confluence. Lots of suckers present in lower part of creek, June 1986.
Sources: Nest: Duane Rubink, U.S. Fish and Wildlife Service, Phoenix, Arizona, 1985.
Fish: Daniel E. Driscoll, 1986.

20. VERDE RIVER
Sycamore Creek: Cliff nest approximately 10 mi upstream of confluence. Lots of suckers present in lower part of creek, June 1986.
Sources: Nest: Duane Rubink, U.S. Fish and Wildlife Service, Phoenix, Arizona, 1985.
Fish: Daniel E. Driscoll, 1986.

21. SUNRISE LAKE
San Carlos Reservation: Two adults sighted during bald eagle nesting survey, 1 May 1986.
Source: Glinski (1986).

22. CHOLLA LAKE
Arizona Public Service Plant Cooling Pond (near Joseph City): Cliff nest less than 1 mi from NE corner of lake, 1969.
Source: Arizona Public Service Personnel, in Stumph and Creighton (1977).
Nest in Canyon on east end. Nest was active and produced young in 1963–1967.
Source: Floyd Thompson (USFWS), in Forbis (1979) and Forbis (1984).

23. CHRISTOPHER CREEK
East Fork of creek, near R Bar C Boy Scout Camp. Tree nest in 1968.
Source: Anonymous report, in Stumph and Creighton (1977).

24. CHRISTOPHER CREEK
4 mi over Roosevelt Mountain from nest 23. Tree nest in 1968.
Source: Anonymous report, in Stumph and Creighton (1977).

25. MORMON LAKE
Tree nest (more than one pair) on lake in 1960s.
Source: Anonymous report, in Stumph and Creighton (1977).

26. SAN CARLOS RESERVATION
15 mi NE of San Carlos Agency. Tree nest on high mountain lake.
Source: Anonymous report, in Stumph and Creighton (1977).

27. BURRO CREEK
Cliff nest 5 mi upstream of highway bridge.
Source: Anonymous report, in Stumph and Creighton (1977).

28. BURRO CREEK
Cliff nest 7.5 mi upstream of highway bridge.
Source: Anonymous report, in Stumph and Creighton (1977).

29. BURRO CREEK
Tree nest on Pine Creek, just upstream of confluence.
Source: Anonymous report, in Stumph and Creighton (1977).

30. FOXBOROUGH LAKE
Tree nest on lake (unknown location).
Source: U.S. Forest Service, Woods Planning Unit Draft Environmental Statement, in Stumph and Creighton (1977).

31. LEONARD CREEK
Eagles sighted during nesting season.
Source: U.S. Forest Service, in Stumph and Creighton (1977).

32. CHEVELON CREEK
Eagles sighted during nesting season.
Source: Museum of Northern Arizona, in Stumph and Creighton (1977).

33. GILA RIVER
Above Safford Valley: Cliff nest with adults present.
Source: Anonymous report, in Stumph and Creighton (1977).

34. MEXICAN HAY LAKE
White Mountains: Eagles sighted at lake.
Source: Jo Penunuri, U.S. Bureau of Reclamation, in Stumph and Creighton (1977).

35. VERDE RIVER
Peck's Lake: upstream of Cottonwood. Adults perched on slag piles annually.
Source: Many reports, 1986–1989. Mark Collie and Florence Knoll, U.S. Forest Service, Verde Ranger District, Camp Verde, Arizona, 1989.

36. COLORADO RIVER
Glenn Canyon Dam: Cliff nest 2 mi below dam, 1975.
Source: Curtis Mossestad, National Park Service, Glenn Canyon Recreation Area, in Stumph and Creighton (1977).
Cliff nest 2.5 mi downstream of dam was utilized by golden eagles in 1976.
Source: Duane Rubink, U.S. Fish and Wildlife Service, Phoenix, Arizona.

37. COLORADO RIVER
Glenn Canyon Dam: Cliff nest 9 mi below dam, 1975.
Source: Duane Rubink, U.S. Fish and Wildlife Service, Phoenix, Arizona.

38. POWELL RESERVOIR
Reflection Canyon, on north fork of reservoir. Cliff nest reported active 1974–1976.
Source: Jack Foster, National Park Service, Glenn Canyon National Recreation Area, in Stumph and Creighton (1977).

39. POWELL RESERVOIR
San Juan Arm of reservoir: Cliff nest reported active 2–3 years on south shore, 11 river miles from confluence with Colorado Arm.
Source: Jack Foster, National Park Service, Glenn Canyon National Recreation Area, in Stumph and Creighton (1977).

40. POWELL RESERVOIR
San Juan Arm of lake: Cliff nest reported active 2–3 years on south shore, 5 river miles from confluence with Colorado Arm.
Source: Jack Foster, National Park Service, Glenn Canyon National Recreation Area, in Stumph and Creighton (1977).

41. POWELL RESERVOIR
San Juan Arm of lake: Cliff nest reported active 2–3 years on north shore, 18 river miles from confluence with Colorado Arm.
Source: Jack Foster, National Park Service, Glenn Canyon National Recreation Area, in Stumph and Creighton (1977).

42. POWELL RESERVOIR
Two adults photographed flushing from two cliff nests in February 1977.
Source: J. Middleton, Park Naturalist, National Park Service, Glenn Canyon National Recreation Area, in Stumph and Creighton (1977).

43. SAN CARLOS RESERVOIR
Confluence of San Carlos River to eastern end of reservoir: Two pairs of adults sighted 13 January 1990.
Source: Daniel E. Driscoll, BioSystems Analysis, Inc., Tempe, Arizona.

44. TROUT CREEK
Just upstream of Big Sandy River confluence: Adult perched above nest in cottonwood tree 1 February 1978.
Source: Duane Rubink, U.S. Fish and Wildlife Service, Phoenix, Arizona.

45. SCOTT RESERVOIR
Adult sighted near an old cliff nest 12 April 1978. No. 22 on Duane Rubink's topography map for flight, which cannot be located in files.
Source: Rubink, unpubl. field notes, 1977–1978.

46. SCOTT RESERVOIR TO SPRINGERVILLE
"An active bald eagle nest, a bird appeared to be incubating stood up when we flew by, remained on the nest. A large cliff nest on the opposite cliff of the same curve."
12 April 1978.
No. 23 on Duane Rubink's topography map for flight, which cannot be located in files.
Flight covered Show Low, Show Low Lake, Scott Reservoir, and Lakeside, and landed at Springerville.
Source: Rubink, unpubl. field notes, 1977–1978

47. UPPER SAN PEDRO RIVER
Adult sighted 0.5 mi south of Arizona Highway 90 bridge, 17 June 1989.
Source: Rosenburg and Stejskal (1989).

48. CLEAR CREEK
Nest approximately 6 mi upstream from Blue Ridge Reservoir.
Source: Floyd Thompson, in Forbis (1979) and Forbis (1984).

49. CLEAR CREEK
Nest approximately 15 mi upstream from Blue Ridge Reservoir.
Source: Floyd Thompson, in Forbis (1979) and Forbis (1984).

50. CHRISTOPHER CREEK
Nest in canyon between Christopher Creek Boy Scout Camp and confluence of Tonto Creek.
Source: Floyd Thompson, in Forbis (1979) and Forbis (1984).

51. SALT RIVER
Nest is 15 mi above Highway 60 bridge, in a pine tree near Dead Horse Crossing. (Note: Possible directions of "above" may include north, south [Ash breeding area ?], or east-upstream [unknown pair on Salt River?]).
Source: Floyd Thompson, in Forbis (1979).

52. MOHAVE RESERVOIR
Nest is 15 mi Upstream of Davis Dam on west side of reservoir on cliff.
Source: Floyd Thompson, in Forbis (1984).

53. COLORADO RIVER
Bald eagle nest seen from road, in Colorado River Canyon near confluence of Pigeon Canyon.
Source: Floyd Thompson, in Forbis (1984).

54. COLORADO RIVER
Nest on Cliff near Grand Canyon village. Hopi Indians taking young from nest.
Source: Floyd Thompson, in Forbis (1984).
Note: This may be a golden eagle nest, since Hopi Indians use golden eagles for religious purposes.

55. COLORADO RIVER
Nest on cliff near Desert View. Hopi Indians taking young from nest.
Source: Floyd Thompson, in Forbis (1984).
Note: This may be a golden eagle nest, since Hopi Indians use golden eagles for religious purposes.

56. LITTLE COLORADO RIVER
Bald eagle nest just outside Grand Canyon National Park boundary.
Source: Floyd Thompson, in Forbis (1984).

57. LITTLE COLORADO RIVER
Nest is 8-10 mi upstream from Cameron, Arizona. Saw nest and eagles.
Source: Floyd Thompson, in Forbis (1984).

58. CHRISTMAS TREE LAKE
Nest in pine tree near Christmas Tree Lake (unknown location).
Source: Floyd Thompson, in Forbis (1984).

59. SAN CARLOS
Nest is just before junction with Highway 7 [70?] along Sawmill Loop Road, north and east of San Carlos.
Source: Floyd Thompson, in Forbis (1984).

60. SAN CARLOS
Nest is in cottonwood tree on 100-150 acre lake, north of Bylas, Arizona (north of Highway 70).
Source: Floyd Thompson, in Forbis (1984).

D7 WILDLIFE OBSERVATIONS

Arizona contains a variety of wildlife species due to the many combinations of elevation, climate, and soil types, creating a diversity of habitat components and vegetative structure. During our study of bald eagles in Arizona, we encountered numerous wildlife species, some of which interacted with the bald eagles. A discussion of these interactions, as well as wildlife species encountered in bald eagle breeding areas, is provided below.

D7.1 WILDLIFE INTERACTIONS

Interactions with other bald eagles (intraspecific) and with other species (interspecific) are common among bald eagles. These interactions can be aggressive, as in territorial defense and attempts to pirate prey, but occasionally are not, such as soaring with other raptors. Many interactions simply involve escorting the intruder out of the nesting area, although some altercations are aggressive. Chases can be accompanied by stooping, locking talons, cartwheeling (both birds tumbling through the sky with talons locked), and vocalizations until the intruder is out of sight. Some altercations involve intense aerial or ground battles. Details on wildlife interactions at each bald eagle breeding area in Arizona are provided in Section D4.

D7.1.1 Interspecific Interactions

In Arizona, interspecific interactions were numerous with common ravens and red-tailed hawks, which often nest within bald eagle breeding areas. Other birds pursued or attacked by nesting bald eagles included adult and subadult golden eagles, osprey, turkey vultures, Harris' hawks, zone-tailed hawks, Swainson's hawks, Cooper's hawks, sharp-shinned hawks, American kestrels, prairie falcons, peregrines, great horned owls, American crows, double-crested cormorants, great blue herons, great egrets. On one occasion at the Alamo territory, an adult locked talons with an osprey and actually forced the intruder into the reservoir, making several stoops on the floating bird (see Section D4.1). As typical elsewhere, eagles often chased ospreys in connection with food competition and piracy.

Adult bald eagles attacked some birds vigorously, while simply escorting others out of the breeding area. The aggressiveness of the attack did not seem to correlate with species, but rather, appeared to depend on the eagles mood at the time (*e.g.*, displacement behavior). In addition to red-tailed hawks and common ravens, golden eagles also nest within many bald eagle breeding areas. The adult bald eagles occasionally soared non-aggressively with golden eagles (Driscoll 1985, Fettig and Bock 1988), but at other times would vigorously attack them (Sherman 1983, Haywood and Ohmart 1982). At the East Verde breeding area, one of the adults struck a golden eagle in the air, and in another instance drove a golden into the ground where it subsequently fought with it (see Section D4.12). A golden eagle apparently killed an adult female bald eagle at the "76" breeding area (see Section D4.26).

Other birds also harass bald eagles. Red-tailed hawks, Harris' hawks, American kestrels, common ravens, western kingbirds, northern orioles, pinyon jays, and Say's phoebes have been observed dive-bombing or otherwise harassing Arizona eagles. In addition, white-throated swifts often whizzed by the nest, causing the adults to duck their heads. Hummingbirds also buzzed around the adults and young at

the nest, and Say's phoebes and western kingbirds were observed flycatching over the nests, occasionally causing the adult eagle to vocalize (Driscoll 1985, Driscoll and Buckley 1986).

Peregrine falcons nest within bald eagle breeding areas, and interactions with this species may appear playful or be very aggressive on the falcon's part. At the Horse Mesa breeding area peregrines initiated many interactions by stooping on the adult eagles. In one instance, an adult peregrine stooped on the female eagle, knocking her off the pinnacle above the nest and dislodging feathers from her back. The subsequent tail-chase, in which the peregrine teasingly remained just out of reach of the eagle, lasted seven minutes (Driscoll and Buckley 1986). A peregrine was apparently directly responsible for the death of the adult male bald eagle at the Ladders territory in 1989 (see Section D4.17). On 3 April, BioSystems biologists observed a peregrine falcon stoop on AM08 and strike a blow in passing. AM08's flight abilities appeared immediately affected as he awkwardly flew to, and crash landed at, the nest. AM08 remained sluggish for days, not foraging again until 14 April. During this time the adult female foraged to feed the two eaglets. AM08 died 6–10 May 1989, probably from brain damage resulting from the peregrine attack (see Section C3.7). Peregrines may also have contributed to the death of the Horse Mesa male in 1987 (see Section D4.14) and may have been responsible at Cibecue for a section of an adult male's ulna being broken out of his wing in 1988 (see Section D4.8); the configuration of the break suggested that the eagle had been struck from above.

Great horned owls also nest within Arizona bald eagle breeding areas. They have interacted with the eagles at several nest sites and are suspected of killing two juveniles. The 1988 Ladders juveniles 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. In addition, it is typical behavior of great horned owls to eat the heads off of their prey. This behavior has been observed by BioSystems biologists on several occasions, and is widely reported by poultry and game farmers. In another instance, a 3–4 week old eaglet was decapitated in the nest at the Horseshoe breeding area in 1989, apparently by a great horned owl.

Interestingly, there are a number of observations of raptors and other birds attempting to enter bald eagle nests containing incubating adults or young. Driscoll (1985) witnessed a red-tailed hawk land on the nest pinnacle at the Redmond breeding area and attempt to enter the nest while the adult male was brooding. The male allowed the hawk to approach within two ft of the nest before spreading his wings and flushing the intruder. At the Cliff and Ive's Wash breeding areas, ravens entered the nest and stole prey items, subsequently delivering the prey to their young (see Sections D4.9 and D4.16). A subadult golden eagle tried to enter the Horseshoe nest in 1990, but was driven off by the adult male (see Section D4.15). A sharp-shinned hawk landed at the Ladders nest in 1986, but was driven away (see Section D4.17).

In addition to birds, interspecific interactions have been recorded with several mammalian species as well. Frazer and Tischendorf (1985) observed some interesting interactions between the eagles and river otters at the East Verde breeding area. On 22 February 1985, the adult male left the nest and attempted to pirate a fish from a river otter feeding on shore. The otter darted forward, then drug the fish back into the water and travelled upstream, while the male returned to the nest. About 40 minutes later, the female returned to the nest. Relieved of his incubation duties, the male flew perch to perch downstream and appeared to be searching for the otter. In a similar instance on 6 March, the adult female flew perch to

perch following a river otter upstream (see Section D4.12). The Ladders eagles have also interacted with river otters (see Section D4.17).

Coyotes have been both the aggressor and on the receiving end of altercations. Hildebrandt (1981) observed a coyote steal a fish from an adult feeding on the river bank. A similar incident was reported at the Fort McDowell breeding area, as well as eagles stealing prey from coyotes (see Section D4.13). Hildebrandt (1981) reported a coyote lunged at a recently fledged juvenile on the ground. In addition, adults eagles have stooped on coyotes at several breeding areas, attempting to drive them away from the nest site. At the Alamo breeding area in 1988, the adults dove on a coyote eight times, striking it twice, and driving it from the nest area (see Section D4.1).

A bobcat climbed the Alamo nest tree on 31 March 1990, although it retreated upon reaching the nest (see Section D4.1). We also observed coyotes, ravens, and turkey vultures interacting with the eagles at cattle carcasses.

Kleptoparasitism (stealing food from other animals) is common among bald eagles. We have observed eagles steal prey from other bald eagles, osprey, turkey vultures, red-tailed hawks, peregrines, common ravens, and great blue herons. In addition, an eagle stole prey from a coyote at the Fort McDowell breeding area (see Section D4.13). In an interesting event at the Alamo breeding area on 23 April 1988, a peregrine flushed a flock of ruddy ducks out of a bay near the eagle nest. The falcon struck a duck, then circled and caught it in mid-air and flew to the west. The adult male bald eagle dove at the falcon, which dropped its prey and perched in a nearby willow. The Alamo adults have also stolen ducks from hunters, picking the downed waterfowl off the reservoir before the hunter's dogs could retrieve the birds. In addition, Arizona bald eagles have taken four raptor species as prey: western screech owl, sharp-shinned hawk, osprey, and turkey vulture. See Section B5 for details on prey species utilized by Arizona bald eagles.

D7.1.2 Intraspecific Interactions

Intraspecific interactions usually involve pursuit, escorting the eagle out of the territory, or aggressive altercations. Many interactions with other bald eagles simply involve escorting the intruder out of the area, although some altercations are aggressive. Chases can be accompanied by stooping, locking talons, cartwheeling, and vocalizations. However, adults have been seen soaring together non-aggressively at several breeding areas (see Sections D4.9, D4.20, and D4.26). The season may influence an adult's reaction to intruders in its territory. The Ladders eagles appeared to allow other eagles in their breeding area during winter (even allowing subadults to feed on carrion near the nest), but became more aggressive after eggs were laid.

In one case, the Fort McDowell adults apparently killed an intruding adult (see Section D4.13), and a similar incident occurred in Florida (Roberts 1985). The reverse has also happened in Arizona, an intruding bald eagle apparently killing one of the resident adults (see Section D4.8, and below). Ron Jackman (BioSystems) also documented a mortality apparently related to an intraspecific altercation in 1990 on the Pit River in northern California. A radio-tagged female was found freshly killed, with puncture wounds in her breast, and a new adult female was courting the male.

Due to the close proximity of the Alamo and Ive's Wash breeding areas (1 km by air), intraspecific interactions are common among the eagles there. In one instance, the two males locked talons in flight, and on another occasion actually plummeted from a perch into Alamo Reservoir, still locked together as

they hit the water. Observed interactions in 1989 totalled 89, about half of which involved the Ive's Wash and other bald eagles (Moller *et al.*. 1989). In 1990, Bock and McLuckie (1990) estimated 116 intraspecific interactions occurred between the Ive's Wash and Alamo eagles. Many of these interactions simply involved perching at territory boundaries and vocalizing. In one interesting interaction, the four Ive's Wash and Alamo adults teamed up to drive a fifth eagle out of the area (Theisfeldt and Linskens 1990). Sweitzer and Moller (1988) noted the Ive's Wash adult male's left eye was swollen shut on 30 April 1988, and was still closed on 13 May. This injury may have been caused by one of the many altercations with ravens or with the Alamo eagles.

At the Redmond breeding area, the adults drove a subadult to the ground where the intruder scurried under a palo verde tree to escape attack (Driscoll 1985). Similarly, the Horse Mesa adults engaged in two interactions which involved stooping and physical contact in 1986. On 16 April 1986, a subadult eagle stooped on the adult female at the nest, knocking her off the nest and dislodging feathers from her back. On 20 April 1986, a subadult (thought to be the same bird) was forced to the ground by both adults. The adults perched above the subadult eagle as it walked off to the west (Driscoll and Buckley 1986).

Many interactions with other bald eagles at the Cibecue breeding area were aggressive (see Section D4.8). In 1987, a near-adult bald eagle entered the territory on 18 April, and attacked the resident female, male, and eaglet over the rest of the nesting season (Carroll and Housser 1987). The adult female was last observed on 18 April, being chased downstream by the near-adult male where he apparently killed her (she was never seen again). 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. On 10 May the eaglet was found dead in the nest, and the near-adult was battling the resident male. On 15 May, the last day of observations, the near-adult was still fighting with the resident male (Carroll and Housser 1987).

At breeding areas where we radio-tagged adults, the pair often interacted with eagles from adjacent breeding areas (Horseshoe and Cliff, Cliff and Bartlett, Pinto and Pinal). In one situation, the Pinal female lost a large portion of her home range to the Pinto female which entered into a polygynous relationship with the Pinal male (see Section D4.22).

Intruding bald eagles also attempted to enter nests with young or incubating adults. Subadult bald eagles tried to land at the Cliff and Ladders nests in 1985 (see Sections D4.9, and D4.17). A subadult bald eagle landed in the Fort McDowell nest tree in 1987, just below the nest where the adult female was incubating, and perched (see Section D4.13). In the case described for Cibecue above, a near-adult entered the nest and attacked the eaglet.

D7.1.3 Summary

Obviously, both interspecific and intraspecific altercations function either in territorial defense or in food acquisition (*e.g.*, kleptoparasitism). Altercations have been documented where the resident adults killed an intruding bald eagle or were killed by an eagle attempting to usurp the breeding area. One intruding near-adult killed an eaglet in the nest (Cibecue 1987). Adult bald eagles in Arizona have also been killed in interactions with golden eagles and peregrines. Bald eagles often steal prey from other species, and less often, prey is taken from the eagles. Observations of bald eagles, as well as other species, attempting to enter or land at bald eagle nests containing young or incubating adults are perplexing, but,

in some cases, were probably food related (*e.g.*, ravens). It is possible that the remaining cases were also involved food, *e.g.*, a resident adult drove an intruder away before it could land and acquire prey from the nest.

D7.2 WILDLIFE SIGHTINGS

While conducting our study on the ecology of bald eagles in Arizona, from 1986–1990, we observed and recorded many interesting species of wildlife. In addition, we have documented many behavioral and ecological traits which may be of interest to biologists working with these animals. Details on wildlife sightings and interactions between bald eagles and other species at each of the 28 known bald eagle breeding areas in Arizona are presented in Section D4. Species of fish observed or sampled in Arizona streams are discussed in Section E2, and data on prey species utilized by bald eagles are presented in Section B5. Fish (as wildlife) are not discussed in the current section, but the most interesting fish observations were razorback suckers taken as prey at the Pinal and Redmond breeding areas.

D7.2.1 Birds

During our field studies in Arizona, we identified 248 species of birds (Table D7.2-1) in incidental sightings. We did not specifically look for birds, and undoubtedly many species (such as vireos, warblers, sparrows, and secretive species) were overlooked. Some species of special interest are described below.

We sighted a red-necked grebe amid rafts of eared and western grebes in Salome Bay on Roosevelt Reservoir in February 1988, representing the second state record for this species. Common loons were also observed on Roosevelt Reservoir, as were tundra swans, Ross' geese, Barrow's goldeneyes, an oldsquaw, and a surf scoter. Horned grebes were seen near Horse Mesa Dam, on Apache Reservoir, in 1986. We sighted American white pelicans on Alamo Reservoir, Roosevelt Reservoir, and Pleasant Reservoir, and brown pelicans on Alamo Reservoir and Firebird Lake. Black-shouldered kites were seen in several breeding areas, and we observed nesting Mississippi kites on the San Pedro River near Dudleyville. Northern goshawks were seen on several occasions at Roosevelt Reservoir in winter, as were short-eared owls. We also observed Harlan's (red-tailed) hawks in several breeding areas, and consistently found one or two birds perched on power poles near the junction of Highway 87 and McDowell Road (near Mesa) each winter. Merlins were another raptor we found mainly during the winter months, but we recorded the birds as late as April. Ospreys and peregrines were commonly seen, and are discussed later in this section.

We found ring-necked pheasants only in the Ladders breeding area, and wild (Merriam's) turkeys only at Ash. Similarly, a purple gallinule was observed only in Humbug Bay at Pleasant Reservoir. However, we also sighted two purple gallinules at Picacho Reservoir (south of Phoenix) in 1987. Sandhill cranes were observed at Roosevelt Reservoir and Horseshoe Reservoir, but only on one occasion each. Wilson's phalaropes were sighted at Redmond and Roosevelt Reservoir. While checking on the Cliff eagles with Tom Gatz (Reclamation) and Robert Mesta (USFWS) we saw a magnolia warbler in a canyon near the nest.

In addition to our sightings, ABENWP personnel also sighted a red-breasted grosbeak at Cibecue, a black-bellied plover and red-breasted merganser at Alamo Reservoir, a pine siskin at Cliff, and a northern shrike, MacGillivray's warbler, hermit warbler, and spotted owl at "76."

Table D7.2-1. Avian species encountered in Arizona bald eagle breeding areas, 1986–1990.*

Common Name	Scientific Name
Common loon	*Gavia immer*
Red-necked grebe	*Podiceps grisegena*
Pied-billed grebe	*Podilymbus podiceps*
Horned grebe	*Podiceps auritus*
Eared grebe	*Podiceps caspicus*
Western grebe	*Aechmophoris occidentalis*
American white pelican	*Pelecanus erythrorhynchos*
Brown pelican	*Pelecanus occidentalis*
Double-crested cormorant	*Phalacrocorax auritus*
American bittern	*Botaurus lentiginosus*
Least bittern	*Ixobrychus exilis*
Great blue heron	*Ardea herodias*
Great egret	*Casmerodius albus*
Snowy egret	*Leucophoyx thula*
Cattle egret	*Bubulcus ibis*
Green-backed heron	*Butorides virescens*
Black-crowned night heron	*Nycticorax nycticorax*
White-faced ibis	*Plegadis chihi*
Tundra swan	*Olor columbianus*
Greater white-fronted goose	*Anser albifrons*
Snow goose	*Chen hyperborea*
Ross' goose	*Chen rossi*
Canada goose	*Branta canadensis*
Wood duck	*Aix sponsa*
Green-winged teal	*Anas carolinensis*
Mallard	*Anas platyrhynchos*
Northern pintail	*Anas acuta*
Blue-winged teal	*Anas discors*
Cinnamon teal	*Anas cyanoptera*
Northern shoveler	*Spatula clypeata*
Gadwall	*Anas strepera*
American wigeon	*Mareca americana*
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Greater scaup	*Aythya marila*
Lesser scaup	*Aythya affinis*
Oldsquaw	*Clangula hyemalis*
Surf scoter	*Melanitta perspicillata*
Common goldeneye	*Bucephala clangula*
Barrow's goldeneye	*Bucephala islandica*
Bufflehead	*Bucephala albeola*

Table D7.2-1. (Page 2 of 6)

Common Name	Scientific Name
Hooded merganser	*Lophodytes cucullatus*
Common merganser	*Mergus merganser*
Ruddy duck	*Oxyura jamaicensis*
Turkey vulture	*Cathartes aura*
Osprey	*Pandion haliaetus*
Black-shouldered kite	*Elanus leucurus*
Mississippi kite	*Ictinia misisippiensis*
Bald eagle	*Haliaeetus leucocephalus*
Northern harrier	*Circus cyaneus*
Sharp-shinned hawk	*Accipiter striatus*
Cooper's hawk	*Accipiter cooperii*
Northern goshawk	*Accipiter gentilis*
Common black hawk	*Buteogallus anthracinus*
Harris' hawk	*Parabuteo unicinctus*
Swainson's hawk	*Buteo swainsoni*
Zone-tailed hawk	*Buteo albonotatus*
Red-tailed hawk	*Buteo jamaicensis*
Harlan's (red-tailed) hawk	*Buteo jamaicensis*
Ferruginous hawk	*Buteo regalis*
Rough-legged hawk	*Buteo lagopus*
Golden eagle	*Aquila chrysaetos*
American kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Peregrine falcon	*Falco peregrinus*
Prairie falcon	*Falco mexicanus*
Ring-necked pheasant	*Phasianus colchicus*
Wild (Merriam's) turkey	*Meleagris gallopavo*
Gambel's quail	*Lophortyx gambelii*
Sora	*Porzana carolina*
Purple gallinule	*Porphyrula martinica*
Common moorhen	*Gallinula chloropus*
American coot	*Fulica americana*
Sandhill crane	*Grus canadensis*
Semipalmated plover	*Charadrius semipalmatus*
Killdeer	*Charadrius vociferous*
Black-necked stilt	*Himantopus mexicanus*
American avocet	*Recurvirostra americana*
Greater yellowlegs	*Totanus melanoleucus*
Lesser yellowlegs	*Totanus flavipes*
Solitary sandpiper	*Tringa solitaria*
Willet	*Catoptrophorus semipalmatus*
Spotted sandpiper	*Actitis macularia*
Long-billed curlew	*Numenius americanus*

Table D7.2-1. (Page 3 of 6)

Common Name	Scientific Name
Western sandpiper	*Ereunetes mauri*
Least sandpiper	*Erolia bairdii*
Long-billed dowitcher	*Limnodromus scolopaceus*
Common snipe	*Capella gallinago*
Wilson's phalarope	*Steganopus tricolor*
Bonaparte's gull	*Larus philadelphia*
Ring-billed gull	*Larus delawarensis*
Herring gull	*Larus argentatus*
Caspian tern	*Hydroprogne caspia*
Forster's tern	*Sterna forsteri*
Rock dove	*Columba livia*
Band-tailed pigeon	*Columba fasciata*
White-winged dove	*Zenaida asiatica*
Mourning dove	*Zenaida macroura*
Inca dove	*Scardafella inca*
Common ground dove	*Columbigallina passerina*
Yellow-billed cuckoo	*Coccyzus americanus*
Greater roadrunner	*Geococcyx californianus*
Common barn owl	*Tyto alba*
Western screech owl	*Otus asio*
Great horned owl	*Bubo virginianus*
Elf owl	*Micrathene whitneyi*
Burrowing owl	*Speotyto cunicularia*
Short-eared owl	*Asio flammeus*
Lesser nighthawk	*Chordeiles acutipennis*
Common nighthawk	*Chordeiles minor*
Common poorwill	*Phalaenoptilus nutallii*
Whip-poor-will	*Caprimulgus vociferus*
White-throated swift	*Aeronautes saxatalis*
Black-chinned hummingbird	*Archilochus alexandri*
Anna's hummingbird	*Calypte anna*
Costa's hummingbird	*Calypte costae*
Broad-tailed hummingbird	*Selasphorus platycercus*
Rufous hummingbird	*Selasphorus rufus*
Belted kingfisher	*Megaceryle alcyon*
Lewis' woodpecker	*Asyndesmus lewis*
Acorn woodpecker	*Melanerpes formicivorus*
Gila woodpecker	*Centurus uropygialis*
Yellow-bellied (red-naped) sapsucker	*Sphyrapicus varius*
Williamson's sapsucker	*Sphyrapicus thyroideus*
Ladder-backed woodpecker	*Dendrocopos scalaris*
Downy woodpecker	*Dendrocopos pubescens*
Hairy woodpecker	*Dendrocopos villosus*

Table D7.2-1. (Page 4 of 6)

Common Name	Scientific Name
Common (red-shafted) flicker	*Colaptes auratus*
Common (gilded) flicker	*Colaptes auratus*
Western wood-pewee	*Contopus sordidulus*
Gray flycatcher	*Empidonax wrightii*
Western flycatcher	*Empidonax difficilis*
Willow flycatcher	*Empidonax traillii*
Black phoebe	*Sayornis nigricans*
Say's phoebe	*Sayornis saya*
Vermillion flycatcher	*Myiodynastes luteiventris*
Ash-throated flycatcher	*Myiarchus cinerascens*
Brown-crested flycatcher	*Myiarchus tyrannulus*
Olivaceous flycatcher	*Myiarchus tuberculifer*
Cassin's kingbird	*Tyrannus vociferans*
Western kingbird	*Tyrannus verticalis*
Eastern kingbird	*Tyrannus tyrannus*
Purple martin	*Progne subis*
Tree swallow	*Iridoprocne bicolor*
Violet-green swallow	*Tachycineta thalassina*
Northern rough-winged swallow	*Stelgidopteryx ruficollis*
Bank swallow	*Riparia riparia*
Cliff swallow	*Petrochelidon pyrrhonota*
Barn swallow	*Hirundo rustica*
Stellar's jay	*Cyanocitta stelleri*
Scrub jay	*Aphelocoma coerulescens*
Pinyon jay	*Gymnorhinus cyanocephalus*
American crow	*Corvus brachyrhynchos*
Common raven	*Corvus corax*
Mountain chickadee	*Parus gambeli*
Bridled titmouse	*Parus wollweberi*
Plain titmouse	*Parus inornatus*
Verdin	*Auriparus flaviceps*
Common bushtit	*Psaltriparus minimus*
Red-breasted nuthatch	*Sitta carolinensis*
White-breasted nuthatch	*Sitta canadensis*
Brown creeper	*Certhia familiaris*
Cactus wren	*Campylorhynchus brunneicapillus*
Rock wren	*Salpinctes obsoletus*
Canyon wren	*Catherpes mexicanus*
Bewick's wren	*Thryomanes bewickii*
Long-billed marsh wren	*Telmatodytes palustris*
American dipper	*Cinclus mexicanus*
Golden-crowned kinglet	*Regulus satrapa*

Table D7.2-1. (Page 5 of 6)

Common Name	Scientific Name
Ruby-crowned kinglet	*Regulus calendula*
Blue-grey gnatcatcher	*Polioptila caerulea*
Black-tailed gnatcatcher	*Polioptila melanura*
Western bluebird	*Sialia mexicana*
Mountain bluebird	*Sialia currucoides*
Townsend's solitaire	*Myadestes townsendi*
American robin	*Turdus migratorius*
Gray catbird	*Dumetella carolinensis*
Northern mockingbird	*Mimus polyglottos*
Sage thrasher	*Oreoscoptes montanus*
Brown thrasher	*Toxostoma rufum*
Bendire's thrasher	*Toxostoma benirei*
Curve-billed thrasher	*Toxostoma curvirostre*
Crissal thrasher	*Toxostoma dorsale*
Water pipit	*Anthus spinoletta*
Phainopepla	*Phainopepla nitens*
Loggerhead shrike	*Lanius ludovicianus*
European starling	*Sturnus vulgaris*
Bell's vireo	*Vireo bellii*
Gray vireo	*Vireo vicinior*
Virginia's warbler	*Vermivora virginiae*
Lucy's warbler	*Vermivora luciae*
Yellow warbler	*Dendroica petechia*
Magnolia warbler	*Dendroica magnolia*
Yellow-rumped (Audubon's) warbler	*Dendroica coronata*
Yellow-rumped (Myrtle) warbler	*Dendroica coronata*
Black-throated gray warbler	*Dendroica nigrescens*
Common yellowthroat	*Geothlypis trichas*
Wilson's warbler	*Wilsonia pusilla*
Painted redstart	*Setophaga picta*
Yellow-breasted chat	*Icteria virens*
Hepatic tanager	*Piranga flava*
Summer tanager	*Piranga rubra*
Western tanager	*Piranga ludoviciana*
Northern cardinal	*Richmondena cardinalis*
Pyrrhuloxia	*Pyrrhuloxia sinuata*
Black-headed grosbeak	*Pheucticus melanocephalus*
Blue grosbeak	*Guiraca caerulea*
Lazuli bunting	*Passerina amoena*
Indigo bunting	*Passerina cyanea*
Green-tailed towhee	*Chlorura chlorura*
Rufous-sided towhee	*Pipilo erythrophthalmus*
Brown (canyon) towhee	*Pipilo fuscus*

Table D7.2-1. (Page 6 of 6)

Common Name	Scientific Name
Abert's towhee	*Pipilo aberti*
Rufous-crowned sparrow	*Aimophila ruficeps*
Chipping sparrow	*Spizella passerina*
Black-chinned sparrow	*Spizella atrogularis*
Vesper sparrow	*Pooecetes gramineus*
Lark sparrow	*Chondestes grammacus*
Black-throated sparrow	*Amphispiza bilineata*
Song sparrow	*Melospiza melodia*
White-throated sparrow	*Zonotrichia albicollis*
White-crowned sparrow	*Zonotrichia leucophrys*
Dark-eyed (Oregon) junco	*Junco oreganus*
Red-winged blackbird	*Agelaius phoeniceus*
Western meadowlark	*Sturnella neglecta*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Brewer's blackbird	*Euphagus cyanocephalus*
Great-tailed grackle	*Quiscalus mexicanus*
Bronzed cowbird	*Tangavius aeneus*
Brown-headed cowbird	*Molothrus ater*
Hooded oriole	*Icterus cucullatus*
Northern (Bullock's) oriole	*Icterus bullockii*
Scott's oriole	*Icterus parisorum*
Purple finch	*Carpodacus purpureus*
Cassin's finch	*Carpodacus cassinii*
House finch	*Carpodacus mexicanus*
Lesser goldfinch	*Carduelis psaltria*
American goldfinch	*Carduelis tristis*
House sparrow	*Passer domesticus*
Additional birds observed by ABENWP personnel	
Red-breasted merganser	*Mergus serrator*
Black-bellied plover	*Squatarola squatarola*
Spotted owl	*Strix occidentalis*
Northern shrike	*Lanius exubitor*
Hermit warbler	*Dendroica occidentalis*
MacGillivray's warbler	*Oporornis tolmiei*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
Lark bunting	*Calamospiza melanocorys*
Pine siskin	*Spinus pinus*

TOTAL SPECIES: 248

* Order follows Checklist of the Birds of Arizona.

Golden eagles were found nesting below Perkinsville on the Verde River, up Salome Creek north of Roosevelt Reservoir, on Squaw Butte at East Verde, in nest 1 at Ladders (1989), in Pinto Creek, and on Black Mesa near the Pinal breeding area. Many other golden eagle nests were found outside Arizona bald eagle breeding areas, and are plotted on a wall map for anyone interested in this species.

Osprey were sighted year-round at the Fort McDowell breeding area on the lower Verde River. In addition, two osprey were seen near a cliff nest on the Verde River (above Cottonwood), in June 1986. Osprey were also commonly sighted at Blue Point, Pinal, Redmond, and Orme in summer and winter months. In one instance, an osprey took one of our bait fish set out for the Orme eagles.

We found peregrine falcons in almost all breeding areas we studied with telemetry, and many others as well. A possible peregrine eyrie was found on the upper Verde River near Perkinsville. In addition, we have seen pairs, and suspect that eyries exist, near Horse Mesa Dam, at Painted Cliffs on Apache Reservoir, near Mormon Flat Dam on Canyon Reservoir, at Alamo Reservoir, near the confluence of Cibecue Creek on the Salt River, near the confluence of the East Verde and Verde rivers, and at the Ladders, Blue Point, and Pinal breeding areas. See Section D4 for details on peregrine falcon sightings at individual bald eagle breeding areas.

We observed a pair of wood ducks in the Horseshoe breeding area each year of our study, even in spring and summer. In 1988, these birds continually flew in and out of a hole in the nest cliff on Chalk Mountain. Although wood ducks are not known to nest in this area, these observations indicate the species may be expanding its nesting range.

D7.2.1.1 Raptors Feeding on Fish. Raptors eat a variety of prey, and occasionally take unusual species. While conducting bald eagle research in Arizona, we observed Harris' hawks and red-tailed hawks, which primarily eat mammalian prey, feeding on or capturing fish. Jakle and Gatz (1984) first reported Harris' hawks feeding on fish in Arizona. In addition, Devine and Stevens (1985) found a great horned owl feeding on a sucker in Connecticut. We observed three Harris' hawks feeding on carrion carp on 11 March 1987 (at the Fort McDowell breeding area), on the lower Verde River. In an interesting event on 14 July 1987, we saw a Harris' hawk aggressively confront a turkey vulture at a carrion carp along the shores of Saguaro Reservoir (in the Blue Point breeding area). The Harris' hawk fed on the fish after successfully displacing the turkey vulture. In a similar incident, we recorded a Harris' hawk displacing a turkey vulture at (then feeding from) a carrion carp on the lower Salt River (in the Orme breeding area) on 14 March 1988. We also witnessed a Harris' hawk take a carrion bass off the water on the lower Salt River (Orme breeding area) on 16 December 1987. The hawk flew a short distance to a sandbar, where it was joined by a second Harris' hawk, both of which fed on the fish. In addition, we observed eight Harris' hawks feeding on (and ripping apart) a carrion American coot on the lower Salt River (Orme breeding area) on 14 December 1987.

In another interesting case, we observed a red-tailed hawk carrying a largemouth bass over School House Point at Roosevelt Reservoir in February 1987. In this same area (near Cougar Point), we photographed a one-legged common black hawk feeding on carrion largemouth bass in January 1989. The black hawk was able to perch and fly with no apparent problems. About 3/4 of the bird's right tarsus was missing. Another raptor species, the northern harrier, caught a sucker on 13 March 1990 on the lower Salt River (Orme breeding area) (Fawcett *et al.* 1990).

D7.2.1.2 Great Blue Heron Rookeries. During our studies of the Arizona bald eagle, we recorded the presence of 14 great blue heron rookeries within breeding areas. On the upper Verde River, we found a great blue heron rookery immediately adjacent to the Perkinsville bald eagle nest. In an interesting observation, we witnessed a green-backed heron sitting in, and flushing from, a nest in a cottonwood tree, across the river from the Perkinsville great blue heron rookery in June 1986. Continuing down the Verde, we found great blue heron rookeries at the confluence of West Clear Creek (Ladders breeding area), upstream of Chalk Mountain (Horseshoe breeding area), near the river ford below Horseshoe Dam (Cliff breeding area), and upstream and downstream of the Fort McDowell bald eagle nest (No. 11).

On the Salt River, we found great blue heron rookeries at the confluence of Cave Creek (Lone Pine breeding area), in the same cottonwood grove as the Pinto eagle nest, upstream of the USFS Blue Point Ranger Station (Blue Point breeding area), and in the same grove as the Orme eagle nest. Great blue heron rookeries were also found on Tonto Creek, between A-Cross road and Roosevelt Reservoir, near the Santa Maria and Big Sandy River confluence (Chino/Alamo breeding area), near the Alamo nest trees on Alamo Reservoir (where double-crested cormorants also nest), and downstream of the Pleasant nest cliff on the Agua Fria River. In addition, a possible black-crowned night heron rookery exists on Salome Creek, above A-Cross road. Bald eagle nests have been built on top of great blue heron nests at the Orme, Cliff, and Pinto breeding areas (see Section C2.2).

D7.2.2 Mammals

During our field studies in Arizona, we identified 36 species of mammals within bald eagle breeding areas (Table D7.2-2) in incidental sightings. We did not specifically look for mammals, and undoubtedly many species (such as mice and other small mammals) were overlooked. Some species of special interest are described below.

We recorded river otters, dens, and scat on the Verde River from the Ladders breeding area (near Camp Verde) to the East Verde breeding area (near the confluence of the East Verde River). A large species of bat (the size of a mourning dove), which the local ranchers call a "cow bat", was sighted on several occasions in the Redmond and Bartlett breeding areas. Black (cinnamon) bears were seen at Redmond, Cibecue, Canyon, Cedar Basin, and Lone Pine. In addition, ABENWP personnel sighted a black bear at the Fort McDowell breeding area (B. Bock, pers. comm.). We found coatis at Saguaro Reservoir (Blue Point breeding area), Redmond, Pinal, and Coolidge. Beaver were seen in almost every bald eagle breeding area in Arizona, and beaver sign was found over much of the Salt and Verde rivers. Porcupines were observed in several breeding areas, as well as along the highways in the low desert, and seemed to be out of the realm of their normal habitat. We only saw pronghorn antelope on the high mesas near Sunset Peak along Highway 17. However, ABENWP personnel found these animals near the Perkinsville breeding area. Wapiti (elk) was recovered as a prey remain from the Lone Pine breeding area, but were only sighted above the Mogollion Rim. Feral burros were observed at the Ive's Wash breeding area. Desert bighorn sheep, some of which were wearing radio-collars, were seen at the Horse Mesa breeding area. In one interesting observation, these sheep were seen crossing the top of Horse Mesa Dam (Driscoll, unpublished field notes).

We had a few close encounters with mountain lions while attempting to capture adult bald eagles in Arizona. In the Bartlett breeding area, we had an interesting meeting with a mountain lion just before midnight on 21 January 1988. We forded the Verde River, between the nest pinnacle and the USGS gaging station, after examining potential capture sites downstream. We stopped on the north bank to put our boots on and had been talking for about five minutes. When we started hiking back to camp, we

Table D7.2-2. Mammalian species encountered in Arizona bald eagle breeding areas, 1986-1990.

Common Name	Scientific Name
Mouse	*Peromyscus* sp.
Banner-tailed kangaroo rat	*Dipodomys spectabilis*
Hispid cotton rat	*Sigmodon hispidus*
Woodrat (packrat)	*Neotoma* sp.
Cliff chipmunk	*Eutamias dorsalis*
Harris' (Yuma antelope) squirrel	*Ammospermophilus harrisii*
Round-tailed ground squirrel	*Spermophilus tereticaudus*
Rock squirrel	*Spermophilus variegatus*
Western pipistrelle	*Pipistrellus hesperus*
Large bat (size of a mourning dove—ranchers call them cow bats)	*Myotis* sp.
Desert cottontail	*Sylvilagus auduboni*
Eastern cottontail	*Sylvilagus floridanus*
Blacktail jackrabbit	*Lepus californicus*
Striped skunk	*Mephitis mephitis*
Hooded skunk	*Mephitis macroura*
Hog-nosed skunk	*Conepatus mesoleucus*
Spotted skunk	*Spilogale gracilis*
Raccoon	*Procyon lotor*
Ringtail	*Bassariscus astutus*
Coati	*Nasua nasua*
Muskrat	*Ondatra zibethicus*
Beaver	*Castor canadensis*
River otter	*Lutra canadensis*
Collared peccary (javelina)	*Tayassu tajacu*
Grey fox	*Urocyon cinereoargenteus*
Coyote	*Canis latrans*
Bobcat	*Felis rufus*
Mountain lion	*Felis concolor*
Black (cinnamon) bear	*Ursus americanus*
Pronghorn antelope	*Antilocapra americana*
Desert bighorn sheep	*Ovis canadensis*
Mule Deer	*Odocoileus hemionus*
White-tailed deer	*Odocoileus virginianus*
Wapiti (American elk)	*Cervus elaphus*
Feral burro	*Equus asinus*
Cow	*Bovus* sp.

spotted a mountain lion about 20 m away, watching us from a small boulder. A stare-down ensued for about 15 seconds, then the lion sprang up the slope without making a sound. The cat stopped twice to look back at us, then vanished into the night.

We had several interesting encounters with mountain lions while attempting to capture the Ladders adults for banding and telemetry purposes. On 1 February 1989, a lion visited our camp site and proceeded to dig us out of our tents. Awakened by the rustle and snorting, we turned on our lights and the lion quickly departed. Upon closer inspection the next day, we found the lion had examined our camp thoroughly (tracks all over camp), and dug a depression under one tent (near a biologists head), removing the ground cloth. Mountain lions entered two other camps we had in the same region in January and February 1989, scrutinized our presence and gear, then departed.

In addition, we spotted a small cat on the upper Verde River in June 1986. The cat seemed too small for a mountain lion, yet had a long tail. The feline disappeared into the brush before we could make a positive identification, but the cat was probably a small lion. We also heard lions calling from above the Horseshoe nest cliff, and sighted the cats at Redmond.

D7.2.3 Herptiles and Others

From 1986–1990, we identified 40 species of herptiles within bald eagle breeding areas (Table D7.2-3). These only represent incidental sightings, since we did not specifically look for herptiles, and undoubtedly many species were overlooked. In one memorable event, an Arizona coral snake slid across the trail as we hiked down from the Redmond observation mountain. The snake crawled under a rock and caught (or bit) a mouse. Half of the snake was still in the trail, and we could hear the mouse squealing from beneath the rock. Rattlesnakes were frequently encountered as we hiked endless miles of desert tracking the bald eagles, usually with our eyes on the air instead of the ground. Although nobody was bitten, many of our late night hikes to trapping sites or distant observation points were interrupted by rattling. This was especially true in hot summer periods, when the snakes were more active at night.

We encountered numerous scorpions, tarantulas, millipedes, and giant centipedes. Tarantulas are actually very docile animals, and do not seem to mind crawling on humans, as long as the person doesn't make any quick movements. Giant centipedes, however, move very fast, have large mandibles, and do not lend themselves to handling. On one occasion, while sleeping, a BioSystems biologist was bitten in the face (through a wool blanket) by a giant centipede.

Table D7.2-3. Herptile species encountered in Arizona bald eagle breeding areas, 1986-1990.

Common Name	Scientific Name
Canyon tree frog	*Hyla arenicolor*
Arizona tree frog	*Hyla wrightorum*
Bullfrog	*Rana catesbeiana*
Leopard frog	*Rana pipiens*
Arizona toad	*Bufo microscaphus*
Great plains toad	*Bufo cognatus*
Red-spotted toad	*Bufo punctatus*
Tree lizard	*Urosaurus ornatus*
Side-blotched lizard	*Uta stansburiana*
Zebra-tailed lizard	*Callisaurus draconoides*
Greater earless lizard	*Holbrookia texana*
Mountain short-horned lizard	*Phrynosoma douglassi*
Desert short-horned lizard	*Phrynosoma platyrhinos*
Regal horned lizard	*Phrynosoma solare*
Great plains skink	*Eumeces obsoletus*
Western whiptail	*Cnemidophorus tigris*
Collared lizard	*Crotaphytus collaris*
Desert spiny lizard	*Sceloporus magister*
Chuckwalla	*Sauromalus obesus*
Gila monster	*Heloderma suspectum*
Glossy snake	*Arizona elegans*
Western ground snake	*Sonora semiannulata*
Sonora gopher snake	*Pituophis melanoleucus*
Western black-necked garter snake	*Thamnophis cyrtopsis*
Mexican garter snake	*Thamnophis eques*
Checkered garter snake	*Thamnophis marcianus*
Common kingsnake	*Lampropeltis getulus*
Sonora whipsnake	*Masticophis bilineatus*
Red racer (coachwhip)	*Masticophis flagellum*
Long-nosed snake	*Rhinocheilus lecontei*
Desert patch-nosed snake	*Salvadora hexalepis*
Rosy boa	*Lichanura trivirgata*
Arizona coral snake	*Micruroides euryxanthus*
Western diamondback rattlesnake	*Crotalus atrox*
Black-tailed rattlesnake	*Crotalus molossus*
Mojave rattlesnake	*Crotalus scutulatus*
Western (prairie) rattlesnake	*Crotalus viridis viridis*
Spiny softshell turtle	*Trionyx spiniferus*
Sonoran mud turtle	*Kinosternon sonoriense*
Desert tortoise	*Gopherus agassizi*

D8 PERSONAL COMMUNICATION

Alamo	Robert Hall, U.S. Bureau of Land Management, Kingman, Arizona
Ash	Mrs. Earl Jackson, Globe, Arizona Dugger Hughes, U.S. Forest Service, Globe Ranger District, Globe, Arizona
Bartlett	Don Pollock, U.S. Forest Service, Cave Creek Ranger District, Cave Creek, Arizona
Chino	Robert Hall, U.S. Bureau of Land Management, Kingman, Arizona
Devil's Post	Tim Tibbitts, Arizona Game and Fish Department, Phoenix, Arizona, interview with Jim Higgs (AGF)
East Verde	Charlie Swaboda, L.F. Ranch
Fort McDowell	Chief Haiawatha Hood, Fort McDowell Indian Tribe
Horse Mesa	Gene Gibbons, Salt River Project, Phoenix, Arizona
Horseshoe	Don Pollock, U.S. Forest Service, Cave Creek Ranger District, Cave Creek, Arizona
Ladders	Doug MacPhee, U.S. Forest Service, Verde Ranger District, Camp Verde, Arizona
Orme	Water Treatment Plant Operators, Salt River Indian Tribe
"76"	Robert Mesta, U.S. Fish and Wildlife Service, Phoenix, Arizona, interview with Troy Neal, "76" Ranch
All Sites	Duane Rubink, U.S. Fish and Wildlife Service, Phoenix, Arizona
All Sites	Robert Mesta, U.S. Fish and Wildlife Service, Phoenix, Arizona
All Sites	Larry Forbis, U.S. Forest Service, Phoenix, Arizona
All Sites	Teryl Grubb, U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Tempe, Arizona
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ECOLOGY OF BALD EAGLES IN ARIZONA

Part E

SPECIAL REPORTS AND APPENDICES

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TABLE OF CONTENTS

E1 HISTORY OF ARIZONA PREY FISH POPULATIONS E-1
E1.1 Early Habitats E-1
E1.2 Endemic Fish Populations E-2
E1.3 Habitat Changes E-4
E1.4 Changes in Fish Communities E-5
E1.5 Summary E-8

E2 PRESENT FISH COMMUNITIES IN CENTRAL ARIZONA RIVERS AND RESERVOIRS E-9
E2.1 Upper Salt River (Km 256–110) E-9
E2.2 Salt River Reservoirs E-9
E2.3 Lower Salt River (Km 21.8–0.0) E-11
E2.4 Upper Verde River E-11
E2.5 Horseshoe Reservoir E-11
E2.6 Middle Verde River E-13
E2.7 Bartlett Reservoir E-15
E2.8 Lower Verde River E-15
E2.9 East Verde River E-16

E3 LIFE HISTORIES OF BALD EAGLE PREY SPECIES IN ARIZONA E-18
E3.1 Native Fish E-18
E3.2 Introduced Fish E-39
E3.3 Mammals E-61
E3.4 Birds E-62

E4 DDE AND PCB'S IN UNHATCHED EGGS OF ARIZONA BALD EAGLES: AN ASSESSMENT OF POSSIBLE EFFECTS ON PRODUCTIVITY E-65

E5 ULTRASTRUCTURE OF BALD EAGLE EGGSHELLS FROM ARIZONA AND ITS RELATIONSHIP TO EGG QUALITY E-73
E5.1 Methods E-75
E5.2 Results and Discussion E-76
E5.3 Summary E-82

E6 AN ANALYSIS OF BALD EAGLE POPULATION GENETICS USING DNA FINGERPRINTING E-96
E6.1 Introduction E-96
E6.2 Materials and Methods E-97
E6.3 Results and Discussion E-99
E6.4 Conclusions E-101
E6.4 Summary E-103
E6.5 Acknowledgments E-104

TABLE OF CONTENTS (Cont.)

E7 ENZYME GENETICS OF BALD EAGLES IN ARIZONA E-105
E7.1 Introduction E-105
E7.2 Materials and Methods E-106
E7.3 Results E-106
E7.4 Discussion E-108

E8 METHODS FOR STUDYING EAGLES E-111
E8.1 Eagle Observations E-111
E8.2 Banding and Telemetry E-120
E8.3 Studies at Nesting Territories E-147
E8.4 Analysis of Tracking Data E-176
E8.5 General Methods for Studying Fisheries E-179

E9 SPECIES LIST E-188

LIST OF TABLES

Table E2-1. Relative abundance of potential eagle prey fish in the Upper Salt River E-10
Table E2-2. Relative abundance of potential eagle prey fish in lakes on the Salt River E-12
Table E2-3. Relative abundance of potential eagle prey fish in the Lower Salt River E-13
Table E2-4. Relative abundance of potential eagle prey fish in the Verde River E-14
Table E2-5. Relative abundance of potential eagle prey fish in Verde River reservoirs E-15
Table E2-6. Relative abundance of potential eagle prey fish in East Verde River E-17
Table E4-1. Productivity of all known and documented bald eagle nesting sites in Arizona, 1987–1989. Young fledged per occupied nest E-65
Table E4-2. Productivity of breeding areas of Arizona bald eagles over 1985–1989 from which an unhatched egg was taken for analysis E-68
Table E4-3. DDE and PCBs in eggs of Arizona bald eagles. Parts per million of the lipid weights E-71
Table E5-1. Thickness of bald eagle eggshells and percent thinning from pre-DDT mean thickness of 0.591 mm E-77
Table E5-2. Number of basal caps and percent of surface area covered by "holes" for whole eggshells from Arizona E-80
Table E6-1. The average number of restriction fragments per individual for all populations from the three restriction enzymes and probes evaluated in this study E-100
Table E6-2. Intra-population similarity coefficients *x* (Jeffreys *et al.*, 1985) E-100
Table E6-3. Interpopulation similarity coefficients (Jeffreys *et al.*, 1985), for two enzyme/probe systems E-103

LIST OF TABLES (cont.)

Table E6-4. Average Percentage Difference (APD) Matrix (Gilbert *et al.* 1990) between four Eagle populations using HaeIII/M13, HinfI/M13 and HinfI/33.6 enzyme/ probe combinations (in that order) E-104
Table E7-1. Nei's genetic distance E-109
Table E7-2. The genetic distance between different taxonomic levels E-110
Table E8-1. Blood samples collected from Arizona bald eagles in 1987 . . . . . E-130
Table E8-2. Blood samples collected from Southwest bald eagles in 1988 . . . . . E-131
Table E8-3. Blood samples collected from Southwest bald eagles in 1989 . . . . . E-132
Table E8-4. Feather samples collected from Arizona bald eagles in 1987 . . . . . E-134
Table E8-5. Feather samples collected from Southwest bald eagles in 1988 . . . . . E-135
Table E8-6. Feather samples collected from Southwest bald eagles in 1989 . . . . . E-136
Table E8-7. Eggshell fragments collected from Arizona bald eagle nests, 1986–1990 . . . . . E-169
Table E8-8. Whole eggs collected at Arizona bald eagle breeding areas, 1986–1990 . . . . . E-170
Table E8-9. Aquatic habitat type definitions used in stream surveys E-183

LIST OF FIGURES

Figure E4-1. Productivity vs. DDE content for Arizona bald eagle eggs (●) compared to curve derived by Wiemeyer *et al.* (1984) for productivity vs. DDE relationships among a larger sample of North American bald eagle nest sites. E-67
Figure E5-1. The avian female reproductive tract, from Taylor (1980) E-74
Figure E5-2. Layers of the avian eggshell, from Becking (1975) E-74
Figure E6-1. Autoradiograms from the three enzyme/probe systems used in this investigation E-98
Figure E6-2. UPGMA clustering analysis of the mean similarity coefficients given in Table E6-3 . . . . . E-102
Figure E7-1. Geographic variation in allele frequencies. Allele frequencies for six enzyme polymorphisms as revealed by electrophoresis E-107
Figure E7-2. Isozyme frequencies in the Arizona bald eagle population E-108
Figure E8-1. Bald eagle observation form—"ObsForm" E-112
Figure E8-2. Diagram of visual Identification (VID) band used on Arizona bald eagles. Each band is engraved with a unique symbol E-121
Figure E8-3. Juvenile bald eagle data form—"JuvForm" E-123
Figure E8-4. Bald eagle capture form—"CapForm" E-137
Figure E8-5. Observation form for tracking migrating eagles by airplane E-147
Figure E8-6. Bald eagle prey delivery and identification form E-150
Figure E8-7. Characteristics used to identify fish species taken by bald eagles in Arizona E-151
Figure E8-8. Bald eagle forage form E-164
Figure E8-9. Bald eagle nest form—"NestForm" E-171
Figure E8-10. Bald eagle habitat mapping form—"HabForm" E-174
Figure E8-11. Aquatic habitat survey form for Arizona streams E-182

LIST OF PLATES

Plate E1. Cross-section of a bald eagle eggshell from Sheep territory, 1987 . . . . . E-83
Plate E2. Cross-section of a bald eagle eggshell from Pinal territory, 1987, showing the numerous clefts (cl) in the outer palisade layer E-84
Plate E3. Cross-section of a bald eagle eggshell from Chino territory, 1987, showing a pore channel (pc) that branches. Outside of shell indicated by arrow E-84
Plate E4. Cross-sections of bald eagle eggshells from Cliff territory in 1989 . . . . . E-85
Plate E5. Inside of bald eagle eggshells with membranes removed E-86
Plate E6. Inside of a bald eagle eggshell from Cliff territory, 1989, with membranes removed E-87
Plate E7. Outside of a bald eagle eggshell from Horseshoe territory, 1989, showing the tiny pits (pi) on the surface of the egg E-87
Plate E8. Bald eagle eggshell from Cool Springs territory, Plumas County, California, 1987, which is 31% thinner than the pre-DDT historical thickness of eggshells from this region (Anderson and Hickey 1972) E-88
Plate E9. Bald eagle eggshell from Rocky Point territory, Plumas County, California, 1986 . . . . . E-89
Plate E10. Bald eagle eggshell from Santa Catalina Island, California, 1990 . . . . . E-90
Plate E11. Cross-sections of bald eagle eggshells from Arizona E-91
Plate E12. Cross-section of a bald eagle eggshell from Pinal, 1987, showing vesicular holes (v) that occur through the calcified layers of the shell. Outside of shell indicated by arrow E-92
Plate E13. View of the outer surface of outer eggshell membrane (om) of bald eagle egg from Cedar Basin territory, 1989, showing organic cores (oc) which are the nucleation sites for calcite crystallization E-92
Plate E14. Cross-sections of bald eagle eggshell from Cliff territory, 1989 . . . . . E-93
Plate E15. Inside of bald eagle eggshell from Cliff territory, 1989 . . . . . E-94
Plate E16. Inside of bald eagle eggshell from Cedar Basin territory, 1989, after partial decalcification in HCl, showing large bump that remains (b) E-95
Plate E17. Cross-section of bald eagle eggshell from Cliff territory, 1989, showing the numerous fibers (fb) by which the bumps are attached to the calcified layer. Outside of shell indicated by arrow E-95
Plate E18. Ron Jackman with the East Verde male bald eagle just before release, March 1987 (photo by D. Driscoll) E-127
Plate E19. Trish Carroll observing the Horseshoe nest from across the river (photo by T. Gatz) E-141
Plate E20. Robin Hunter recording prey deliveries at Willow Springs Canyon (Blue Point) nest (photo by P. Carroll) E-148
Plate E21. Frank Hein observing the nest cliff at Horseshoe breeding area (photo by P. Becker) E-148
Plate E22. Paula Becker collecting prey remains at Horseshoe (photo by F. Hein) E-160
Plate E23. Robin Hunter recording prey deliveries at Ladders breeding area (photo by P. Carroll) E-162
Plate E24. Daniel Driscoll preparing to descend to the Redmond nest, May 1988 (photo by T. Gatz) E-173

LIST OF PLATES (cont.)

Plate E25. Jack Barclay monitoring post-fledging juvenile bald eagles at the Orme breeding area, May 1987 (photo by T. Gatz) E-178
Plate E26. Robin Hunter and Grainger Hunt recording home range and foraging data at the Horseshoe breeding area (photo by T. Gatz) E-178
Plate E27. Ed Bianchi and Jeff Simms seining fish on the lower Verde River (photo by P. Becker) E-179
Plate E28. Frank Hein and "Woodie" at Horseshoe (photo by P. Becker) E-186

E1 HISTORY OF ARIZONA PREY FISH POPULATIONS

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For the bald eagle, today's Arizona is much different than that of a century or so ago. Reports from early Anglo-American settlers describe a landscape with far more riparian environment, more extensive waterways, a greater diversity of aquatic habitats, and a different prey base. If bald eagles did nest in the same areas of Arizona prehistorically as they do today, they have survived immense changes.

Knowledge of the extent to which bald eagles nested in Arizona prior to this century is limited to one historical report of a nest at Stoneman Lake (one of the very few natural lakes in Arizona)(Mearns 1890), and general references to nests at unspecified locations in the White Mountains (Henshaw 1875). It is nevertheless interesting to speculate on the question of how the current population might compare in size and distribution with that of pre-Anglo times. The key to such insight lies in largely exploring the character of pristine food supplies for bald eagles, namely fish populations. We approach the question by: (1) exploring the character of the original habitat (see Section D2.6 for details); (2) examining what is known of the original fish fauna that might have been suitable as bald eagle prey; and (3) viewing the ways in which habitat changes may have caused the observed transformation of fish communities.

E1.1 EARLY HABITATS

Early travelers through the Gila basin often noted in their journals the presence of cottonwood and willow trees (Davis 1982). Cottonwoods fringed much of the Gila River but were less prevalent from the Pima Village (15–20 mi. upstream from the Salt) to the Colorado River (op. cit.). The Lower Colorado River, including and below its confluence with the Gila, was primarily forested with cottonwood in 6–12-mi.-wide bottoms. In southeastern Arizona, smaller watercourses were often reported as marshy, with few large trees, and were open and unchannelled (Hastings and Turner 1965). The Verde River near Perkinsville was described to Minckley and Alger (1968) by a knowledgeable local resident: "... the river flowed slowly, impeded by many beaver dams, and extensive marshes occupied the flood plains. Here cottonwood and other large trees were uncommon as was mesquite, and the dominant tree was desert willow on the terraces and along tributary washes."

Fur trappers, traveling through what today is Arizona, were the first to leave records of wildlife occurrence (Davis 1982). From them we learn that beaver were abundant in both high mountain and low desert streams of the Gila and Colorado rivers; both the Verde and Salt rivers also had beaver populations (Davis op. cit.). In 1830, a single party smuggled into the U.S. an estimated 1500 beaver pelts from the Gila River drainage, then claimed by Mexico.

Beaver dams created pools and ponds along Arizona's watercourses, features that today have all but vanished; travelers encountered small lakes and ponds along the Gila River where now there are none. The portion of the Gila below the Salt River reportedly had overflowed, creating lakes, ponds, and lagoons, and reports of ducks, geese, and brant (probably old name for Canada geese, genus *Branta*; "geese" probably referred to snow geese) were common in the area. Beaver were said to thrive wherever

there were sufficient stands of cottonwood, willow, and other riparian trees and shrubs (Davis 1982). Otter were also present in the Gila but were evidently rare compared to beaver.

E1.2 ENDEMIC FISH POPULATIONS

The prehistorical and historical records indicate that both the aboriginal people of Arizona and later the "pioneers" found fish abundant enough to supplement their diet. Records from the latter support the contention that fish resources were abundant in many of the regions of the state in which they traveled.

The use of fish by native Americans in Arizona indicates that at least in certain locations, fish were abundant enough to become an important part of their food base and culture. The Colorado River basin once supported an endemic assemblage of fishes first utilized as a resource by Indians and later by American travelers and settlers. Aboriginal people inhabiting a pueblo near Perkinsville in Yavapai County between 1300 and 1400 A.D. utilized five fish species: Sonora sucker, desert sucker, razorback sucker, roundtail chub, and Colorado squawfish (Minckley and Alger 1968). Researchers discovered the remains of razorback sucker, humpback chub, and Colorado squawfish in Catclaw Cave, located along the Colorado River, Mohave county (Miller 1955). Another Indian village called Snaketown (300 B.C.–1400 A.D.), in Maricopa and Pinal counties, contained fish remains possibly from razorback sucker and Colorado squawfish (op. cit.). Along the San Pedro River in Cochise County, the Indian site Quiburi contained remains of razorback sucker and Colorado squawfish in a trash heap dating 1704–1763 A.D. (op. cit.). The Maricopa, who occupied the lower Colorado and Gila rivers, dried and stored fish for later consumption (Rostlund 1952). According to Haase (1972), the Pima, Yuma, and Maricopa were described as fishermen who used nets and other tackle year-round to sustain themselves on an abundance of fish.

Davis (1882) reports on fish abundances from accounts of the first Anglo-American travelers as they moved through and settled in the region during 1824–1865. The Gila River, in what is now Gila National Forest, New Mexico, was described by a fur trapper as "a creek full of fish." Further downstream at the Arizona–New Mexico border, travelers reported that they caught enough fish for all for both supper and breakfast. The largest of these weighed 30 pounds and measured four in. between the eyes (probably a squawfish). Fish were described as abundant on parts of the San Pedro River. On the Gila near the Pima Villages (often a stopping place for travelers), fish resembling "... buffalo fish of the Mississippi ..." (razorback suckers) were caught by herding. Further downstream where the Salt meets the Gila a party reported that many fish were seen in clear water.

On Ash Creek where it meets the Agua Fria River, a party in search of Apache crossed "innumerable beaver dams" and caught some fish of the "... same species as are found in the Colorado and Gila." At the confluence of the Salt River with Tonto Creek, the same party caught 200 fish with a "willow drag;" fish weighing from 10–20 pounds (probably squawfish) were reportedly captured. At Grapevine Springs, four to five hauls with a "willow drag" produced 50 suckers. For the next five or six days about half the party's subsistence was supplied by fish they had caught. A note of disappointment was written concerning the party's inability to catch the larger fish weighing from 10–40 pounds. Another party described Eagle Creek as having plenty of fish. Davis (op. cit.) summarizes by saying that fish in the Gila drainage were usually described as abundant.

There is further evidence of a wealth of native fishes even after the turn of the century. Minckley (1973) interviewed "old timers" from the Phoenix valley who attested that bonytail chub, roundtail chub, Colorado squawfish, and razorback suckers were very abundant in canals fed by the Gila, Salt and Verde rivers during the early 1900s. Like the harvest along the lower Colorado River (Miller 1961), fish were gathered in such numbers that they filled wagon boxes. They were used for human consumption, feed for domestic animals, and fertilizer. Commercial fishermen worked the lower Salt River, selling squawfish and razorback suckers in nearby towns to construction workers building dams on the river (Minckley 1973). Razorback suckers also had a commercial market in Tombstone in the 1880s (Hendrickson and Minckley 1985).

Since we know practically nothing about bald eagle distribution and foraging habits prior to human alteration of Arizona's indigenous fish fauna, we can only speculate on the significance of each historically important fish species to bald eagles. Seven species large enough for bald eagle prey occurred throughout Arizona's larger water courses: Colorado squawfish, bonytail chub, roundtail chub, razorback sucker, flannelmouth sucker, Sonora sucker, and desert sucker. The life histories summarized here give us some insight on the potential historic prey base (see Section E3 for life histories in more detail).

Adult Colorado squawfish occupy water too deep for eagle attack even when the fish are spawning (*see* Section E3 for details). However, juvenile squawfish up to 8 in. in length often occupy shallow backwaters and would be vulnerable to eagle predation. Subadults are vulnerable at times while feeding or basking near the surface. The large size of the adults preclude capture, but historically probably provide important scavenging opportunities.

The razorback sucker, in contrast to the squawfish, frequents marshes, lakes and quieter parts of rivers. In riverine environments, adult razorbacks occasionally move into shallow areas where they are available to eagles. This vulnerability would increase during spawning, when razorbacks sometimes use water only 0.3 m deep. In reservoirs, populations tend to enter shallow riverine areas only during their spawning season. Razorback suckers, reintroduced into the Salt River, have recently appeared as prey remains in two bald eagle nests (Pinal and Redmond), although whether the fish were taken alive or as carrion is unknown.

Roundtail chub prefer deep, shaded pools, especially with some overhanging cover. There is no evidence that spawning occurs in water shallow enough for eagle attack, except possibly in small creeks. To our knowledge no roundtail chub have been found as prey remains in bald eagle nests, even though the species is widely distributed in the Salt and Verde rivers (see Sections E2 and E3).

Little is known about the bonytail chub. It reportedly occurs in the main channels of larger rivers, usually downstream of roundtail chub. This fish is usually found too deep for capture by eagles.

The flannelmouth sucker occupies pools and deeper runs but it is collected in water only an inch deep. This species may have been available on a regular basis. It is uncertain if spawning creates conditions of increased availability. We do not know if spawning increased vulnerability to eagle predation.

The Sonora sucker is generally a pool dweller that may move into runs at night. This fish may be infrequently available except when feeding at mid-depths and occasionally on the surface. When

spawning in shallow riffles, vulnerability is increased. Sonora suckers are currently fed upon by bald eagles in Arizona as frequently evidenced in prey remains and observations.

There is very little literature on the desert sucker, but it was heavily utilized by bald eagles during this study. We found that a number of its habits rendered it vulnerable to bald eagles. Its tendency to feed on the surface of large rocks often brings it within striking depth of eagles as does its spawning in shallow runs and riffles.

Some of these eight endemic species become available to eagles as carrion resulting from spawning mortality. In our studies of bald eagles in California we found that post-spawning die-offs of Sacramento sucker provided a significant portion of the diet during the eagles' breeding season. Post-spawning mortality of salmon is of course a critical food source for eagles using western habitats. Seasonal mortality among the Arizona endemics also resulted from stranding and low oxygenation associated with highly variable flows of the desert rivers.

E1.3 HABITAT CHANGES

Arizona's waterways and aquatic ecosystems have undergone dramatic changes in recent decades. The U.S. Fish and Wildlife Service (Brinson *et al.* 1981) estimate the loss of riparian habitat in the United States to average 70 percent and as much as 95 percent in some areas. Unfortunately, there is no comprehensive inventory of loss specific to Arizona (R. R. Johnson, pers. comm.). Much of Arizona's original floodplain forests are now converted to urban areas or cultivated agricultural land. The lower Gila River for 250 mi. below Florence, Arizona has, for the most part, been de-watered due to damming and diversion (Miller 1961, Minckley 1985). Much of the remaining riparian habitat is dominated by saltcedar (tamarisk)(Haase 1972), an invader that has replaced about 400,000 hectares of native vegetation in the western states. This exotic has very limited value to most wildlife (Brinson *et al.* 1981) and apparently none to bald eagles due primarily to its dense growth form.

Arizona, although one of the nation's largest states, ranks relatively low among them in the overall amount of perennial stream that can support a fishery (Brinson *et al.* 1981). Despite this, large metropolitan areas continue to consume water at rates above the national average and to contest rural areas for control and transfer of their water supplies, further jeopardizing existing riparian communities. Along the Colorado River, riparian vegetation is disappearing at a rate of 1200 hectares per year, and pure cottonwood communities have declined from an estimated 2000 to 200 hectares as a result of altered hydrologic regimes, impoundment, and agriculture (Brinson *et al.* 1981).

These losses of aquatic and riparian ecosystems apparently began with the influx of Anglo-American settlement in Arizona. Impacts by the aboriginal, Spanish-, and Mexican-dominated occupations of Arizona appear minimal in the light of the historical record (Hastings and Turner 1965, Hendrickson and Minckley 1985, Haase 1972). By the mid-1800s, Anglo-American settlers began moving westward to occupy Arizona and California. By 1884 it was said that "every running stream and permanent spring were settled upon, ranch house built, and adjacent ranges stocked" (Hastings and Turner 1965 from Report of Governor 1896).

By 1885, cattlemen worried about the overstocking of the range and the availability of grass for their herds (Hastings and Turner 1965). By 1891 the problem grew to such proportions that it was said in the

"Southwest Stockman" that "the malady of overcrowding is with us in an aggravated form." Drought caught the cattlemen off guard in 1892, causing herd losses reported to be 50–75 percent for Pima and Cochise counties alone. An abundance of historical evidence shows that the ranges were virtually denuded of cover in the late 1880s and 1890s. The combination of over-grazing and drought were deemed the primary causes of the poor range conditions at that time (op. cit.).

Abuse of the range land and heavy rains resulted in severe arroyo cutting in southeastern Arizona from 1883 to 1905 (Hastings and Turner 1965, Hendrickson and Minckley 1985). The extent of erosion is less known in other parts of the state; however, during the 20-year period from 1875 to 1895, arroyo cutting occurred from the Altar Valley, Sonora to Kanab Creek, Utah, and from the Sonoyta River, Arizona to Rio Puerco, New Mexico (Hastings and Turner 1965). Erosion also altered parts of the Gila during a similar time period (1891–1917)(Minckley 1979). The arroyo cutting in low-gradient streams is attributed to drought, excessive grazing, alluvial areas, and lowering of the base level of the Gila River (op. cit.). Hastings and Turner (1965) determined that large-scale grazing and climatic events caused the arroyo cutting that occurred in southeastern Arizona. As a result of erosion, previously open and marshy water courses became entrenched and many became dry sandy arroyos. Malaria, which was once widespread, retreated along with the perennial creeks and marshes that had held fish and beaver. The marshes were reduced to scattered remnants of a formerly widespread distribution (Hendrickson and Minckley 1985). Continuing settlement, farming, and the expansion of urban areas has resulted in continuing reductions of aquatic wetlands and riparian environments. Diversions, water regulation, channelization, ground water mining, and filling have all contributed to degradation.

E1.4 CHANGES IN FISH COMMUNITIES

Over the past 100 years, fish communities in Arizona have been dramatically altered. One can still find large native fishes in impressive numbers in certain locations, e.g., desert and Sonora suckers below dams on the Salt and Verde rivers. Minckley (1966) reported the capture of approximately 6000 desert and Sonora suckers, weighing an estimated two tons, with one haul of a 60-foot seine on the Salt River. Bald eagles now commonly use these two suckers as forage, and if eagle were present in Arizona in pristine times, it is probable that they preyed on suckers then as well. Similarly, other fish, such as flannelmouth and razorback suckers, which inhabited Arizona rivers prehistorically, may also have been used by eagles, but these and other fish are extirpated from much of their range and they are rare. Most are in danger of extinction (Minckley 1985, Johnson and Rinne 1982).

The impact of aboriginal people on fisheries' resources is not known, but it is likely that large standing crops of fish, were present when early travelers arrived. Under such circumstances, a large segment of the fish population usually consists of older individuals that, instead of being cropped regularly and extensively by humans, die and become carrion for scavengers.

The impact of modern technology on the native fisheries is better understood than that of prehistoric times. The extreme reductions and range changes among the native fish fauna are largely the result of water regulation and hydroelectric projects plus the introduction of exotic fishes (Miller 1961, Minckley and Deacon 1968).

E1.4.1 Effects of Dams on Water Temperatures

The effect of dams on western rivers and their indigenous fish fauna can be illustrated using the well documented case of Flaming Gorge Reservoir, which was created in 1962. Approximately 90 mi. of Green River was inundated upon closure of Flaming Gorge Dam (Vanicek *et al.* 1970). After closure of the dam, chemical and physical characteristics of the Green River below the dam became dependent on reservoir conditions at the penstocks and the amount of discharge. Releases became dependent upon downstream water and electric power demand. The major changes that occurred below the dam are documented by Stalnaker and Holden (1973). These included reduced seasonal fluctuation in river flow, increased daily fluctuation in flow, lower summer temperatures, higher winter temperatures, and greatly reduced turbidity. Temperature effects are discussed below.

Before impoundment, water temperatures from Greendale to Jensen, Utah began rising in March from winter lows of 33°F and reached a mean of 72° in July (Vanicek *et al.* 1970). Starting in August, water temperatures declined steadily until December. After impoundment, temperatures at Greendale fluctuated little seasonally, ranging only from 35–55°. Flows before impoundment were lowest during the winter months and increased gradually until peak runoff in May or June. Following the peak, flows receded during the summer and were uniformly low during the fall (op. cit.).

Seven large indigenous fish species had occurred prior to impoundment: Colorado squawfish, bonytail chub, humpback chub, roundtail chub, razorback sucker, bluehead sucker, and flannelmouth sucker (Stalnaker and Holden 1973). However, surveys of the fish fauna after impoundment of Flaming Gorge Reservoir showed reductions in the ranges of large native fishes. Just before completion of the dam, fish were eradicated with rotenone to clear the water of species undesirable for a game-fish fishery. After the fish eradication project, these native fishes did not recolonize the waters below the dam although conditions there appeared suitable.

At Jensen, located below the mouth of the Yampa River downstream of the dam, temperature patterns resembled pre-impoundment conditions except for slightly higher winter and slightly lower summer temperatures. The Yampa retained its original characteristics, and below the confluence of the two rivers it moderated the effect of damming the Green River. Overall, fish habitat was greatly altered upstream of the confluence of the Yampa River and even somewhat below by the effects of damming and the artificial regulation of water. Below the confluence, however, the Green River contained all the species present before the dam was built (Stalnaker and Holden 1973).

Several years after impoundment only bluehead suckers, flannelmouth suckers, and roundtail chub were found above the Yampa River, and none of these were known to reproduce there (Stalnaker and Holden 1973). Vanicek and Kramer (1969) reported that no Colorado squawfish were collected less than 65 mi. (104 km) below the dam and no Colorado chubs less than 47 mi. (76 km) below the Dam. Vanicek *et al.* (1970) reported that no reproduction of native fishes was found to occur for 104 km downstream.

The decline in these fishes was thought to result primarily from changes in water temperature (Vanicek *et al.* 1970, Holden and Stalnaker 1975, Vanicek and Kramer 1969). Bulkley and Pimentel (1983) noted that water temperatures downstream from the dam were below the lower avoidance temperatures of razorback sucker and were probably too low for Colorado squawfish, bonytail chub and humpback chub as well. Magnison *et al.* (1979) determined that temperature regimes below Flaming Gorge Dam were unsuitable for most of the endemic fishes. Essentially, introduced rainbow and brown trout had replaced

the large native fishes in the cold, clear water created by the Flaming Gorge Dam downstream to the confluence of the Yampa River (Vanicek *et al.* 1970, Stalnaker and Holden 1973).

The lower Colorado River has changed character as well (Dill 1944, Miller 1961).

> In its natural condition the river was swift, silt laden, and subject to spectacular fluctuations in volume and turbidity, annually carrying thousands of tons of silt into the Gulf of California. Its maximum flow was usually attained in June, diminished greatly in August, and was very low from September to February. At Yuma, a peak flow of 250,000 cfs occurred in 1916 and a minimum daily flow of only 18 cfs [was] recorded in the drought year of 1934. (Dill 1944)
>
> The succession of dams lying between Lake Mead and Yuma has transformed the Colorado into a series of deep, placid reservoirs with connecting channels of clear water and regulated volume. The water temperatures have been strikingly modified. Originally it varied from about 50–90°F or more annually. Now, below Hoover Dam and Davis Dam, the fluctuation is from 54–62°F, providing temperatures suitable for the development of an important trout fishery. (Miller 1961)

Similar effects have also occurred on the Salt and Verde rivers as a result of damming.

Temperature alterations reported in many studies contribute to the observed reductions in native fishes. Marsh (1985) reported that temperature effects reduced the number of areas thermally suitable for reproduction of Colorado squawfish, razorback suckers, humpback chub, and bonytail chub. Of course, temperature is only one of several factors that have contributed to native fish population declines.

Black and Bulkley (1985) found growth rates for Colorado squawfish to be optimal at 77°F and 18 percent of optimal at 59°F. The implication is very significant: dams with hypolimnetic releases reduce reproduction and growth through thermal effects. Historically, Colorado squawfish occurred below the "trout zone" in major rivers (Jordan 1891 and other sources). By creating dam tailwaters, the habitats that qualify as trout water have increased and, in fact, are stocked with salmonids.

E1.4.2 Effects of Regulated Flows

Flow patterns of regulated rivers can contribute to the decline of native fishes. Seasonal flow regimes appear important to spawning Colorado squawfish. Haynes *et al.* (1984) found spawning occurred as water levels receded and ceased with the onset of lower summer flows. High spring flows played an important role by flushing spawning substrate and flooding shoreline embayments which served as rearing areas. They state "... it is reasonable to suggest that the seasonal flow regime is an important limiting factor both for spawning and larval survival."

Colorado squawfish are also known to migrate up to 200 km to spawn in white water canyons. Other endemics, such as razorback and flannelmouth suckers, may have also migrated to spawn (Jordan 1891, Chamberlain 1904, Ellison 1980 *in* Minckley 1983). Dams would have prevented these migrations of spawning adults as well as blocked dispersing young.

E1.4.3 Effects of Exotic Fishes

The widespread introduction of exotic fishes has created an additional impact to native fishes. Carp had established populations in the Colorado River by about 1900 (Dill 1944, Ellis 1914). Carp are known

to eat the spawn of other fishes, alter habitat by eating and uprooting aquatic vegetation, and compete with other fish for food and space (Minckley 1983, Moyle 1984, Becker 1983). Under the right conditions, carp may dominate the fish fauna and alter the entire aquatic community (Cahn 1929).

Another widespread, aggressive, hardy species, the green sunfish, suppresses native fishes and eliminates others in streams (Lemly 1985). Both channel and flathead catfish are piscivorous (Minckley 1973); Marsh and Brooks (1989) believe that catfish predation is largely responsible for the low survival rate of stocked razorback suckers. They report that catfish are abundant enough to consume an estimated 900 juvenile suckers per day. Minckley (1983) asserts that the abundance of reservoirs provides a constant source of exotic fishes and that these native fishes are "naive" prey for other fishes (*see* Miller 1961).

E1.5 SUMMARY

Arizona's waterways have undergone radical alteration since the first Anglo-Americans came in search of beaver. These extreme and widespread changes have occurred in a minute fraction of the evolutionary histories of the native species that depend on these waterways. Virtually overnight, the impoundment-channel systems that have replaced Arizona's wild rivers have created new, artificial environments. The need for water and energy has induced changes in seasonal flows, water chemistry, temperatures, and faunal relationships that are alien to native fishes. We cannot expect even the current species assemblages to be stable, so far removed as they are from natural community relationships.

Water development affects nearly all of Arizona's rivers. Water is manipulated to meet municipal demand, hydroelectric power generation, flood control, and irrigation. It is our understanding that nowhere in Arizona state law or policy is water allocated for maintenance of fish populations and productivity (Ziebell and Roy 1989). Presently, eagles in Arizona rely on a prey base largely composed of exotic fishes. The continued presence of eagles is very dependent on maintaining the fish prey base, which may in turn require the protection of instream flows.

Today's fish fauna of the Colorado River system is often referred to as "depauperate" and "relict," but historically the large native fish provided food for native Americans and pioneers. Fish populations large enough for use by these people probably also formed a prey base for bald eagles if they occurred here. Even now, native suckers are a main prey of nesting bald eagles in Arizona, and other sucker species of the genus *Catastomas* often represent the main prey of bald eagle populations nesting outside Arizona (BioSystems 1985, Swenson, Alt, and Eng 1986).

If bald eagles nested extensively in Arizona prehistorically, it is possible that they have been negatively affected by loss of nesting trees, huntable waterways, and changes in stream productivity, prey abundance, vulnerability, and species composition. Certain habitat features (trees, free-flowing rivers) and prey (squawfish, razorback suckers) that previously could have supported bald eagles were once relatively abundant and extensive in Arizona, but are now much reduced and restricted. Conversely, other recent, man-induced habitat features (numerous man-made lakes and reservoirs, less turbid, cooler, regulated reaches) and introduced prey (carp, catfish, etc.) appear to benefit bald eagles, and it is possible that these changes have positively affected bald eagles in Arizona. Conclusions as to whether food supply, considered separately as a component of carrying capacity, would have permitted greater or lesser breeding densities of bald eagles in pristine Arizona cannot be drawn with the data at hand.

E2 PRESENT FISH COMMUNITIES IN CENTRAL ARIZONA RIVERS AND RESERVOIRS

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In this section, we characterize the relative abundance and distribution of potential bald eagle prey in the Salt and Verde rivers and their associated reservoirs. Sources of information include published report by the AGF and USFWS, personnel communications with state and federal agency personnel, and field data from D. Hendrickson of the AGF Nongame Branch, M. Jakle of the Bureau of Reclamation, C. Zeibell of the University of Arizona, and our own fisheries surveys.

We used this information on the relative abundance of potential bald eagle prey to determine: (1) if bald eagles forage randomly or selectively on prey species within nesting territories; (2) if the absence of nesting bald eagles in areas of the Salt and Verde rivers is due to inadequate prey populations or the lack of key foraging species; and, (3) how water development (i.e., construction of reservoirs and water management in regulated river reaches) has affected prey populations.

E2.1 UPPER SALT RIVER (Km 256–110)

Species composition and relative abundance of prey fish in the upper Salt River changes substantially from the confluence of the Black and White rivers (Km 256) to Roosevelt Reservoir Diversion Dam (Km 110) (Table E2-1). Four groups of fish comprise the bulk of prey in the river including suckers (desert and Sonora), carp, catfish (flathead and channel) and smallmouth bass. Suckers, catfish and smallmouth bass dominate the fish community in the Salt River upper sections (Km 256–Km 224). In the mid-river reaches (Km 224 and Km 192) the relative abundance of smallmouth bass decreases substantially and carp are important in the fish community. Catfish, carp and suckers dominate the fish community in the downstream reaches (Km 192 to Km 159). Interestingly, roundtail chub comprise 19 percent of the fish community between the region 175 Km–159 Km but are relatively rare in other reaches. Downriver of 159 Km, suckers comprise 5 percent or less of the community and carp and catfish are the major prey fish inhabiting the river.

E2.2 SALT RIVER RESERVOIRS

A series of four reservoirs was built on the Salt River between 1911 and 1930 resulting in the inundation of 91 Km of river. Roosevelt Reservoir is furthest upriver followed by Apache Reservoir, Canyon Reservoir and Saguaro Reservoir. Rinne (1975) contains descriptions of these reservoirs.

Largemouth bass and bluegills comprise over 58 percent of potential prey fish in all the reservoirs except for Apache where they comprise only 39 percent of potential prey (Table E2-2). Carp are present in all the reservoirs and comprise between 5 percent and 7 percent of potential prey. Similarly, catfish are present in the reservoirs (2–5% of potential prey). The major difference in fish communities in the reservoirs is the relative abundance of black crappie and yellow bass. Black crappie are quite common

Table E2-1. Relative abundance of potential eagle prey fish in the Upper Salt River.

	River Km								
Species	240-256 (%)	224-240 (%)	208-224 (%)	192-208 (%)	175-192 (%)	159-175 (%)	143-159 (%)	127-143 (%)	110-127 (%)
Sonora Sucker	24	30	—	—	33	19	2	<1	<1
Desert Sucker	9	12	—	—	17	2	2	<1	—
Total Suckers	33	42	—	—	50	22	5	<1	<1
Roundtail Chub	<1	5	—	—	<1	19	—	<1	11
Colorado Squawfish	—	—	—	—	—	—	1	—	—
Carp	—	—	—	—	24	15	59	15	15
Flathead Catfish	—	—	—	—	<1	9	9	4	1
Channel Catfish	40	19	—	—	24	33	23	74	58
Total Catfish	40	19	—	—	24	42	32	78	60
Smallmouth Bass	26	32	—	—	1	1	1	<1	—
Green Sunfish	<1	1	—	—	—	1	2	7	15
Rainbow Trout	—	<1	—	—	<1	—	—	—	—
N (Total)	288	241	—	—	503	292	82	1680	1739
Collection years:	1988	1986, 1988			1986, 1988	1986, 1988	1986, 1988	1981, 1988	1981, 1988
Methods:	EF*	EF*			EF,GN,* SN,TN	EF,GN,*	EF,SN*	EF*	EF*
Sources:	1	1			1,2	1,2	1,2	2	2

1. D.A. Hendrickson (Arizona Game and Fish Dept.)
2. J. Hanson (USFWS).

* EF = electrofishing; GN = gill netting; Sn = seine netting; TN = trammel netting.

in Roosevelt Reservoir (8% of potential prey) but they are relatively rare in the other reservoirs; whereas, yellow bass are common in Apache, Canyon, and Saguaro Reservoir but rare in Roosevelt Reservoir (Table E2-2).

E2.3 LOWER SALT RIVER (Km 21.8–0.0)

The Salt River below Saguaro Reservoir is unique in that flows are regulated by SRP and that the river abruptly ends at Granite Reef Dam. All the water reaching Granite Reef Dam is diverted into canals for domestic use in the greater Phoenix area.

In a 1973 study, suckers comprised 50 percent of the potential prey fish in the lower Salt River (Table E2-3) with desert suckers slightly more abundant than Sonora suckers (30% and 20%, respectively) (USFWS 1976). Less abundant species were green sunfish (16%), carp (12%) and largemouth bass (11%). Catfish (mainly yellow bullheads) made up 7 percent of the collected species.

E2.4 UPPER VERDE RIVER

Data needed to calculate the relative abundance of eagle prey fish in the upper Verde River is available for only two areas: upriver of Highway 17 Bridge to Perkinsville. The fish community above the Highway 17 Bridge consists primarily of native species with suckers, roundtail chub, and squawfish comprising 80 percent of prey fish (Table E2-4). Lower numbers of green sunfish, smallmouth bass, carp and catfish can also be found in this reach. The abundance of squawfish in this area is an artifact (possibly temporary) of extensive planting by the AGF and we doubt that they are abundant in downstream areas. The fish community in the Childs area is considerably different from the upstream community in that introduced fish namely carp, catfish, smallmouth bass and other centrarchid species comprise over 84 percent of prey fish. The fish community in the river between these two areas is in transition from one dominated by native fishes to one dominated by introduced fish. Downstream of Childs near Horseshoe Reservoir, carp and catfish dominated the riverine fish community (J. Warnecke pers. comm.).

E2.5 HORSESHOE RESERVOIR

Horseshoe Reservoir was constructed in 1946 and is operated primarily as a storage facility. When full, the reservoir inundates approximately 10 Km of the river. Horseshoe Reservoir is relatively shallow and has a higher surface to volume ratio than most Arizona reservoirs. As a result, water released from the reservoir is more similar to riverine water in temperature and water quality than other reservoirs on the Salt or Verde rivers. In some years, Horseshoe Reservoir is totally drained so that only riverine conditions are present.

Largemouth bass, bluegills and green sunfish are the most abundant prey fish in the reservoir comprising 92 percent of the fish community (Table E2-5). Carp and black crappie are less abundant in the reservoir. The abundance of crappie in the lake may be underestimated due to their movements into deeper, open water of the reservoir where sampling is more difficult.

Table E2-2. Relative abundance of potential eagle prey fish in lakes on the Salt River.

Species	Roosevelt Lake (Percent)	Apache Lake (Percent)	Canyon Lake (Percent)	Saguaro Lake (Percent)
Sonora Sucker	1	<1	—	—
Buffalo spp.	<1	3	<1	
Carp	7	6	7	5
Goldfish	<1		—	—
Flathead Catfish	<1	<1	—	—
Yellow Bullhead	<1	2	<1	<1
Channel Catfish	2	3	<1	5
Yellow Bass	<1	34	15	29
Yellow Perch	—	—	—	<1
Walleye	—	3	5	3
Smallmouth Bass	2	5	<1	—
Largemouth Bass	30	19	28	27
Green Sunfish	4	4	10	1
Bluegill	46	20	31	31
Black Crappie	8	2	<1	—
Rainbow Trout	—	—	2	1
N (Total):	6203	1953	3021	1485
Collection Years:	1984-1985	1985	1984-1985	1985,1988
Methods:	EF,GN,SN*	EF,GN,SN*	EF,GN,SN*	EF,GN,SN*
Sources:	1	1	1	1

1. J. Warnecke 1988
*EF = Electrofishing, GN = Gill netting, SN = Seine netting

Table E2-3. Relative abundance of potential eagle prey fish in the Lower Salt River.

Species	River Km 0-22 (Percent)
Sonora Sucker	20
Desert Sucker	30
Total Suckers	**50**
Carp	12
Yellow Bullhead	7
Channel Catfish	< 1
Total Catfish	**7**
Largemouth Bass	11
Green Sunfish	16
Rainbow Trout	< 1
N (Total):	1901
Collection Years:	1975
Methods:	EF,SN,GN*
Sources:	1

1. USFWS (1976)
* EF = electrofishing; SN = seine netting; GN = gill netting.

E2.6 MIDDLE VERDE RIVER

For this discussion, the middle Verde River is that portion of the river between Horseshoe Reservoir and Bartlett Reservoir. The river runs for approximately 20 Km between the reservoirs. Flow in this portion of the Verde River is completely regulated by SRP, with water being released from the epilimnion. Turbidity and temperature of water entering and leaving the Horseshoe Reservoir are similar. No quantitative sampling has occurred in this reach but carp and catfish are though to be the most abundant fish in this reach (J. Warnecke AGF and qualitative surveys by BioSystems, 1989).

Table E2-4. Relative abundance of potential eagle prey fish in the Verde River.

Species	Above Hwy 17 Bridge (Percent)	East Verde Territory (Percent)	Lower Verde River (Percent)
Sonora Sucker	15	14	9
Desert Sucker	16	4	42
Razorback Sucker	2	—	—
Unknown Sucker	4	—	—
Total Suckers	**37**	**17**	**50**
Roundtail Chub	17	—	1
Colorado Squawfish	26	—	—
Carp	2	44	24
Flathead Catfish	<1	7	—
Yellow Bullhead	—	—	14
Channel Catfish	<1	10	9
Total Catfish	**1**	**17**	**23**
Smallmouth Bass	6	14	—
Largemouth Bass	—	3	6
Unknown Bass	<1	—	—
Green Sunfish	12	3	4
Bluegill	—	3	<1
Rainbow Trout	—	—	<1
N (Total):	1868	81	2879
Collection Years:	1987-1988	1986,1988	1975
Methods:	EF*	EF,GN,TN*	EF,GN,SN*
Sources:	1,2	2,3	4

1. C. Ziebell (University of Arizona)
2. D.A. Hendrickson (Arizona Game and Fish Dept.)
3. M. Jakle (Bureau of Reclamation)
4. USFWS (1976)

* EF= electrofishing; GN = gill netting; TN = trammel netting; SN = seine netting.

Table E2-5. Relative abundance of potential eagle prey fish in Verde River reservoirs.

Species	Horseshoe Lake (Percent)	Bartlett Lake (Percent)
Carp	6	4
Goldfish	<1	<1
Flathead Catfish	—	<1
Channel Catfish	<1	2
Smallmouth	<1	<1
Largemouth	38	14
Green Sunfish	37	3
Bluegill	17	70
Black Crappie	2	6
N (Total)	1413	4397
Collection Years:	1987	1984-1985
Methods:	EF,SN	EF,GN,SN
Sources:	1	1

1. J. Warnecke (Arizona Game and Fish Dept.)
* EF = electrofishing; GN = gill netting; SN = seine netting.

E2.7 BARTLETT RESERVOIR

Bartlett Reservoir was completed by the Bureau of Reclamation in 1939; its primary function is to provide irrigation water. In AGF surveys, bluegills were the most abundant prey fish collected in Bartlett Reservoir, comprising 70 percent of the fish community (Table E2-5). Largemouth bass were substantially less abundant at 14 percent while black crappie (6%), carp (4%) and green sunfish (3%) comprised a very small portion of prey fish.

E2.8 LOWER VERDE RIVER

In 1973, suckers comprised over 50 percent of the potential prey fish present in the Verde River from Bartlett Dam to its confluence with the Salt River (USFWS 1976). Desert suckers were more abundant than Sonora suckers at that time (41.5% to 8.6%, respectively)(Table E2-4). Carp and catfish (primarily yellow bullheads) had almost equal abundance comprising 24 percent and 23 percent of the potential prey fish present. Only two species, largemouth bass (6%) and green sunfish (3.5%) accounted for more than 1 percent of prey available).

E2.9 EAST VERDE RIVER

Variations in species composition and abundance were recorded from the East Verde River (Table E2-6). In the upper river reaches, above Doll Baby Ranch salmonids were dominant species present, with rainbow trout comprising 62.1 percent of the total composition. In the middle reaches (12.4 Km to 19.6 Km) the fish community composition changed to being dominated by Sonora suckers (50.8%) and smallmouth bass (40.0%)(Table E2-6). Similarly, in the downstream reaches (0.1 Km to 5.3 Km) changes in composition were recorded, with carp being the predominant fish species (51.9%) and smallmouth bass were also of importance (37.0%) in this river section.

Table E2-6. Relative abundance of potential eagle prey fish in the East Verde River.

Species	Above Doll Baby Ranch (Percent)	Km 12–20 (Percent)	Km 0–5 (Percent)
Sonora Sucker	—	51	—
Desert Sucker	12	—	—
Total Suckers	**12**	**51**	**—**
Roundtail Chub	4	2	—
Carp	—	—	52
Flathead Catfish	—	—	2
Yellow Bullhead	2	8	2
Channel Catfish	—	—	6
Total Catfish	**2**	**8**	**9**
Smallmouth Bass	< 1	40	37
Green Sunfish	< 1	—	2
Rainbow Trout	62	—	—
Brown Trout	< 1	—	—
Brook Trout	< 1	—	—
N (Total)	530	65	54
Collection Years:	1979,1986-87	1987	1987
Methods:	EF,SN*	EF,GN*	EF,GN*
Sources:	1,2	3	3

1. D. Bancroft (1980).
2. M. Jakle (Bureau of Reclamation).
3. BioSystems Analysis, Inc.

* EF = electrofishing; SN = seine netting; GN = gill netting.

E3 LIFE HISTORIES OF BALD EAGLE PREY SPECIES IN ARIZONA

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The survival of bald eagles in Arizona and probably throughout their range depends on the availability of fish. Since bald eagles seldom capture prey deeper than 0.6 m below the water surface, their foraging habitat is somewhat limited. It is remarkable that bald eagles can provide their chicks with a constant supply of food when environmental conditions during a single nesting season are so variable. For example, flows and reservoir volumes may fluctuate greatly, changing habitat conditions and fish distributions. Further, fish behavior changes considerably depending on reproductive status. Eagles have not only been able to adapt to these seasonal changes in fish availability, but also to widespread changes in Arizona fish communities during the last 100 years, due to exotic introductions, dam construction and water diversions.

To fully appreciate the adaptability of bald eagles and their ability to change foraging strategies in response to prey availability, an understanding of the life history and behavior of their prey is necessary. This section of the report forms the core of information on the life histories of potential past and present prey species of Arizona bald eagles which we used to: (1) identify additional fisheries work needed during our study; (2) explain current patterns in the foraging behavior of Arizona eagles; (3) speculate on the availability of prey during pristine times; and, (4) speculate on effects of past and future water development on bald eagle populations. This section has been organized to present the life histories of native species first, then introduced species.

E3.1 NATIVE FISH

E3.1.1 Colorado Squawfish (*Ptychocheilus lucius*)

Status. Colorado squawfish (CSF) were extirpated in Arizona before 1960, but captive propagation is underway and reintroductions into the Salt and Verde drainages began in 1985 (Arizona Game and Fish Dept. 1988). It is listed as endangered Federally and populations reintroduced in the above drainages are classified as "experimental nonessential" under section 10(j) of the ESA, 1973 (Brooks 1986a).

Description. The CSF is one of the world's largest minnows (family Cyprinidae) and the largest piscivore endemic to the Colorado River Drainage. This fish is highly predacious and has been reported to become piscivorous at only 50 mm long in the wild. Adults in captivity are often fed trout which they readily devour (Vanicek and Kramer 1969, Toney 1974, Pimentel *et al.* 1985). The specific name *lucius* means pike and Moyle (1976) characterized this fish as a roving predator with lie-in-wait affinities. Their large size and purported migratory behavior (Sigler and Miller 1963, Minckley 1973) resulted in the common name "salmon" or other names which included the vernacular salmon. Jordan and Everman (1896) reported that CSF attain 36 kg and 150 cm length and Miller (1961) stated, "it probably approached a maximum length of 6 ft and a weight of nearly 100 pounds, although record weights over the past 35 years are not known to exceed 40–50 pounds." Gilbert and Scofield (1898) reported that individuals 4–5 ft long were frequently taken from the Gila and lower Colorado.

Distribution. CSF are endemic to the Colorado River basin. Early records show they were present throughout the mainstream Colorado and most of its major tributaries from the Green River, Wyoming south to Yuma, Arizona including the Gila, Salt, and Verde rivers. Although no preserved specimens of *P. lucius* are known from the Verde, Minckley and Alger (1968) received testimony from a resident of Camp Verde which supports the contention that it occurred there in the early 1900s. Miller (1955) reported that young CSF were collected on the Salt at the mouth of Cibecue Creek in May of 1950. Naturally occurring populations are now confined to the Upper Colorado River Basin (UCRB), above Lee's Ferry, in mainstream rivers and tributaries (USFWS 1978).

Habitat. Pimentel and Bulkley (1983) found the preference range of juvenile CSF (age 0–1) for total dissolved solids to be wide: 560–1,150 mg/l with avoidance above 4,400 mg/l. Bulkley *et al.* (1981) stated that the preferred temperature for adult CSF was 25°C. However, Holden (1977) reported CSF showed little preference for temperature as fish of all sizes were found in almost the entire range of temperatures, 11–27°C, encountered during August and September on the Green River. In a stamina tunnel CSF generally exhibited increased performance with water temperature for fish averaging 121 mm TL at 20°C swimming 50 cm/s and fish 451 mm TL at 20°C swimming 108 cm/s for 2-minute tests at which 50 percent of the fish fatigued (Berry and Pimentel 1985). Berry (1988) reported 14 day old larvae were more susceptible to cold shock than 40-day-old fish. In this study, fish were acclimated to 22°C and then subjected to cold shock of 10° and 15°C. This treatment resulted in mortality and behavioral changes in 14-day-old larval fish but did not affect 40-day-old CSF.

The importance of river size as a component of CFS habitat has not been formally evaluated. However, CSF have always been considered a "large river" fish and are rarely found in small tributaries except during periods of high runoff (Holden and Wick 1981). Minckley (1973) also noted that it has been implied that CSF and other members of the genus *Ptychocheilus* are "big river" fishes characterized by water deeper than 1 m with moderate current. Holden and Wick (1981) maintain that stream size and summer temperature appear to be the determining factors in habitat selection with the upstream end of CSF range limited to the lower end of river occupied by trout (the cold-water zone).

For young-of-the-year (30–64 mm) CSF in the Green River, Holden (1977) reported that fish preferred backwaters 1–2 ft deep, no current, and a firm silt bottom. Juveniles (65–200 mm) also preferred backwaters, no current, and silt bottoms but were found over a wide range of depths from 0.5–6 ft, deep. Subadults (200+ mm) were found in a variety of velocities and depths but preferred sand bottoms, eddies and runs to backwaters. Similarly, Holden and Wick (1981) reported that as CSF reached 150–200 mm long the number in backwater habitats drop off dramatically indicating that they may move to the main river channel. Backwaters may become limited during the winter when they freeze.

Habitat preferences for adult CSF were reported by Holden and Wick (1982) to change with season and habitat availability. They noted that available information indicated that adult CSF prefer run habitat along shores of medium depth during pre and post-runoff periods, and prefer backwaters during high-runoff periods but also use runs at these times. This pattern was observed by Miller *et al.* (1982a) in the Yampa River. These squawfish were found in eddies near mouths of irrigation returns and shorelines of runs during pre-runoff periods but sought out large backwaters during high-runoff periods, and used deep holes and diverse habitats during post-runoff periods.

Tyus and McAda (1984) monitored the movements of radio-tagged CSF in the Green, White and Yampa rivers. Habitat and substrate use varied between river system and time of year. Overall, CSF found

along shoreline were associated with sandy substrate the majority of the time. They were also found to use eddy, run, backwater, and pool habitats and silt, boulder, rubble, and gravel substrates. Depths and velocities for habitat occupied by CSF are provided in Tyus and McAda 1984.

Further information on habitat selection obtained from radio-tagged and conventionally tagged CSF was reported by Tyus *et al.* (1984a). Adult fish in the Green River preferred shoreline habitat (which the authors defined specifically as shallow, low velocity, waters next to shore) followed by eddy habitat (defined as deep shoreline whirlpools with upstream velocity). Very little use was made of runs (defined as channels with swift, laminar flow), backwaters (defined as semi-isolated water bodies with no measurable velocities), or pools (defined as deep, quiet portions of the stream). Sandy substrate was associated with over 70 percent of the observations followed by silt, rubble, gravel, and boulder, respectively.

Spawning. Male CSF first become mature at age 5 (317–376 mm) and females at age 6 (425–441 mm) under hatchery conditions (Hamman 1981). Nearly all sexually mature squawfish in the Green River were age 7 and over (Vanicek and Kramer 1969). Spawning males have small tubercles on the head, opercula, and pectoral and pelvic fins. These eventually spread over the entire surface of the fish except for the abdominal area and caudal fin (Vanicek and Kramer 1969, Tyus and McAda 1984, Hamman 1981). Females may acquire small tubercles on the head, opercula, and pelvic fins but most do not (Hammond 1981). Sexually mature fish have been shown to make long potamodromous spawning runs of hundreds of kilometers (Tyus *et al.* 1984b, Tyus 1985).

Hamman (1981) observed captive CSF spawned at Willow Beach National Fish Hatchery. He reported that a female was nudged by two males and that the spawning act took place at a depth of 25–45 cm. The spawning act was repeated several times over a period of 48 hours. Females broadcast adhesive eggs 1.5–2.0 mm in diameter which develop rapidly and hatch in 96 hr at 20°C. Hamman (1981) reported that larval CSF swim to the surface 72–96 hours after hatching and were 6.5–7.5 mm long.

Spawning in the Upper Colorado River Basin has been reported to occur over rubble substrate in whitewater canyons (Tyus and McAda 1984). At the primary site of spawning in the Yampa River, ripe radio-tagged fish were found at depths from 0.9–2.1 m and water velocities that ranged from 0.0–0.1 m/s. Spawning occurs naturally at 20–22°C (Vanicek and Kramer 1969, Toney 1974, Hamman 1981, Tyus and McAda 1984, Haynes et al 1984). In the Upper Colorado River Basin spawning occurs from mid June–August (Haynes *et al.* 1984, Tyus *et al.* 1984b, Tyus and McAda 1984). However, Keading *et al.* (1988) showed that temperatures in the Lower Colorado historically reached suitable spawning temperature by May. Vanicek and Kramer's (1969) conclusion that water temperature and receding water level were important spawning stimuli has been substantiated by others (Haynes *et al.* 1984, Tyus and McAda 1984). Spawning ceased with the onset of lower, summer flows (Haynes *et al.* 1984). Flow regime, especially peak levels, may affect success of spawning and survival of young, e.g., high flows in spring flood shoreline embayments that later become nursery areas for young (Tyus and McAda 1984).

Movements. Tyus and McAda (1984) reported two basic types of behavior for radio-tagged CSF in the Green and Yampa rivers: sedentary and highly mobile. Movements of sedentary fish during mid-June through July were related to sexual maturity. The seven CSF tagged in the Yampa River and one in the Green River exhibited high mobility which was linked to a potamodromous spawning migration to the lower 32 km of the Yampa River in early July. Collections of fish revealed 34 CSF in spawning condition with one tuberculate male flowing with milt. A 190-km reach of the Yampa River was sampled

for larval fish and revealed larval CSF only in the lower 20 km of the river. Radio-tagged fish moved up to 205 km to reach spawning grounds and four conventionally tagged fish from the Green and Yampa rivers were recaptured on the spawning grounds 2–120 km from their initial capture locations (Tyus 1985). Fish demonstrated both positive and negative rheotaxis in reaching common spawning areas located in the lower Yampa. Radio-telemetry observations from the Yampa River indicated more movement may occur at night during spawning (Tyus and McAda 1984). Fidelity to a spawning site was demonstrated when three squawfish, radio-tagged in 1981 and 1982, returned to the same location in 1983 to spawn (Tyus 1985). Tyus (1985) suspected that CSF may imprint to natal streams and that initiation of spawning seems to hasten the arrival of others to the spawning area. He speculated that conspecific odors may be involved in hastening arrival of other spawning CSF as they are in salmonids. Tyus *et al.* (1984b) reported that radio-telemetered fish remained on spawning areas from June 26–July 10. For these fish, 96 percent of total movement during the study period from April–September was attributed to spawning migration.

Tyus (1984) monitored diel, short term, local movements of radio-tagged CSF during pre-spawning, spawning, and post-spawning periods. The only strong pattern found was during post-spawning when activity peaked between 800–1200 hr.

Young migrate downstream after adults spawn (Haynes *et al.* 1984, Tyus and McAda 1984) followed by the upstream movement of young adult fish (Tyus *et al.* 1984b). Paulin *et al.* (1989 in press) concluded from laboratory drift studies on 1–36-week-old CSF that downstream drift in larval and post-larval fish was common at night, especially at water velocities greater than 3 cm/sec. This drift is believed to serve an important function in transferring larvae from the swift, canyon habitats in which they were spawned to productive downstream nursery areas. Drift is the result of active choice by mesolarvae and older fish, and may be due to active and passive factors in younger fish.

Food Habits. Few studies have been conducted on the food habits of CSF. Vanicek and Kramer (1969) found fish up to 50 mm consumed cladocerans, copepods, and chironomids. As squawfish get larger they utilize insects in increasing proportions until 100 mm long at which time fish become the major food item. Fish was the only food item found in squawfish over 200 mm long. Although most of the fish remains were unidentifiable, redside shiners were the most common food item identified. Koster (1960) reported that a 590-mm female CSF contained part of a flannelmouth sucker in its digestive tract. Toney (1974) found that CSF in raceways would only accept trout as feed and greatly preferred crippled individuals although the CSF were fully capable of catching healthy trout.

Fishermen along the Green River have reported large, dead CSF containing channel catfish lodged in their esophagus with spines extended. Pimental *et al.* (1985) subjected channel catfish 51–125 mm long with spines removed (clipped off) and catfish with spines along with trout to predation by 60 hatchery-reared CSF that were 360–512 mm long. CSF rejected ingested catfish with spines removed 60 times but consumed trout readily on the first try. Only two catfish with spines were ingested and retained. Observations over two months showed no ill effects. Squawfish would eat trout daily but would reject catfish unless starved for five days. They reported four documented cases of CSF choking on channel catfish in the Green River and concluded that three of these cases occurred when water temperatures were low possibly making the catfish vulnerable. They further speculated that channel catfish may only be made vulnerable by environmental conditions, e.g., low temperatures, or when in ill health.

Age and Growth. Based on reports of CSF reaching up to 2 m long, potential life expectancy is 20–50 years (Holden and Wick 1981). Vanicek and Kramer (1969) reported the capture of one relatively large fish (for recent times) that was female, 610 mm in length, weighing 2.3 kg, and aged approximately 11 years old. They found that nearly all fish over age 7 were sexually mature but males mature as early as age 5 and females as early as age 6 (Hammon 1981).

CSF from the Green River grew 50 mm per year until age 3 after which annual increments increased for a couple of years and then decreased from then on (Vanicek and Kramer 1969, Holden and Wick 1981). Mean total lengths (in mm) for various year classes were as follows: age 1—44; age 2—95; age 3—162; age 4—238; age 5—320; age 6—391; age 7—454; age 8—499; and age 9—536 mm (Vanicek and Kramer 1969). The weight-length relationship for Green River fish was determined to be

$$\log Wgr = -5.4177 + 3.126 \log Lmm \text{ (Vanicek and Kramer 1969)}$$

Kaeding and Osmundson (1988) suggested that growth only occurs at temperatures above 13°C with optimal growth at 25°C which coincides with the estimated preferred temperature. They estimated that water temperatures of the Upper Colorado River Basin exceeds 13°C for only six months a year while the middle and lower Colorado exceed this temperature for 7–9 months providing a much longer growing season. Yearling CSF held in tanks at 15°, 20°, 25°, and 30°C and fed excess food, grew an average rate from 5.4 mm at 15°C to a maximum of 25.4 mm at 25°C in 84 days (Black and Bulkley 1985). Comparatively, growth rates at 15°, 20°, and 30°C were 18, 54, and 51 percent, respectively, of that obtained at 25°C.

E3.1.2 Bonytail Chub *(Gila elegans)*

Status. Bonytail chub (BTC) are very rare; Minckley (1985) stated, "This is likely the most endangered species in the region." Hatchery produced stock is being released into Lake Mohave and may soon provide for reintroduction into the Salt and Gila rivers. It is listed Federally as endangered (Arizona Game and Fish Dept. 1988).

Description. The name bonytail comes from its conspicuous hard, pencil-like caudal peduncle. The BTC has several traits which show adaptation to swift water and high swimming speed: streamlined body; high aspect ratio; narrow, terete caudal peduncle; deeply forked caudal fin; expansive, strongly falcate, fins; embedded or absent scales; and dorsal hump.

In the past there has been confusion concerning the bonytail's place in the "*Gila* complex" of related fishes and the use of the vernacular bonytail for other fishes (Holden and Stalnaker 1970, Rinne 1976, Smith *et al.* 1979, Minckley 1973, Minckley 1985). As a result information concerning the BTC has often been combined with that of the roundtail chub. Confounding the problem, young of both fishes are difficult to distinguish in the field until individuals reach two years of age and greater than 200 mm long (Vanicek and Kramer 1969). Bonytails can hybridize with the humpback chub and roundtail chub possibly creating intergrades (Hamman 1981).

Information on this species is rather limited largely due to its rapid decline in this century. Valdez and Clemmer 1982 reported that BTC were apparently common in collections from the lower Colorado River basin near the turn of the century. Currently, this fish is so rare that no natural populations remain for study or evaluation (Minckley 1985).

Distribution. BTC were once widespread in the Colorado River basin extending from the Green River, Wyoming south to Yuma, Arizona, east into the Gila River, Arizona to Ft. Thomas and the Salt River to Tempe, Arizona (Minckley 1985, Holden 1980).

Habitat. Pimentel and Bulkley (1983) found juvenile BTC to prefer total dissolved solid concentrations between 4,100–4,700 mg/l selecting water four times more concentrated than now inhabited in nature. They avoided concentrations above 6,600 mg/l and below 560 mg/l. The temperature preference for this species was found to lie between 24–25°C (Bulkley *et al.* 1981 in Berry and Pimentel 1985). In a stamina tunnel BTC generally exhibited increased performance as water temperature increased. Fishes averaging 97 mm TL in water at 20°C maintained a speed of 62 cm/s for 2-minute tests at which 50 percent of the fish fatigued. The BTC generally had greater swimming ability than the Colorado squawfish when similar sized individuals were compared (Berry and Pimentel 1985).

Little is known of the bonytail's physical habitat requirements. BTC captured in Grey Canyon, Green River suggest that they prefer areas adjacent to deep, swift water (Valdez and Clemmer 1982). Valdez and Clemmer (1982) reported that chub caught in the upper Colorado River basin used deep, swift, rock–sand areas in the main river channels. However, Vanicek and Kramer (1969) found in the Green River that both BTC and RTC were generally found in pools and eddies in the absence of strong current. These fish were located over silt–boulder bottom types. They also reported BTC to be only occasionally found adjacent to swift water and pointed out that none were found in swift water. Young chubs which included RTC were found in quiet water or shallow pools over silt–sand and gravel bottoms. No differences in habitat selection was found between the two species in the Green River nor any seasonal changes observed (Vanicek 1967 in Valdez and Clemmer 1982).

Lake Mohave contains a population of BTC which has been speculated to confine itself to the warmer non-riverine portion due to the cold water releases from Hoover Dam (Valdez and Clemmer 1982). Jordan (1891) reported that roundtail chub were commonly found at the foot of the mountains but was replaced by BTC in the river channels not ascending streams as far as the former.

Spawning. Male BTC become reproductively mature as early as two years and females at three years of age under hatchery conditions (Hamman 1985). Both males and females produce fine tubercles on the head, opercula, pectoral fins, and pelvic fins when ripe. In addition, breeding males also have a light orange coloration at the base of the pectoral and pelvic fins not found on females (Hamman 1982).

Vanicek and Kramer (1969) inferred from collections of ripe females and young that spawning occurred in mid-June to early July when water temperatures reached 18°C. In Lake Mohave spawning occurred in May (Jonez and Sumner 1954 in Bozek *et al.* 1984). The optimum temperature for spawning was determined to be 20°C based on hatching success under hatchery conditions (Hamman 1985).

Fecundity was reported to average 25,090 eggs/female or 21,514 eggs/kg of body weight for fish ranging from 487–564 mm TL. Egg diameter ranges from 2.0–2.3 millimeters. Eggs incubated in 20–21°C water hatched in 97–174 hours and those at 12–13°C in 344 hours. The newly hatched fry averaged 6.8 millimeters. Fry swam to the surface at 48–120 hours and fed near the surface for the first 14 days (Hamman 1982).

Hatching survival changes with temperature. Marsh (1985) reported that eggs incubated at 5°, 10°, 15°, 20°, 25°, and 30°C had hatching successes of 0, 0, 35, 32, 0.5, and 0 percent, respectively. Hamman

(1982 reported in Hamman 1985) reported that eggs incubated at 20–21°C, 16–17°C, and 12–13°C had hatching successes of 90, 55 and 4 percent, respectively.

Eggs are adhesive as are the newly hatched prolarvae. Prolarvae are weakly motile after hatching and can apparently adhere to objects with the anterioventral portion of the head with the body extended perpendicularly. The mechanism of this adhesion is unknown (Marsh 1985).

Although sympatric in the Green River, spawning by BTC and roundtail chub is thought to be spatially segregated, but not temporally, since ripe adults of the same species were captured in separate gill net sets over the same period (Vanicek and Kramer 1969). Spawning was observed in Lake Mohave by Jonez and Sumner (1954 in Vanicek and Kramer 1969). An estimated 500 fish congregated over a gravel bar up to 9 m deep. Females were escorted by 3–5 males and adhesive eggs were broadcast on the gravel shelf.

Food Habits. Kirsch (1889) reported that the food of this fish collected on the Gila near Ft. Thomas consisted almost entirely of "Gasterpods" and "caddis-worms" which they crushed with their pharyngeals.

Vanicek and Kramer (1969) reported the combined food habits of BTC and RTC less than 200 mm long and those of BTC up to 390 mm long. Chironomid larvae and Ephemeroptera nymphs were the most abundant food items in small fish up to 50 mm long. As the chubs grew larger they consumed a greater diversity of food items including a variety of aquatic and terrestrial insects. The bonytails (distinguished at 200 mm TL) ingested terrestrial insects, plant debris, and filamentous algae. But, unlike the RTC did not consume fish. No seasonal or geographic differences in diet were found.

Age and Growth. The maximum length for BTC is 52 cm SL and large individuals from Lake Mohave show marks on their otoliths which indicate these may be more than 30 years old (Keading et al 1986, Holden 1980). The oldest and largest specimen collected by Vanicek and Kramer (1969) on the Green River was aged by scale to seven years, weighed 442 grams, and was 388 mm TL. They reported average total length (in mm) based on scale samples for roundtail and bonytail chub up to 200 mm and bonytail greater than 200 mm long: age 1—55; age 2—100; age 3—158; age 4—258; age 5—322 mm; age 6—355; age 7—373 millimeters.

The length-weight relationship for fish from the Green River was determined to be

$$\log Wgr = -4.7899 + 2.860 \log Lmm \text{ (Vanicek and Kramer 1969)}$$

E3.1.3 Flannelmouth Sucker (*Catostomus latipinnis*)

Status. The flannelmouth sucker (FMS) is the most common native "big-river" fish in the upper Colorado River basin (Tyus *et al.* 1982, Stalnaker and Holden 1973, Holden and Stalnaker 1975). Its distribution below the Grand Canyon has been reduced tremendously and Minckley (1985) recommended that it be considered a candidate for Federal listing in the lower Colorado River basin.

Description. This very large sucker has been reported to reached 1.5–2.0 ft long and 3–5 pounds (Jordan 1891). Some of the flannelmouth's morphology includes elongate, terete body; broad head flattened above; heavy, broad, blunt snout overhanging the mouth; very large, fleshy lips; slim caudal peduncle; and large falcate dorsal fin (Ellis 1914, Jordan 1891, Sigler and Miller 1963).

In clear water, FMS were brownish-green dorsally, yellowish or orange laterally, and white ventrally. In areas with sandy bottoms and turbid water, suckers were duller: light tan dorsally, and silver to white on the sides and belly (Holden and Stalnaker 1975). The ventral surface of the head has been reported to be pinkish (Sigler and Miller 1963).

FMS hybridize with *Catostomus* and *Xyrauchen* (Hubbs and Miller 1953, Minckley 1973, Holden and Stalnaker 1975). Because the FMS has not been studied extensively, little is known of its biology.

Distribution. Its former distribution most likely paralleled that of Colorado squawfish and razorback suckers (Minckley 1973). It inhabited the entire Colorado River basin in moderate to large rivers (Minckley and Holden 1980).

Habitat. FMS inhabit large rivers, are adapted for life in tributary streams (Sigler and Miller 1963, Holden and Stalnaker 1975), and are absent from impoundments (Minckley and Holden 1980). This sucker is typically found in pools, deeper runs, and often enters the mouths of small tributaries (Holden and Minckley 1980). However, Holden and Stalnaker (1975) reported collecting this sucker in all habitat types: fast current, riffles, eddies, and stagnant backwaters of mainstream rivers. Sigler and Miller (1963) characterized habitat for a typical river or stream, e.g., Hideout Canyon, Green River, as varying from 6–150 ft in average width with little or no vegetation and clear to murky water flowing up to 1800 cfs. The substrate often consists of rocks, gravel or mud. Depth of capture have ranged from 1–6 ft in depth in reaches with depths up to 20 ft. Young live in moderately swift to slow flowing marginal waters of swift-flowing streams in much shallower water than adults (Sigler and Miller 1963).

Distribution may be affected by water temperature. Suttkus and Clemmer (1979 in Minckley 1985) reported FMS in the Paria River remained there when temperatures exceeded those of the mainstream Colorado but moved into the Colorado as water temperature declined in the winter.

Spawning. McAda and Wydoski (1985) reported spawning habits of FMS in the upper Colorado River basin. In the Gunnison and Colorado rivers, first maturity was found to occur at age 4 for males, and most fish were mature by age 7. All female suckers longer than 490 mm were found to be mature. The smallest mature male was 391 mm and the smallest mature female was 405 mm TL.

Fecundity ranged from 4,000 eggs in suckers 450 mm long to 40,000 for a sucker 500 mm long. Mature egg diameter ranged from 1.97–3.15 averaging 2.39 millimeters. Fish from the Gunnison and Colorado rivers were significantly more fecund than those from the Yampa River.

Ripe males were collected in early April–June; ripe females were collected during May and early June. In the Yampa and Colorado rivers, ripe males and females were collected on upstream points of cobble bars in water about 1 m deep, with a water velocity of about 1 m/s. Although no spawning activity was observed, the collection of ripe females only over the cobble bars suggested spawning might occur nearby.

Minckley and Holden (1980) reported spawning occurs in the early summer at temperatures near 13°C in riffles over coarse gravel bottoms. Spawning in the Grand Canyon apparently occurs in the tributaries to the Colorado River due to constant cold, hypolimnetic releases from Lake Powell (Minckley 1985).

Food. FMS have been reported to be herbivorous to omnivorous (Ellis 1914, Minckley 1973). Ellis (1914) found seeds formed a large portion of the diet in fish collected in August from the Grand River. Other stomach contents included diatoms, algae, macrophytes, mud, and slime. In the Salt River, FMS may feed extensively on bottom invertebrates (Minckley 1973).

Age and Growth. FMS may live nine years or more (McAda and Wydoski 1985). Ellis (1914) reported that the largest suckers may reach 30 inches. Adult sizes are generally 300–400 mm SL (Minckley and Holden 1980).

McAda and Wydoski (1985) calculated total lengths (in mm) from scale annuli at different ages for FMS from four rivers in the upper Colorado River basin. Sizes are estimated from their graphically presented data: age 1—72; age 2—144; age 3—264; age 4—362; age 5—436; age 6—454; age 7—472; and age 8—486 millimeters. The incremental growth peaked at age 3 and decreased as fish became older.

The length–weight relationship for the Yampa–Green and Colorado–Gunnison rivers was

$$\log Wgr = -5.37 + 3.13 \log Lmm$$

and

$$\log Wgr = -5.21 + 3.09 \log Lmm$$

respectively (McAda and Wydoski 1985).

E3.1.4 Razorback Sucker (*Xyraunchen texanus*)

Status. The razorback sucker (RBS) is listed in Arizona as "state endangered" but was deferred from federal listing via a memorandum of understanding between the Arizona Game and Fish Commission and the U.S. Fish & Wildlife Service (Johnson 1985, Arizona Game and Fish Dept. 1988). After the creation of reservoirs on the Colorado and Salt rivers, RBS flourished initially but have declined over the years (Hubbs and Miller 1953, Minkley 1968, Johnson 1985). The long term status of reintroductions into the Gila, Verde, and Salt rivers is still unknown (Arizona Game and Fish Dept.). The razorback sucker was officially listed as endangered on 19 November 1991.

Description. The most distinguishing feature of the RBS is its nuchal keel, but it also possesses a depressed head, and flattened breast, all are purportedly adaptations to the high, torrential, flows of the Colorado River and its tributaries (Hubbs and Miller 1953). This unusual fish with its hump was known as "buffalo fish" or just "buffalo" where it was common. Huge adult RBS which reach 5–6 Kg and 1 m long live most of their lives in large, deep waters chiefly in main channels of rivers and larger tributaries (Hubbs and Miller 1953, Jordan 1891).

RBS possess unusually long, fuzzy gill rakers similar to those of the planktivorous, lacustrine, Catostomid *Chasmistes* (Hubbs and Miller 1953). Such rakers are an effective adaptation for the capture and consumption of minute organisms. This fish also has a long digestive tract, over three times its body length (Dill 1944), poorly differentiated stomach, no pyloric caecae, and well developed hearing (Loudermilk 1981).

Xyraunchen hybridizes with *Catostomous* which commonly hybridizes interspecifically in nature (Hubbs and Miller 1953). They suggested that these suckers spawned in small streams where other species of

catostomids also spawn or did so in the past before modified stream conditions. RBS were said to migrate on spawning runs according to early reports (Jordan 1891).

The razorback sucker is so rare that basic life history information is difficult to obtain, and its specific habitat requirements remain largely unknown (Tyus 1987).

Distribution. Presently, RBS occur in the UCRB and in lakes Mead, Mohave, and Havasu on the lower Colorado, but were once widespread throughout the larger rivers of the Colorado River basin including the Gila, San Pedro, Salt, and Verde rivers (Holden 1980, Minckley 1973).

Habitat. Bulkley and Pimentel (1983) found adult thermal preferenda to lie between 22.9° and 24.8°C based on electronic shultbox studies. Upper and lower avoidance temperatures were estimated at 27.4–31.6°C and 8.0–14.7°C, respectively. Bozek *et al.* (1984) reported hatching and development time were strongly affected by water temperature. Hatching was not successful below 8°C and was reduced at 10°C but was similar in success at temperatures from 12–20°C. Hatching and development time were strongly influenced by temperature. For example, during experiments up to 22 days were required at 10°C for hatching but only seven days at 20°C.

The habitats of RBS and CSF are similar, although the suckers are more likely to frequent marshes, lakes and quieter parts of rivers (Minckley and Deacon 1968). RBS seem to avoid whitewater habitat in rivers and were most abundant in flat-water sections in the Green River (Tyus 1987). Because of their apparent preference for deep water, they are rarely observed in reservoirs except during spawning (need ref). In the upper basin Holden and Stalnaker (1975) collected RBS almost exclusively in stagnant, quiet backwater areas. Radio-tagged suckers in the Green and Duchesne rivers showed similar preferences for depth (0.6–3.4 m) and velocity (0.0–3.4 m) (Tyus 1987). These fish were found most commonly in runs near shore during the spring and on mid-channel sandbars in summer until July when all radio-tagged fish moved to deep pools. These bars were composed of unconsolidated coarse sand with dips and ridges in water less than 2 m deep and mean velocity over the bars was 0.5 m/s. Holden and Stalnaker (1975) reported that 10–15 suckers used a quiet cut off channel at the mouth of the Yampa in March and November and concentrated in the mouths of washes in Canyonlands National Park during high water in the early summer.

Six young-of-the-year collected in the Green River showed a preference for eddies with a velocity of about 0.2 fps, depth of 1.0 ft, and substrate consisting of soft silt (Holden 1977). Bozek *et al.* (1984) pointed out the habit of subadults to use macrophytes, e.g., the use of *Chara* beds in hatchery ponds, which rendered them nearly impossible to view or seine in a stream-pond system at UNLV. They suggest that this explains, in part, why investigators may not have collected many subadults in reservoirs.

A radio-tagged sucker was released in early May and monitored for two weeks (McAda and Wydoski 1980). Although this fish was usually found in quiet water near shore, it was found twice in swift, shallow water on the outer edge of a gravel bar where it remained four hours on one occasion in water only 0.3 m deep. The physical characteristics of the site were similar to those of nearby spawning areas. The other four radio-tagged RBS were only found in quiet water.

Spawning. RBS eggs are 2.1–3.2 mm in diameter and hatch in 96–168 hr at 20°–22°C. Upon hatching larvae are 5–7 mm long and swim to the surface after 6–7 days (Toney 1974, Hamman 1985). For 2–3 days after swim up, post larvae in aquaria used the upper one-third of the water column and displayed

little tendency to seek shelter. Loudermilk (1981) suggested that these fish would have been carried away in a mild current. After this period they moved to the bottom and began feeding on or near the substrate and used cover when disturbed. After 15 days from hatching, they rarely entered the upper 1/2 of the water column.

Male RBS grown in hatchery ponds became sexually mature in as little as two years (with some individuals less than 350 mm TL) while females mature in three years at an average length greater than 390 mm TL (Hamman 1985). Breeding males are dark-olivaceous to black dorsally, with a bright-orange belly, and dark-pink to reddish lateral band. Males are covered with tubercles which are located on the anal fin, pectoral fins, pelvic fins, lower lobe of the caudal fin, and along sides both above and below the lateral line, and on the ventrum of the caudal peduncle. Breeding females remain olivaceous dorsally, which fades to off-white, yellowish, or mottled ventrally. Females may have small, low profile tubercles on their anal fin, lower lobe of the caudal fin, and below the lateral line on the caudal peduncle (Minckley 1983).

Local testimony to Jordan (1891) and later to Hubbs and Miller (1953) indicated that RBS made rather extensive upstream spawning migrations but are capable of spawning in lentic environments such as reservoirs (Bozak *et al.* 1984, Minckley 1983, Douglas 1952, others), and hatchery ponds (Hamman 1985).

Hamman (1985) found the mean fecundity to be 49,838 ova/kg (range 12,398–142,686/fish) for 3-year-old, female hatchery-reared suckers. Minckley (1983) found that RBS from L. Mohave produced 1,680–1,908 ova/cm SL or 74,600–144,000/fish and found similar fecundities, based on standard length, for RBS from the Green River, reported by McAda and Wydoski (1980).

Results from hatchery propagation of RBS show the optimum temperature to be 20–22°C (68–71°F) (Inslee 1982, Hamman 1985). However, the widest range of spawning temperatures was 10–20°C reported for L. Mohave (Bozek *et al.* 1984). Large aggregations of spawning suckers in November were comprised mostly of ripe males (3.0:1, 90% ripe) and nonripe females (15% ripe). Peak spawning occurred January–February and subsided in May when water temperatures exceeded 20°C. Minckley (1983) reported male:female sex ratios of 1.8:1 and 3.57:1 for pre-spawning and spawning periods, respectively.

Lentic Conditions. Razorback suckers use lap-zone gravel substrate for spawning in reservoirs of the lower Colorado River (Loudermilk 1981). Douglas (1952) reported observations of RBS spawning in Lake Havasu during March 1950 which are considered typical and generally agree with observations by other authors (Minckley 1983, Bozek et al 1984, Mueller 1989). He observed two groups of spawning suckers moving along lake margins approximately 15 ft from shore and 18 in. deep. The following is the description he provided of the spawning act, "in group one six fish were noted revolving clockwise at a slow rate in four foot diameter circles. Suddenly the caudal fins of all fish began to vibrate violently and one fish jumped clear of the water. It appeared that five of the fish, presumably males, were exerting pressure on one fish, presumably a female; three were crowded together on the female's right side and two on her left. The two most proximate males were pressing against the sides of the female with their heads just behind her hump. Ensuing violent motion raised bottom silt so that further observations were prohibited. Following the spawning act the fish separated and moved away singly." Loudermilk (1981) reported that RBS practice multiple spawning with a small percentage of gonadal material released with each spawning act. Densities of eggs measured in redds by Mueller (1989) substantiate this. Samples

taken from spawning depressions yielded only 10.5–16.7 eggs/m_2 and 0.7–5.7 larvae/m_2. RBS eggs are transparent and adhere to gravel and rocks (Sigler and Miller 1963).

In L. Mohave, Bozek *et al.* (1984) reported that spawning was so intense that individual redds were hard to distinguish with "thousands" of fish observed spawning over gravel flats. Groups of 4–8 males would join and follow a female entering the spawning area from deeper water or join one already in the area. Males remained close to the female until she settled to a location on the bottom. With two males on each side of the female, the group would begin to vibrate rapidly, resulting in the deposition of eggs over and within the gravel substrate. A large number of redds were positioned near isolated boulders. Under laboratory conditions, eggs deposited on gravel quickly fell into interstitial spaces and became attached to the substrate. In spite of intense spawning activity eggs were rarely observed on the surface of redds and only a few were collected in substrate samples (Mueller *et al.* 1981 in Bozek *et al.* 1984).

Bozek *et al.* (1984) reported the frequent use of redds 0.3 m deep and that spawning predominantly occurred in water less than 1 m deep. Mueller *et al.* 1982 (in Bozek *et al.* 1984) reported similar spawning depths and Minckley (1983) reported that spawning occurred at depths less than 5 meters. Douglas (1952) reported spawning at depths that ranged from 0.25 to approximately 1.8 m. Bozek *et al.* (1984) characterized spawning habitat as gravel or gravel mix substrate in shallow areas having flat, shelf-like morphometry along shoreline or in the mouth of inundated gravel washes and Minckley (1983) mentioned the reported use of inflowing hotsprings. The latter author also reported that the greatest concentrations of suckers were found over gravel, cobble substrate. Redds measured in L. Mohave, many of which contained eggs, were comprised mostly of large gravel, located at depths of 0.6–3.44 m, and ranged in size from 0.25–4.0 m^2 with the majority measuring 0.5 m^2 (Mueller *et al.* 1982 in Bozek *et al.* 1984).

<u>Lotic Conditions</u>. Spawning under lotic conditions has been reported by several investigators. Mueller (1989) used SCUBA equipment to observe spawning RBS in the clear flowing water below Hoover Dam in the winter (January–March). Spawning activities were found to be restricted to a 300 m_2 area of scoured sands and gravels from an adjacent dry wash. One redd was found in late-January but most spawning activity occurred in February and March. Vigorous and repeated activity disturbed substrate and resulted in redds measuring 0.25–1 m^2 at depths from 1.2–2.0 m and mean water velocities ranged from 0.0–0.37 m/s. Spawning fish flushed away fine materials leaving gravels and cobbles. Although spawning occurred from January–March, eggs and larvae were recovered from redds only in January and February. In one case many eggs and larvae were found immediately downstream in large cobble substrate, probably the result of drift.

Historically, RBS may have also used smaller tributaries with pool-and-riffle habitat to spawn before returning to the larger river channel. Jordan (1891) reported that RBS and other large native fishes of the Colorado River ascended the medium-sized Rio Animas "in the spring, going back to deep water after spawning in the summer." Collections of this fish and hybrids in Tonto Creek may provide evidence for this contention (Hubbs and Miller 1953).

Spawning behavior under lotic conditions was reported to be similar to that in reservoirs. On spawning beds below Hoover Dam, small fish (40 cm TL) which appeared to be males maintained stationary position on the downstream end of the spawning site. Larger fish, presumably female, periodically moved into the spawning area from the adjacent river attracting some of the otherwise stationary males to form groups of 3–8 fish with only one female. These groups would spawn over depressions while

oriented into the current, or swim around the area before dispersing. The spawning act only lasted a few seconds (Mueller 1989).

Temperatures that accompanied active spawning ranged from 6–16°C on the Colorado and Yampa rivers in April and May (McAda and Wydoski 1980). RBS in spawning condition were collected over gravel bars with cobble substrate at depths from 0.7–1.0 m and velocities of 0.89–0.95 m/s. Tyus (1987) captured 101 RBS in spawning condition from May 3–June 15 in the upper Green River. Radio-tagged suckers showed variation in spawning activity from year to year. Some RBS moved between suspected spawning areas within one season while others moved between them in successive seasons. Most ripe fish were collected over coarse sand substrate, but some were collected near gravel and cobble bars. Water temperatures ranged from 10.5° (on May 10) to 18°C (on June 14) and ripe females were collected at water temperatures from 11.5–18°C. Some RBS were found to stage in eddies before spawning (Tyus 1987).

Movements. Paulin *et al.* (1989 in press) found RBS larvae to drift less than CSF even though they were at an earlier developmental stage. They concluded from laboratory drift studies on two-week-old RBS that downstream drift of larvae and post-larvae was common at night, especially when water velocity exceeded 3 cm/sec. Brooks (1985 meetings) also found that young RBS drift downstream at night. Tyus (1987) followed the movements of RBS in the Green River and found that about half of the suckers were sedentary (did not move more than 10 km) while the rest moved great distances averaging 59.3 km from the point of release (range was 13–206 km). The fish that moved 206 km did so in five years. Some fish moved to suspected spawning areas within one season, while others moved between them in successive years.

Of radio-tagged RBS, 21 were recaptured at least once and were found at two or more suspected spawning areas. Some fish moved upstream while others moved downstream to these areas (Tyus 1987). McAda & Wydowski (1980) tagged a female that was capture 21 km from its initial location after two weeks in the mouth of the Yampa River. It was ripe and probably spawning. The authors felt that this may have represented a migration to a spawning area. Some RBS remain at the mouth of the Yampa from late fall through the winter and are joined the following spring by others from the Green River possibly to spawn during the spring. Suckers apparently leave the mouth of the Yampa in late spring or early summer as stream flows decrease and water temperatures increase.

In October an adult female was monitored for three days in an inundated gravel pit along the Colorado. Diurnal observations during October revealed it remained below 3 m most of the time and was most active in the late evening (1900–2200 hr) and late morning (1000–1200 hr). The activities of this female and that of two male RBS the following spring were such that these fish were never tracked together in the pond and appeared to move independently of one another (McAda and Wydoski 1980).

Food Habits. Hubbs and Miller (1953) reported plankton between gill rakers and pharyngeal pads of preserved RBS from museum collections. Adult suckers (378–530 mm SL) from L. Mohave were analyzed for gut contents. Marsh (1987) found the animal component of the stomach contents was dominated by planktonic crustaceans. *Bosmina* sp. was the most abundant animal ingested, found in 100 percent of digestive tracts, followed by *Daphnia* sp., rotifers, benthic ostracods, copepods, and chironomid larvae. Plant material consisted of the diatom *Fragillaria crotenensis*, found in nearly 90 percent of digestive tracts, and filamentous algae. Detritus occurred in 56 percent of digestive tracts.

Dill (1944) examined gut contents of four RBS from the Colorado and found silt rich in microscopic organisms, especially diatoms and filamentous algae.

Others have found midge larvae and algae; algae and plant debris, along with Ephemoptera, Trichoptera, and larval Diptera; mud containing chironomid larvae and plant material (McAda and Wydoski 1980). Minckley (1973) reported that RBS taken in May in L. Mohave had their entire digestive tracts filled with planktonic crustaceans. He observed RBS feeding at a depth of 6 meters. In general, RBS are both planktivorous and benthic feeders, with anatomy apparently adapted to retaining extremely fine food and food of low nutrition or resistant to digestion.

Age and Growth. The age structure and growth of RBS has not been established for various waters inhabited by RBS because of unreliability in reading scales (McAda and Wydoski 1980, Minckley 1983, Bozek *et al.* 1984). However, some otoliths have been read. Bozek *et al.* (1984) reported that 17 RBS from L. Mohave aged by Arizona Game and Fish Dept. were 30–32 years old. A male sucker 662 mm long from California was aged at 22 years (McAda and Wydoski 1980). A 560 mm sucker collected from the Green River was estimated to be 19 years old (Tyus 1987).

The length weight relationship reported for RBS from the Colorado River was

$$\log Wg = 3.16 \log TLmm - 5.36 \text{ (McAda and Wydoski 1980)}$$

Adult females are generally larger than males (McAda and Wydoski 1980, Minckley 1983, Bozek *et al.* 1984, Tyus 1987).

Toney (1974) reported that fry in raceways grew 35 mm in 1.5 months and reached a maximum of 76 mm TL in 2.5 months on a diet of Daphnia and black fly larvae. Hamman (1985) reported that RBS grew faster in earthen ponds than raceways, but provided few details.

RBS from the lower Colorado River basin appear to grow faster than those from the upper Colorado River basin based on comparisons with fish from L. Mohave (McAda and Wydoski 1980, Tyus 1987). RBS from L. Mohave ranged from 448–705 mm TL and from 0.97–4.5 kg (Bozek *et al.* 1984). These measurements are higher than those reported from the upper basin by McAda and Wydoski (1980).

After reaching adulthood, RBS may continue to grow at a very slow rate. McAda and Wydoski (1980) recaptured a fish tagged 1.5 years earlier which showed no growth and an additional scale annulus could not be found. Another recaptured sucker 508 mm grew only 8 mm in 3.5 years. Minckley (1983) reported that RBS in L. Mohave grew only 0.5 cm/year since 1964 based on size–frequency distributions.

Predation and Disease. Brooks (1985 AZ–NM meetings) found that stocked fingerling RBS in the Gila River were heavily preyed upon by flathead catfish and to a lesser extent by channel catfish. Minckley (1983) noted incidents of direct predation on RBS eggs by channel catfish and carp reported by others. Bluegill, smallmouth bass and largemouth bass were also implicated in depredation in reservoirs. Marsh and Brooks (unpubl. draft 1986–1988) showed juveniles stocked in the Gila River during autumn were consumed by flathead and channel catfish at an estimated rate of 900 individuals/km, but predation slowed in the winter when channel catfish did not feed as actively. Brooks (1986) found stocked fingerlings to be in 46 percent and 79 percent of channel and flathead catfish stomachs, respectively.

Bozek *et al.* (1984) analyzed the stomach contents of 201 carp and 63 catfish from L. Mohave. Although carp had appeared to be feeding directly on eggs, none could be found in stomachs, and only four catfish had eggs in their stomachs. They concluded that predation of eggs certainly exists but may not be a major source of mortality. However, Minckley (1983) believes predation on eggs and larvae to be a major factor in limiting recruitment in the L. Mohave population.

A high incidence of disease was found in the L. Mohave population (Minckley 1983, Bozek *et al.* 1984). Bozek *et al.* (1984) observed that the incidence of gross bacterial infection was higher during spawning months and decreased noticeably after the spawning period had ended in May. The infections were significantly more prevalent in ripe females than non-ripe females. They suggested that the abrasions resulting from spawning may have contributed to the cause of illness. A large percentage of RBS in L. Mohave were blind, diseased, and appeared to be old. Bozek *et al.* (1984) reported that 40 percent of the fish examined were blind in at least one eye. Similar findings were reported by Minckley (1983). He also reported that an average of 7.3 large (all were greater than 50 cm) RBS carcasses/km were found along the shoreline of L. Mohave in the spring of 1979. No explanation for the mortality was provided.

Minckley (1983) suggested that old RBS, probably from year classes produced in the early 1950s, grew an average of 7 cm in their seventh year and less than 1 cm in 1964 and there after (based on growth rates of known age fish and on size–frequency distributions of fish caught in L. Mohave).

Bozek *et al.* 1984 almost all sampling occurred during spawning season in spawning areas where only adult fish would be expected. The RBS fishery in Saguaro Reservoir provided 6 tons to local commercial fisherman in 1949. The suckers were so abundant at times that 500 were harvested in a single day with grab hooks used to snare individuals among spawning aggregations (Minckley and Deacon 1968, Hubbs and Miller 1953, Sigler and Miller 1963). When Saguaro Reservoir was drained in 1966, no RBS were found; apparently this population had been extirpated (Minckley and Deacon 1968).

Populations in the lower basin reservoirs are thought to be declining. Even the L. Mohave population is believed to be comprised of old, senescing individuals because few young fish have been found (Minckley and Deacon 1968, Johnson 1985, Minckley 1983).

Holden and Stalnaker (1975) reported that RBS were rare in the middle and Upper Colorado River Basins and collected them almost exclusively in stagnant, quiet backwater areas.

E3.1.5 Desert Sucker (*Catostomus clarki*)

Status. The desert sucker (DS) is generally common (Minckley 1980). As with all native Arizona fishes, the DS has declined since the arrival of European settlers in the southwest. Southern DS populations are becoming rare due to reductions of surface waters. Populations in other areas in Arizona and New Mexico seem relatively stable (Minckley 1985).

Description. *C. clarki* is broadly sympatric with *C. insignis* (Sonora sucker) and the two commonly hybridize. Miscegenation is geographically widespread (Clarkson and Minckley 1988).

In large rivers, such as the Verde River, specimens more than 350 mm and 0.5 kg are common (Minckley and Alger 1968). The DS has specialized adaptations for herbivory, the most specialized being its cartilage-sheathed jaws for scraping algae from solid substrate. This fish has a terminal mouth with large lips and small papillae on both the lower lip and the oral surface of the upper lip. The peritoneum

is black to dusky, enclosing intestines up to 8.8 times the fish's standard length (Smith 1966 in Minckley 1973). Minckley (1973) is convinced that the large variation in morphology for this complex is due to the presence of more than one species. He also believes in the retention of the genus *Pantosteus* for this species.

This species has not been studied extensively, resulting in many gaps in the literature concerning even basic biology.

Distribution. This species occupies the lower Colorado River basin downstream from the Grand Canyon. This includes the pluvial White River and Meadow Valley Wash in Nevada; the Virgin River basin in Utah, Arizona, and Nevada; the Bill Williams River basin in Arizona; and the Gila River drainage in Arizona, New Mexico, and northern Sonora, Mexico (Minckley 1980).

Habitat. The DS is highly resistant to high water temperatures, intermittency and other low-desert adversities (Minckley 1985). *Catostomus clarki* is able to withstand low oxygen concentrations which contributes to the survival of the species under catastrophic conditions. In oxygen depletion experiments, Lowe *et al.* (1967) reported no deaths of DS until oxygen levels fell below 1.5 ppm. This fish can survive under highly crowded conditions and reduced flow for long periods of time (this report).

Desert suckers are generally found in small to moderately large streams with pool-riffle development (Minckley 1980). Smaller individuals (< 300 mm long) of this species live in shallow, swift riffles over boulder–gravel bottoms (Minckley and Alger 1968). Large suckers occupy deep channels and flowing pools (Minckley and Alger 1968). This species achieves its greatest abundance in hard bottomed streams of intermediate elevation but can also ascend as high as 1,800 m in mountain brooks and downstream into low-desert creeks, rivers, and canals (Minckley 1985, Marsh and Minckley 1982). The desert sucker and Sonora sucker are often syntopic in deeper habitats (Schreiber and Minckley 1981, this report). The shifting bottoms of the lower Gila River apparently formed a barrier to this species which has not been recorded downstream from the confluence with the Salt River (Minckley 1985).

Large individuals in Aravaipa Creek occurred in pools and, to a lesser extent, riffles. Small adults and young are predominately riffle fish, especially over gravel–rubble bottoms. The very young lived in warm quiet backwaters along the stream, moving into faster water as juveniles, then into riffles, pools or pool-like areas as adults (Barber and Minckley 1966). The DS were associated with more turbulent waters in Aravaipa Creek moving from protected places near boulders into riffles and rapids, then returning. Large adults frequent strong flowing, deeper waters near undercut banks and obstructions (Schreiber and Minckley 1981).

Ivanyi (1989) reported DS from small creeks in southern Arizona appeared to be associated with pools with cover such as undercut banks, tree branches, logs, other debris and high water flow in, around, or through pools. Fry were found in backwater pools with fine substrate such as silt or mud. Pool substrate varied from 100 percent and to 30–40 percent cobble mixed with sand and gravel. Adult fish did not use pools with silt or mud substrate and were rarely found in riffles.

The habitats used by *C. clarki* reported here varies widely. Minckley (1973) generalized habitat use which corresponds largely to our observations of this sucker in eagle nesting territories. He stated, "they tend to live more in rapids than in pools, or at least move to swift areas to feed and spawn as large adults, while living in flowing pools during the day".

Spawning. Minckley (1980) reported that spawning occurs January–May, but we observed spawning or spawning related activity from March–June in the Salt River below Stewart Mountain Dam. The conditions there are not natural with retarded spring warming due to releases from the reservoir. Ivanyi (1989) reported spawning to have occurred in late May and possibly in June for suckers in southern Arizona creeks. Male and female DS showed enlarged gonads from late January–April. Males had tubercles on the anal and caudal fins. Spawning coloration in males was expressed as a horizontal stripe pattern February to mid-April. Female suckers did not have tubercles or display any sexually related change in color (Ivanyi 1989).

In southeastern Arizona, gravid females averaged 1,140 eggs/female (range 450–2,772) and eggs measured 1–2 mm in diameter during the reproductive season.

Movements. Siebert (1980 in Ivanyi 1989) found that DS moved away from a gorge area in the winter and came back in the summer in Aravaipa Creek. This movement was believed to be influenced by high temperature avoidance in the summer. Movements such as these were not reported by Ivanyi (1989) or Bestgen *et al.* (1987) in other waters.

Food Habits. The DS is largely herbivorous feeding on diatoms and other types of algae which it scrapes from rocks and other surfaces by pulling its body along with its lips. Not all algae are preferred as forage. This species showed an avoidance of *Cladophora glomerata* preferring instead its epiphytes, e.g. diatoms and *Oedegonium* (Schreiber and Minckley 1981).

For DS from Aravaipa and Bonita creeks, invertebrates represented 10.2 and 18.2 percent of the ingested volume with a frequency of occurrence of 51.6 and 88.9 percent, respectively. However, invertebrates were far less important by volume than vegetative material in the diet of the DS. Detritus and sand were also ingested. Sand comprised up to 53 percent of the stomach contents in fish from Aravaipa Creek (Clarkson and Minckley 1988). This sand was thought to have been sieved and trapped by epilithic and epiphytic foods in riffles and later ingested by DS.

In Sycamore Creek, Maricopa Co., DS fed both day and night with crepuscular peaks (Fisher *et al.* 1981). Feeding time increased when food was scarce (of course). These fish consumed benthic diatoms and small amounts of detritus. Ivanyi (1989) found that the DS was primarily a herbivore and fed on plant matter. Fry fed almost exclusively on diatoms. The primary foods of suckers from Preston Springs were amorphous plant material, diatoms and filamentous algae (Williams and Williams 1982).

In Aravaipa Creek, Dipteran larvae were a common component of the diet in January and April as were tubellarians in July. Baetid mayflies were a common component of the diet the following January as well. Bottom dwelling tubellarians were used by DS in April until July when they made up more than 40 percent of the stomach contents. The flatworms were abundant on riffle bottoms at that time. Schreiber and Minckley (1981) concluded that some degree of facultative use of invertebrates was indicated. Filamentous algae was the major component of the diet throughout the year.

C3.1.6 Sonora Sucker (*Catostomus insignis*)

Status. This species has declined, especially in the southern half of its range, but is generally common (Minckley 1980). In the Gila River, the Sonora sucker (SS) remains one of the most widespread native fish (Minckley 1985).

Description. The SS is similar in size to the flannelmouth sucker, commonly exceeding 400 mm TL. The largest individuals have been reported to reach nearly 800 mm TL and weighed over 2 kg.

This species is a carnivore with a chubby, fusiform body, large lips, deep caudal peduncle, large scales, and bicolored appearance. The ventral surface varies from pure white to yellow and the upper surface is dark. The line of division between dark and light is sharply defined and located 3–5 scales below the lateral line (Minckley 1973, Snyder 1898).

Hybridization was known to occur with the razorback sucker (Hubbs and Miller 1953) and has been reported to occur with the broadly sympatric desert sucker (Clarkson and Minckley 1988) in the Gila River system. Like the desert sucker, this fish species has been little studied.

Distribution. This species is widely distributed between 300–2,000 m elevation in the Gila and Bill Williams river basins of Arizona and New Mexico. This includes the headwaters of the San Pedro and Santa Cruz rivers in northern Sonora, Mexico (Minckley 1980).

Habitat. This fish is associated with gravelly or rocky pools of creeks and rivers (Minckley 1980) and is typically a pool dweller, living near undercut banks, boulders, logs or other debris (Schreiber and Minckley 1981). It has been reported to frequent mid-depths and the surface in search of food (Minckley 1973, Schreiber and Minckley 1981). The lentic habitats of reservoirs are not conducive to Sonora suckers which disappear after a few years of impoundment (Minckley 1973, Minckley 1985).

Minckley (1980) reported that large suckers tend to remain in cover during daylight but move into runs and deeper riffles at night. In Aravaipa Creek, it has been collected from riffles but was rare in shallow, turbulent areas. However, smaller individuals may frequent these areas (Barber and Minckley 1966).

Spawning. Bestgen *et al.* (1987) reported an extended spawning season from March until May. This time frame was estimated by collections of larvae fish. Minckley (1973) reported a spawning season from February through at least early July with little correspondence of peak spawning for any specific pattern of stream flow or temperature. He noted that Sonora suckers appear to have reproductive failure in some years.

According to Minckley (1985), stocks in the Salt River apparently are not self sustaining but result from dispersal from the Verde River. This lack of recruitment occurs in unnaturally cold water produced by releases from upstream dams.

Movement. Bestgen *et al.* (1987) found only two SS out of 53 recaptures had moved appreciably. After 160–170 days these recaptured fish had traveled 4 and 5.3 km upstream. Movement was apparently low despite of two potentially displacing flood events.

Food. The Sonora sucker is principally a facultative insectivore which, at times, will ingest algae, mud, seeds and other plant material (Schreiber and Minckley 1981, Minckley 1973, Clarkson and Minckley 1988, Minckley 1985). This sucker in Aravaipa and Bonita creeks was found to consume, by volume, 60.5 and 54.8 percent animal material, respectively. They consumed primarily Ephemeropteran nymphs. Sand, up to 9.4 percent total volume, and detritus were also ingested (Clarkson and Minckley 1988).

Sonora suckers also exhibit opportunistic traits. The consumption of invertebrates often, but not always, followed their abundance patterns in the environment (Minckley 1973, Schreiber and Minckley 1981). In Aravaipa Creek the SS used 38 food categories with a 44 percent food overlap with the other fishes found in the creek. Baetid nymphs and chironomid larvae were important food items. Foods most unique to this fish were tiny, bottom dwelling forms such as acarina and microcrustaceans.

Minckley (1973) reported that cottonwood (*Populus fremontii*) seeds may be taken seasonally. The fish lift their head clear of the water to suck at the seeds that accumulate behind obstructions. Young have been reported to feed along the margin of streams upon tiny crustaceans, protozoans and other plant and animal groups (Minckley 1973).

E3.1.7 Roundtail Chub (*Gila robusta*)

Status. This species is relatively abundant and is one of the few native sport fishes in Arizona (Neve 1976, Ziebell and Roy 1989).

However, the roundtail chub (RTC) has declined in this century, and Bestgen (1985) estimated a reduction in range of 20 percent.

Description. There are four subspecies of this large minnow including *G. r. jordani, G. r. grahami, G. r. robusta,* and *G. r. seminuda* (Holden and Minckley 1980). The scope of the following discussion will be limited to *G. r. robusta* and *G. r. grahami*. However, Minckley (1985) reported that the taxonomic status of *G. r. grahami* is questionable as it was not found to be distinguishable from *G. r. robusta* by R. R. Miller. As mentioned for *G. elegans*, there has been much taxonomic confusion concerning the *Gila* complex.

The RTC is adapted for life in lotic environments although not nearly as well for swift water as the bonytail chub. Some components of its morphology includes streamlined body, small scales, slightly falcate fins, and slender caudal peduncle (Miller 1946). In large individuals, the back may be greatly arched and the head flattened and concave in outline (Snyder 1915). When it occurs in the absence of the squawfish or bonytail, it can be considered the dominant native carnivore by virtue of raptorial pharyngeal teeth; expansive, terminal mouth; and opportunistic, carnivorous feeding habits. In some populations, females have been shown to be significantly larger than males from the same area (Neve 1976).

Distribution. RTC occurred throughout the Colorado River basin, south through the Rio Yaqui basin, to Rio Piaxtla, Sinaloa, Mexico (Holden and Minckley 1980). The fish was regarded as very abundant in the Salt River where it exceeded all other fish in number but was not found in the mainstream Colorado River (Gilbert and Scolfield 1989).

G. r. grahami inhabits tributaries of the Gila, Salt, and Verde rivers including the Black, and East Verde as well as Aravaipa, Fossil, and Tonto Creeks. This subspecies is apparently restricted to headwater areas and is further isolated by barrier falls (Neve 1976).

Habitat. RTC generally occur in warm streams and were replaced in the larger, swifter river channels by bonytail chub (Gilbert and Scofield 1898, Jordan 1891, Holden and Minckley 1980). Holden and Stalnaker 1975, reported that numbers diminished rapidly from the downstream portions of rivers as the largest stream orders were approached.

The occurrence of RTC in all habitat types from riffles to stagnant backwaters has been documented (Holden and stalnaker 1975, Neve 1976). The preferred RTC habitats in rivers was listed by Tyus *et al.* (1982) as channels with boulders or overhanging cliffs; riffles, shallow runs, eddy/run interfaces. In the Green River, where RTC occur sympatrically with bonytail chub, both were found to occupy pools and eddies over silt boulder substrate in the absence of, but some times adjacent to, strong current (Vanicek and Kramer 1969).

While young frequent the margins of flowing water, adults prefer shaded, deep pools, especially those with overhanging cover provided by vegetation, undercut banks, boulders, logs, roots, or other debris (Vanicek *et al.* 1970, Neve 1976, Bestgen 1985, Minckley 1985, Holden and Minckley 1980, Ziebell and Roy 1989). In the Verde River, RTC were associated with riffle-pool habitat about 2 m deep with undercut banks and cover. Where these habitats were lacking, RTC were also lacking. The study area covered 85 km of river but only 5 km (6%) contained 85 percent of the chubs collected (Ziebell and Roy 1989).

Spawning. RTC become sexually mature by age 2 or 3 but the age of sexual maturity can vary up to two years among populations and occurs sooner in small streams (Bestgen 1985, Neve 1976, Minckley 1985). Breeding tubercles are present on both males and females. Muth *et al.* (1985) reported that males have tubercles distributed uniformly over theirs bodies while females have tubercles restricted to the head, opercula, and caudal peduncle. Both sexes had moderate to bright orange-red coloration on the ventrolateral surfaces and all fins except the dorsal fin. Neve (1976) reported the protrusion of the genital papilla in females prior to spawning.

Neve (1976) observed RTC spawning in March in Fossil Creek. Several males escorted a single female and the spawning act occurred in a pool–riffle area. Males were in close contact with females. Gametes were released 6–10 cm over sand–rock substrate. Females then moved to the bottom for varying lengths of time and often rose from the bottom to resume spawning activity. Ripe chubs which may have been close to spawning were collected in the Yampa River at a depth of 1.0–3.0 m deep, velocity 0.2–0.4 m/s, over silt covered gravel (Muth *et al.* 1985).

The yellow eggs are adhesive and ranged 1.2–2.1 in diameter from fish in Fossil Creek. Eggs from the Yampa River ranged 1.6–2.4 mm in diameter before fertilization and 2.5–3.1 afterwards (Muth *et al.* 1985, Neve 1976). At 19°C, eggs hatched in 126–156 hours with 94 percent success under hatchery conditions (Muth *et al.* 1985). In Fossil Creek, females had a fecundity of 1,000–4,300 mature eggs/female (100–260 mm long) while those from the Yampa River had a fecundity of about 34,760–37,546 eggs/female (444–455 mm TL) for fish 5–7 years old (Neve 1976, Muth *et al.* 1985).

Bestgen (1985) stated that temperature is an overriding environmental cue in this chub's reproductive cycle. RTC from the upper Colorado River basin spawn when temperatures reach approximately 17–19°C in mid-June to mid-July (Vanicek and Kramer 1969, Muth *et al.* 1985). Chubs in Fossil Creek spawned in March, May, and June (Neve 1976). In the upper Gila River basin they spawned in late spring to early summer (Bestgen 1985). Vanicek and Kramer (1969) reported that, although sympatric in the study area, bonytail chub and RTC spawning appeared to be isolated spatially but not temporally.

Movements. Siebert (1980, in Ziebell and Roy 1989) reported roundtail chub moved a maximum distance of 4.5 km but 1–2 km was more usual. Ziebell and Roy (1989) reported that one chub recaptured on the Verde River had moved only 100 m from its original release point.

Food Habits. Neve (1976) classified the trophic relationship of the RTC as opportunistic omnivore. "Because of the diversity of the types of organisms consumed by the chubs, it seems apparent the fish exploit every habitat available in the stream for food sources. These habitats include backwaters, sediments, riffle areas, vegetation and the water surface." Although RTC primarily eat aquatic insects, the range of food items is wide from invertebrates to vertebrates including gastropods, crayfish, fish, frogs, and lizards (Bestgen 1985, Snyder 1915, Schreiber and Minckley 1981, Vanicek and Kramer 1969). Mastication of some food items occurs and filamentous algae, sand and detritus may occur in stomachs (Schreiber and Minckley 1981).

Small chubs (less than 50 mm long) from Fossil Creek consumed only diatoms and filamentous algae with no apparent seasonal variability (Neve 1976). Small chubs from the Green River primarily consumed chironomid larvae and Ephemeroptera nymphs (Vanicek and Kramer 1969). In Fossil Creek, adults consumed primarily insect larvae: chironomidae, formicidae, Diptera, Hymenoptera, Coleoptera, Trichoptera, Odonata, and Ephemeroptera. Diatoms, algae, ostracods, lizards, and macrophytes were also eaten. No fish were eaten and plant material did not appear to have been digested. Seasonal variation in food habits was observed for adults (Neve 1976). In the Green River, RTC and bonytail chub (50–200 mm long) consumed a greater diversity of food items than smaller chubs. Adult chubs (greater than 200 mm long) appeared sporadic in food habits, consuming aquatic insects, terrestrial insects, fish, algae, and plant debris. The insects ingested included Hymenoptera, Orthoptera, Ephemeroptera, Plecoptera, Hemiptera, Coleoptera, and Diptera (Vanicek and Kramer 1969).

Bestgen (1985) analyzed the food habits of RTC in the presence of trout. RTC did not utilize all available food items, especially terrestrial invertebrates. This may show selectivity favoring part of the available food organisms or, possibly, resource partitioning in the presence of competition.

Age and Growth. The oldest fish collected by Vanicek and Kramer (1969) was aged at seven years old and was a 366-mm female. Specimens 50 cm in length do occur, but most are 25–35 cm (Minckley 1973). Fish in rivers live longer than those in creeks by as much as two years and attain a larger size. Maturation occurs sooner in the smaller water bodies (Bestgen 1985).

No fish under 36 mm long was found to have scales by Neve (1976). In Fossil Creek, the average total lengths (in mm) at different ages were reported by Neve (1976): age 0—68; age 1—127; age 2—174; age 3—217; and, age 5—321 millimeters. Vanicek and Kramer (1969) reported average total lengths for roundtail and bonytail chub up to 200 mm and roundtail chub over 200 mm: age 1—55; age 2—99; age 3—156; age 4—218; age 5—267; age 6—312; and, age 7—340 millimeters.

The length-weight relationship for chub in Fossil Creek and the Green River was

$$Wgr = -4.4077 + 2.7379 \log Lmm$$

and

$$Wgr = -5.2462 + 3.086 \log Lmm$$

respectively (Neve 1976, Vanicek and Kramer 1969).

The length-weight relationship for this chub shows that growth is almost isometric (Neve 1976).

Annual growth increments were greatest for the first year of life but decreased there after (Vanicek and Kramer 1969, Neve 1976). No difference in growth was found between the sexes. A "goodness of

growth" test indicated that chub in the Green River grew slower after Flaming Gorge Reservoir was impounded (Vanicek and Kramer 1969).

E3.2 INTRODUCED FISH

E3.2.1 Bluegill (*Lepomis macrochirus*)

Description. Bluegill are extremely prolific, and may produce up to 50,000 eggs per female at each spawning. The high reproductive potential of bluegills allows them to become quite abundant when introduced into lacustrine habitats. Compared to other sunfish, bluegill are generalists in their feeding habits which further allows adaptation to a wide range of environmental conditions (Moyle 1976). Bluegill have a laterally compressed body, small mouth and a blue-black spot at the posterior edge of the operculum (Becker 1983).

Distribution. Originally, bluegill were restricted to the freshwaters of eastern and central North America, ranging from coastal Virginia and Florida, west to Texas and northern Mexico, and north to Ontario and the Great Lakes region. Bluegill have since been transplanted throughout North America, Europe and South Africa (Moyle 1976, Lee *et al.* 1980). In Arizona, bluegill generally inhabit waters below 2,500 m in elevation (Minckley 1973). They are quite abundant in all the reservoirs on the Salt and Verde rivers.

Habitat. Bluegill are capable of surviving a wide variety of environmental conditions. They feed at water temperatures between 10–31°C (Kitchell *et al.* 1974). This species survives in waters with high turbidity, and with oxygen levels as low as 0.6 ppm under winter conditions (Cooper and Washburn 1949). They prefer slightly alkaline waters of under 900 ppm total alkalinity (McCarraher 1971), but tolerate a pH range of 4.0–10.3 (Trama 1954). They have also been taken in water with 4.5 ppt salinity (Bailey *et al.* 1954).

Bluegill prefer the littoral zone in warm, shallow lakes, reservoirs, ponds and sloughs at low altitudes (Moyle 1976). They also can be found in streams in low velocity habitats. A moderate amount of rooted vegetation offers bluegill the benefits of concealment and foraging substrate. They are commonly associated with silt, sand or gravel substrates (Becker 1983).

Bluegill occur in virtually any portion of the water column; in the aquatic plants; and in the shallows (Moyle 1976). The deep body and flexible fins are well-adapted for hovering at all levels and then darting forward to pick up food items (Keast and Webb 1966). Large bluegill generally inhabit macrophyte beds in deeper waters.

Spawning. In Arizona, spawning activity begins in April and May. Spawning optimally takes place at water temperatures between 19.4–26.7°C. In Arizona, an early peak of spawning activity occurs, followed about a month later by a second peak (Becker 1983, Minckley 1973).

Males appear first in the shallow water of spawning areas. Typically, breeding takes place on sand or gravel bars, or mud bottoms that contain pieces of debris such as twigs or dead leaves (Wang 1986). Water depth of the nests is commonly 10 cm for smaller fish and 100 cm for large males. Spawning bluegill prefer habitats that are free of plants and receive maximum sunshine. Males sweep out depressions 5–15 cm deep and about 30 cm in diameter (Becker 1983). Occasionally, males build

isolated nests, but bluegill typically breed in crowded colonies with an average of 40 to 50 nests within a 20 m^2 area (Harlan and Speaker 1956).

In the spawning ritual, a male circles the nest rim frequently and rapidly when a female is present. Courtship movements are accompanied by distinctive grunting sounds (Gerald 1971). Males assume a bright orange to rust-red color on their breast and a bluish sheen across their body; females are less brightly colored but have a full body shape (Avila 1976). As a pair settle into their nest, they face the same direction, side by side; the male stays on the outside and the female on the inside. The couple circles the nest, and at spawning, the female tilts her body and deposits eggs while the male remains upright and emits milt. Spawning sessions may last 15–90 minutes (Avila 1976). Other males and females may also intrude and attempt to spawn with the breeding pair. A female may deposit her eggs in several nests. After spawning, the male defends the nest and fans the eggs to keep them free of debris (Becker 1983).

The prolific female bluegill may produce 2,000–50,000 eggs, depending on the size and age of the fish (Emig 1961). The demersal, adhesive eggs are pale yellow to amber and range from 1.09 mm (Merrimer 1971) to 1.4 mm (Meyer 1970). Carlander (1977) recorded laboratory incubation times of 71, 34 and 32.5 hours at 22.6°C, 26.9°C and 27.3°C, respectively. In the field, eggs often hatch in two to three days at approximately 20°C (Wang 1986). As many as 62,000 fry may emerge from one nest, although bluegill typically produce 2,000–18,000 young per nest (Emig 1966). Newly-hatched larvae are about 2–3 mm in length. They remain in the nesting area until eyes become pigmented and the yolk sac is completely absorbed (Scott and Crossman 1973). About six days after hatching, fry are free-swimming and move into pelagic waters (Werner 1969).

Movements. Bluegill shift habitats over the course of their life cycle. Fry remain in the limnetic zone until they reach about 12 to 12.5 mm SL. In this habitat, the young evade predators and feed on the abundant zooplankton resource. Distribution of young in the epilimnion is patchy, which may indicate that fry aggregate into schools (Werner 1969). When juveniles reach between 12.4 and 14 mm SL, they return to the littoral zone and remain for several years feeding on vegetation.

Seasonal movements of bluegill include winter aggregations in the deep littoral zone; they typically move into tall, perennial vegetation (Hall and Werner 1977). Bluegill disperse and migrate in the spring up sluggish streams or into channels which have warmed before the main body of water (Becker 1983). Commonly, they locate near shade or other forms of cover. In the summer, bluegill occupy small territories and move little; an individual may remain in the same place for hours. Bluegill commonly feed in open water during the day and move into vegetation at dusk. As temperatures decrease in the fall to about 20°C, bluegill again form schools (Hall and Werner 1977).

Bluegill spend most of their lives in fairly restricted areas, even in large bodies of water. An Iowa study showed that 60 percent of displaced large bluegill returned to their original capture area (Kudrna 1965). Savitz *et al.* (1983) also found that bluegill established home areas and excluded cogenerics from their territories.

Food Habits. Bluegill are omnivorous and opportunistic feeders. Adults prefer larvae of aquatic insects such as midges, mayflies, caddisflies and dragonflies. They also consume planktonic crustaceans, flying insects and snails (Moyle 1976). Fry obtain a large portion of their diet from zooplankton, and feed

primarily on *Daphnia* while juvenile bluegill feed mostly on insects in the littoral zone (Mittelbach 1981, Werner and Hall 1988; Osenberg *et al.* 1988).

Bluegill are specialized for feeding on small items; their mouths are reduced and protrusible, which permits an efficient exploitation of a variety of small prey, especially zooplankton. Their laterally compressed bodies allow precise maneuvering; such adroitness is useful for gleaning large numbers of organisms from the bottom surfaces of vegetation or in the open water (Werner and Hall 1977).

Juveniles in the epilimnion selectively prey on copepods in preference to other zooplankton. They also show a diel periodicity with peak activity at dusk and secondarily at dawn; activity is low during the day and night. Adults feed nearly continuously during the growing season, with peak periods in mid-afternoon and evening. Feeding occurs intermittently at night. Optimum temperature is 27°C and extreme temperatures for feeding range from a low of 10°C to a maximum of 31°C (Kitchell *et al.* 1974, Stuntz 1976).

In Pine Flat Reservoir in California, bluegill forage on fish eggs, midge larvae and cladocerans in March to June; flying insects in July to October; and midge larvae and cladocerans from November to February (Goodson 1965). Bluegill consume 5 percent of their body weight per day in the summer, but only 0.14 percent in the winter (Moyle 1969).

Age and Growth. Young bluegill grow rapidly. Snow *et al.* (1962) reported juveniles at 19 mm in August and 38 mm by September. In Wisconsin, mean lengths for bluegill were 53 mm in their first year, 72 mm in their second, 88 mm in their third, 110 mm in their fourth, 124 mm in their fifth, 138 mm in their sixth, 149 mm in their seventh, 163 mm in their eighth, and 166 mm in their ninth (Becker 1983).

Bluegill grow rapidly when water temperatures are between 15-25°C (Moyle 1976). Exceptionally cold or turbid water is likely to produce stunted fish. Slow growth is also common under crowded conditions such as small impoundments. Condition and growth seems improved in waters with a strong predator population such as largemouth bass. In Arizona, large populations of stunted bluegill are common in ponds in which the largemouth bass stock has been depleted (Miller 1967).

Males attain sexual maturity by the second to third year and females by the third to fourth year. The maximum size reported was a bluegill caught in Ohio that was 300 mm in length and weighed 2.64 kg (Trautman 1957).

E3.2.2 Common Carp (*Cyprinus carpio*)

Description. The introduction of carp to the United States is now considered a serious mistake; it has been highly deleterious to native fish, game fish and waterfowl habitat. Carp have low value as a forage fish, and their feeding habits tear up valuable areas of the littoral zone (Moyle 1976, McGinnis 1984). They grow rapidly and achieve large sizes in polluted waters that support few other fish. Carp are large-scaled, heavy-bodied minnows. Adults are gold green in color with red pectoral, pelvic and anal fins (Becker 1983).

Distribution. Carp are native to temperate portions of Eurasia and were introduced into the United States in 1877 (Lee *et al.* 1980). They are now widely distributed in North America below the 50th parallel. In Arizona, carp were first stocked in ponds in 1885 (Taggart 1885), and in rivers in 1895 by Evermann

and Rutter and 1898 by Gilbert and Scofield. Their range extends to almost all waters in the state below an elevation of 2,000 m (Minckley 1973).

Habitat. Carp are most abundant in warm, turbid water at low altitudes. They remain active in water temperatures ranging from 4–34°C, but the optimum temperature for growth is around 24°C (McCrimmon 1968). Carp can also use atmospheric oxygen and therefore tolerate very low oxygen levels (0.5–3.0 ppm) (MacKay 1963). Carp also withstand high turbidity, sudden temperature changes and pollution (Wydoski and Whitney 1979).

Preferred habitats include large, shallow lakes and rivers. They are rarely found deeper than 30 m and avoid swift waters except during spring spawning runs (Becker 1983). Carp are commonly associated with eutrophic waters with silty bottoms and also favor lush quantities of submerged and emergent aquatic vegetation (Wydoski and Whitney 1979).

Spawning. Carp reproduce over a relatively long period in Arizona, from late February through June or July (Minckley 1973). Breeding activity is stimulated as water temperatures approach 15°C; peak activity occurs at temperatures of 18.3–23.9°C (Mraz and Cooper 1957). Maximum temperature for spawning is about 28°C (Moyle 1976). Breeding males become darker in color and develop fine tubercles on their head.

First indications of spawning is the presence of large compact schools in open areas. Schools soon break off into smaller groups of varying combinations: a pair; one female and two to four males or six to seven males; or two females and three to four males (Becker 1983). Subsequently, groups move into shallow, weedy locations and show preference for recently flooded areas in lakes, ponds, tributary streams, swamps and marshes. Preferred substrates for egg deposition include submerged plants, tree roots, dead leaves and floating plants and logs (Wang 1986). Carp spawn in depths of 8–183 cm (Becker 1983).

Spawning occurs at all hours, but peaks in the late evening or morning. Carp are broadcast spawners; a female scatters her eggs over vegetation while males come alongside and emit milt (Swee and McCrimmon 1966). As mating activity intensifies, carp frequently break the water surface with their dorsal fins and splash violently. Typically, a female deposits clusters of 500–600 eggs over an area of 2 m in diameter (Jester 1974) but may deposit eggs singly (Wang 1986).

Depending on her size, a female lays about 50,000 to 620,000 eggs, (Mansueti and Hardy 1967). The demersal, pale yellow eggs (usually 1.5–2.1 mm in diameter) are adhesive and affix onto plants or bottom debris in the spawning area (Wang 1986). At 20°C, larvae hatch-out in three to five days, at lengths of 4.28–5.70 mm TL (Swee and McCrimmon 1966). In four to five days, carp fry absorb their yolk sac and begin feeding on zooplankton.

By the end of their first week, most fry move into beds of emerged or submerged vegetation (Moyle 1976). These juveniles remain in this protected cover until they reach about 25 mm in length, approximately 18 days after hatching. At this larger size, the young school and move into slightly deeper waters among vegetation for the remainder of the summer. When young carp reach 76–102 mm, they leave the shallow, woody habitat and move into more open waters.

Movements. Carp range extensively. In tagging studies in Missouri, carp were collected as far as 1,088 km from their initial capture site (Sigler 1958). The Nebraska Game and Parks Commission reported

a carp which covered 1,629 km on the Missouri, Mississippi and White rivers (Becker 1983). Spawning migrations from reservoirs into streams and rivers are quite common.

Food Habits. Carp are omnivorous and consume a variety of plant and animal tissues. They forage on the bottom, sucking up mouthfuls of ooze and detritus. Carp glean invertebrate prey from the substrate and reject the silt and sand, and inadvertently feed on aquatic plants. Trails of churned up substrate and turbid water are left in their wake. Other prey sources have been observed in Arizona impoundments and in the lower Colorado River; the Asiatic clam *Corbicula* has become a major prey item during particular times of the year (Minckley 1973). However, studies on this predator–prey relationship report that carp may actually benefit more from the detrital material consumed than the clams themselves (Prokopovich 1969).

Other common items in their diet include larval and adult insects, fish, crustaceans and molluscs, oligochaete worms, free-living flat worms, leeches and water mites. Plant materials typically consumed include many kinds of weed and tree seeds, wild rice, aquatic plants and algae. Carp may even feed at the surface on floating organisms or algae (Scott and Crossman 1973). In winter, they feed almost exclusively on animals such as crustaceans and dipterous larvae (Moen 1953).

Age and Growth. Carp growth varies considerably, depending on summer water temperatures, length of growing season, quality of water and food availability. Young-of-year in Wisconsin attained lengths between 70 to 107 mm and averaged 93 mm by the end of the first growing season (Becker 1983). In the second year, carp may double in length and then continue to add 10–12 cm in the following years. However, growth tends to slow after the fourth or fifth year (Moyle 1976). Males mature in the second year and females in the third year (Miller 1952). In the Mississippi River, the average length was 196 mm in their first year, 376 mm in their second, 486 mm in their third, 561 mm in their fourth, and 655 mm in their fifth (Christenson and Smith 1965). Longevity usually ranges from nine to fifteen years. A maximum age of 47 years has been recorded (Brown 1957). The largest carp ever caught was from South Africa and weighed 39.9 kg; the record carp for North America is 26.3 kg from Iowa (Becker 1983). Mortality by predation is probably minimal for adults, but young carp may fall prey to a variety of predatory fishes and birds (Scott and Crossman 1973).

E3.2.3 Black Crappie (*Pomoxis nigromaculatus*)

Description. Black crappie are one of the most common centrarchids in Arizona impoundments, and typically rank second or third in warmwater fisheries (Minckley 1973). They differ from the closely related white crappies in their preference for clear, cool waters (Goodson 1966). Black crappie commonly school and are far more pelagic throughout much of the year than other centrarchids. Adults commonly average 178–254 mm, and show dark green coloration on the back and upper head, lighter sides, and uneven, distinct dark blotches (Becker 1983).

Distribution. Black crappie were originally restricted to fresh waters (and rarely brackish waters) of eastern and central North America. They were native along the Atlantic slope from Virginia to Florida, along the Gulf Coast to central Texas, north to North Dakota and eastern Montana, and east to the Appalachians (Lee *et al.* 1980). They have been widely introduced throughout the United States (Scott and Crossman 1973).

Habitat. Black crappie are considered suited to slightly alkaline, eutrophic conditions. They tolerate waters with salinities as high as 2 ppt and their total alkalinity threshold is 900 ppm. Maximum

carbonate levels are 250 ppm (Goodson 1966). Habitats as warm as 28.3°C are utilized but cooler temperatures near 24°C are preferred. When winter temperatures approach freezing, crappies can withstand low dissolved oxygen levels down to 1.4 ppm (Moore 1942).

Commonly, this species occupies clear, quiet waters of large ponds, small lakes and bays. Other common habitats include shallow waters of large lakes and low flow areas of larger rivers (Scott and Crossman 1973). In Arizona, crappies are rarely abundant in streams or rivers (Becker 1983). Black crappie are nearly always associated with copious growths of aquatic vegetation and sandy to murky bottom substrates (Scott and Crossman 1973). Clear to slightly turbid waters are suitable for this species. Juveniles are often found swarming in quiet shallow waters with patchy vegetation. Adult crappie frequently rest suspended and motionless in the water column (Keast 1968).

Spawning. In Arizona, the spawning season for black crappie extends over spring and summer (Minckley 1973). Breeding activity initiates when temperatures rise to 14.5°C. Optimum temperatures for spawning range from 17.8–20°C. With the stimulus of warmer waters, breeding males develop a darker, more iridescent color on their head and breast; females are somewhat lighter.

Typical of centrarchids, black crappies nest in colonies. Males excavate nests in sand, gravel or muddy bottoms and near vegetation, commonly *Chara*. Most spawning occurs at the base of vegetation, indicating that plant material may be a limiting factor for reproduction. Nests are typically built in shallow waters from 25–600 cm deep but may be in waters down to 2 m or more. Males build nests by sweeping out an area 20–23 cm in diameter; they space nests 1.5–1.8 m away from each other. Females may spawn with several different males in more than one nest (Becker 1983).

Merriner (1971) found fecundity ranged from 3,000–188,000 eggs in 3–8-year-old females, and average production was about 132,000 eggs per kg of fish. Fertilized eggs are whitish, demersal and adhesive, and average 0.93 mm in diameter (Scott and Crossman 1973). Incubation time is three to five days and newly-hatched larvae may measure from 3.6–4.1 mm TL (Wang 1986). Transparent young are guarded by the male for a few days; fry subsequently leave the nest (Scott and Crossman 1973). Post-larvae venture to the surface in small schools and eventually disperse into shallow weedy areas (Wang 1986).

Movements. Movements of black crappie include migrations. They have been observed migrating several kilometers in large bodies of water (Schneberger 1972). In the Mississippi River, black crappie frequently move during the winter freezes, and peak movements occur when ice has its greatest cover (Greenbank 1956). Black crappies are also gregarious and travel in schools of 20–25 fish. They spend their days around large submerged objects and in shaded areas in waters 1–3 m deep. In the evenings and early mornings, they move offshore to forage in open water (Goodson 1966).

Food Habits. Black crappie are carnivorous and their feeding habits change with size and age. Young-of-year feed primarily on zooplankton such as calanoid and cyclopoid copepods. As they reach 15–30 mm in length, they begin foraging on fish fry. The main diet for juveniles longer than 50 mm is free-swimming dipterous larvae (*Chaoborus* and *Procladius*). Young crappie feed diurnally and probably make forays into the hypolimnion to feed. As they grow to lengths of 160–240 mm, black crappie progressively change their foraging to both small invertebrates and fish.

Beyond sizes of 240 mm, crappie increasingly prey on a variety of small fishes. Compared to other centrarchids, this switch to a more pisciverous diet occurs much later; black crappie may be as old as

three years. However, invertebrates still make up a substantial part of the diet of even large crappie (Goodson 1966). Black crappie have numerous fine, long gill rakers that effectively glean planktonic crustaceans and insect larvae. Seasonally, fish are important in the diet of this species in the summer months, particularly July and August. Cladocerans account for the majority of food volume in November and December.

Foraging in schools is common and most activity occurs at dawn and dusk. Feeding virtually ceases during daylight hours (Childers and Shoemaker 1953).

Age and Growth. Black crappie are a relatively short-lived fish. Individuals up to nine years of age have been reported, but black crappies usually do not live beyond five years (Wydowski and Whitney 1979). In California, Stevens (1959) did not find any black crappie beyond eight years old. In Oklahoma, 98 percent of the black crappie population was under five years old (Hall *et al.* 1954). In Arizona, they rarely live beyond four years (Warnecke, pers. comm.).

Black crappie grow most rapidly in the first year of life and annual increments decrease in each successive year. In Colorado, Willis *et al.* (1984) reported average lengths of 81 mm in their first year, 149 mm in their second, 188 mm in their third, 222 mm in their fourth, 246 mm in their fifth, and 286 mm in their sixth.

A length-weight relationship was determined for this population as

$$\log W = -4.682 + 2.930 \log TL \text{ (weight in g, TL in mm)}$$

Both sexes have similar growth rates; black crappie mature at two to three years of age, at lengths of 17.8 cm to 20.3 cm (Vanderpuye and Carlander 1971; Sigler 1959).

Extensive mortalities have been observed in individuals approaching two years of age and older. In Wisconsin, annual mortality rates for black crappie are reported as 64 percent in 2-3-year-olds and 91 percent in 3-4-year-olds. In California, substantial die-offs occurred in the spring during and following spawning (Goodson 1966). Warnecke (pers. comm.) states that high mortality of black crappie often occurs during their spawning season in Arizona reservoirs, including Bartlett and Horseshoe reservoirs, Roosevelt Reservoir and San Carlos Reservoir. Although the cause of death was not determined, mortalities were probably related to the high physiological investment during spawning.

Ellison (1984) has correlated high death rates during the growing season with water temperature and fish size. Many black crappie over 200 mm died during the month of July and August when temperatures were 26-28°C. Mortalities of 71 percent, 89 percent and 100 percent occurred in size classes of 200-209 mm, 210-219 mm and 220-229 mm, respectively.

E3.2.4 Green Sunfish (*Lepomis cyanellus*)

Description. Green sunfish are well-adapted to near shore vegetation. The enlarged mouth enables them to feed on relatively large prey. The fusiform body makes them adept at pursuing prey in vegetation beds. Green sunfish are also aggressive and exhibit strong territorial behavior and homing tendencies within vegetated habitat (Werner and Hall 1977). Green sunfish are brown to olive in color on the dorsal region with many emerald reflections, and their opercular flap has a black center. Total lengths typically range from 102-127 mm (Becker 1983).

Distribution. Green sunfish are native to most of the Mississippi drainage system, including the Great Lakes (Moyle 1976). The introduction of green sunfish to Arizona was first noted in 1926 (Miller and Lowe 1967). Large populations are present in the San Carlos River; tributaries to the mainstream of the Salt River in Salt River Canyon; Burro Creek, many smaller streams of the Bill Williams River basin; and almost all the reservoirs in Arizona. Small numbers also occur in marginal trout waters above 2,200 m in elevation, and a few green sunfish have been found in trout lakes along the Mogollon Rim (Minckley 1973).

Habitat. Green sunfish are a pioneer species and are well-adapted for moving into areas and surviving where other species cannot. They can survive high temperatures of over 36°C, low oxygen levels (less than 3 ppm) and high alkalinities (up to 2,000 mg/l) (McCarraher 1972). Green sunfish also withstand high turbidity better than any other sunfish except orange-spotted sunfish (Carlander 1977).

Preferred temperatures of green sunfish are warm waters ranging from 26.2–28.2°C (Beitinger *et al.* 1975). They commonly inhabit ponds, lakes, small brooks and rivers of low gradient preferring shallow water with abundant vegetation (Moyle 1976, Minckley 1973). They are also abundant in clear to turbid waters. In Arizona, green sunfish tend to become most abundant in rocky areas of either lakes or streams where other sunfish species are absent or uncommon (Minckley 1973).

Green sunfish are often the sole inhabitant of streams disrupted by man and have been responsible for the loss of many native fishes through predation. Moyle and Nichols (1973) reported such conditions in the Sierra Nevada foothills of California. Sunfish were most abundant in small intermittent streams, especially in turbid pools with muddy-bottoms and large amounts of vegetation.

Spawning. Green sunfish usually breed when water temperatures range from 15–28°C; peak spawning activity occurs at temperatures of 20–28°C (Scott and Crossman 1973). Spawning activity generally occurs in late May or early June and continues through June to early August (Hunter 1963). Multiple spawning cycles commonly occur every eight to nine days during the season (Scott and Crossman 1973). First indications of spawning are males congregating and moving into shallow waters. Breeding males exhibit prominent, yellowish-white lines along the margins of their dorsal, caudal and anal fins, and dark vertical bars along their sides (Hunter 1963).

A few days after arriving on spawning grounds, males begin to construct nests. Spawning typically occurs in water less than 40 cm deep; on substrates of sand, gravel or bedrock; and in areas receiving maximum sunshine (Becker 1983). Green sunfish may nest singly but often form colonies, with nests separated by 30–50 cm (Minckley 1973). A male builds a nest by vertically rising above the substrate and thrusting sand and gravel outward with its tail. Larger pebbles are removed with its mouth. Nests vary in size from 15–38 cm in diameter (Carlander 1977).

Initially, large numbers of green sunfish gather around the nests of the first spawners. Stimulated by the breeding activity, members of this group begin building their own nests nearby; consequently, colonies are formed and these groups exhibit synchronized spawning (Becker 1983, Hunter 1963). Each male aggressively defends his nest against other trespassing males and, to a lesser extent, against females (Moyle 1976).

During courtship, male green sunfish rush toward the female and then retreat to the nest while making grunting sounds (Gerald 1971). The male and female circle in the nest side by side, and then release milt

and eggs. After spawning, the male drives off the female and begins guarding the nest (Hunter 1963). Both sexes may spawn with more than one individual. Each spawning usually takes place over a period of one to two days (Scott and Crossman 1973).

Fecundity in green sunfish may range from 2,000–10,000 eggs (Wang 1986). Eggs adhere to the nest substrate, and are demersal and yellow. Eggs may vary in size from 0.8–1.44 mm in diameter (Kaya and Hasler 1972, Meyer 1970). Wang (1986) reported a 3–4-day incubation period at 19–23°C. Emerging larvae are 3.5–3.7 mm in length, with fry becoming free swimming at 6 mm (Taubert 1977). Males stop guarding the young as they become free swimming (Scott and Crossman 1973). Post-larvae rise from the nest and move into shallow water near or among vegetation (Wang 1986).

Movements. Green sunfish are somewhat stationary. In tagging studies, 95.6 percent of the fish were recaptured within 16 km of release sites (Funk 1957). Green sunfish also show strong homing tendencies; when displaced, they return to home areas more quickly than bluegill, pumpkinseeds (Kudrna 1965) and largemouth bass (Hasler and Wisby 1958). Hasler and Wisby (1958) also observed that green sunfish return in the spring to the same area occupied the previous summer. Green sunfish are most active and feed at dawn and dusk (Ellis 1974).

Food Habits. Adult green sunfish are omnivorous and opportunistic predators. They have a larger mouth than most other sunfish of the same size, and they prey on the larger, more active invertebrates within their territories. Young green sunfish (less than 80 mm SL) forage on zooplankton, crustaceans and insect larvae, especially mayfly larvae. As they increase in size, they depend more on crayfish, terrestrial insects and fish, but may also feed on zooplankton (Moyle 1976, Siewert 1973).

Seasonal variations in diet include a heavy use of mosquitofish and largemouth bass eggs and fry throughout the spring. During the winter, they concentrate more on invertebrates (Carlander 1977). Green sunfish frequently hunt in a "sit-and-wait" fashion within dense vegetation (Werner and Hall 1977).

Age and Growth. Compared to other sunfishes, green sunfish grow slowly and seldom reach sizes greater than 150 mm SL (Moyle 1976). In Ohio, young-of-year were 20 to 64 mm long by October (Scott and Crossman 1973). In Minnesota, green sunfish averaged 43 mm TL in their first year, 74 mm in their second, 99 mm in their third, 127 mm in their fourth, 150 mm in their fifth, 168 mm in their sixth, and 183 mm in their seventh (Hubbs and Cooper 1935). Green sunfish have been found to reach lengths of over 300 mm SL and achieve weights of nearly 1 kg; but large, stunted populations commonly occur where 4–5-year-old fish are only 100 to 120 mm SL (Moyle 1976). In Arizona, green sunfish rarely grow beyond 150 mm TL and a weight of more than a few grams (Minckley 1973).

In Canada, life expectancy in the wild was seven to nine years (Scott and Crossman 1973). Males tend to live longer and grow faster than females (Becker 1983); all green sunfish mature by their third year (Hubbs and Cooper 1935).

E3.2.5 Smallmouth Bass (*Micropterus dolomieui*)

Description. Smallmouth bass are primarily cool water, stream fish. Adult smallmouth bass are less piscivorous than largemouth bass and instead rely more on insect food (McGinnis 1984). Smallmouth bass are, however, suited to slightly alkaline waters similar to the largemouth bass. As the common name indicates, they have a small mouth in which the maxillary does not extend beyond the center of the eye; in larger fish, the maxillary does not reach beyond the posterior of the eye (Wydoski and Whitney

1979). Lengths commonly range from 233–349 mm TL. Smallmouth bass may be olive to green or brown to yellow–brown on the back and head, and they lack the dark horizontal band typical of other basses.

Distribution. Originally, smallmouth bass ranged from the Great Lakes and St. Lawrence River drainage in Canada, south to Georgia, west to Oklahoma and north into Minnesota. Introduced and self-sustaining populations occur across the continental United States and Canada, and in Hawaii, Asia and Africa. Smallmouth bass were introduced to Europe and South America, but their present status there is unknown.

Smallmouth bass were probably introduced to Arizona waters in the early 1940s. More recently, their distribution has ranged from mainstream waters of the lower Colorado River and the Verde River system, into the Salt River basin below 2,200 m in elevation. This species is apparently rare in the larger reservoirs and the lower Colorado River. Populations are abundant in the Verde River system but the fish are small in size and susceptible to parasitism. However, in the 1970s, bass stocked in the Upper Salt River system experienced a population explosion. With few competitors, the smallmouth bass gorged themselves on a rich supply of minnows and suckers; subsequently, reducing or eliminating populations of native fish in some streams (Minckley 1973).

Habitat. Smallmouth bass characteristically prefer cool, clear waters of streams, large lakes, and rivers. Suitable summer temperatures range from 21°C to 27°C but fish become lethargic and sedentary below 10°C (Emig 1966). Smallmouth bass are fairly intolerant of low oxygen levels, and lethal concentrations were determined as 0.96 ppm and 0.87 ppm at Deer River and Beebe Lake, New York, respectively, at a temperature of 21°C (Burdick *et al.* 1954). Suited to slightly alkaline, eutrophic lakes, they are successful in waters with less than 900 ppm total alkalinity, 250 ppm carbonate alkalinity and 200 ppm K + Na (McCarraher 1971).

Smallmouth bass favor stream habitats with a moderate current and rocky substrates. Typically, smallmouth bass live in pools and runs of rivers and streams. In a field study of smallmouth bass in streams, Rankin (1986) found that coarse substrate, depth and slow current were of basic importance. Smallmouth bass selected currents below 15 cm/s, but velocities under 5 cm/s were avoided unless in the lee of rocks. Typically, they were found close to the bottom substrate (within 15 cm) but avoided shallow areas of streams (areas under 45 cm). Favored substrates of smallmouth bass include boulder, rubble and cobble, which is likewise home to their prey, crayfish and other large invertebrates (deMarch 1976).

Lakes that best support smallmouth bass are over 100 acres of clear water, have thermal stratification more than 9 m deep, and contain scanty vegetation and large shoals of rock and gravel. Smallmouth bass are usually found in water less than 12 m deep but occasionally occur at greater depths (Webster 1954). Often, they are found over rocky bars and ledges in water 1.5–6 m deep (Coble 1975).

Spawning. Smallmouth bass spawn in lakes, streams and rivers. As temperatures rise above 15.6°C, males move into shallow water in lakes or into quiet areas of streams. Usually, they select nest areas near shore and cover, and typical sites are by undercut banks, submerged logs or in deeper water. Frequently, nests are built at depths of 2.4–3.7 m, although nests have been found as deep as 6 m (Mraz 1964). Nests are usually built 0.3–2.4 m from the shore (Turner and MacCrimmon 1970). Males choose a substrate of sand, gravel or rubble; when unavailable, they will use woody debris and broken clam shells.

Males may prepare several nests before spawning, with vigorous sweeping motions of the tail. Nests are circular, saucer-shaped depressions (5–10 cm deep) usually measuring 61 cm in diameter but may range from 30.5–122 cm (Pflieger 1966). Silt and plant material are swept away during construction, but large stones, stems and roots are left in the nest. Smallmouth bass may also build nests in colonies.

Spawning may occur soon after nest construction but may be delayed depending on temperature and female availability. Cleary (1956) noted that spawning water temperatures were usually 16.7–17.8°C. Actual spawning occurs during daylight hours. Prior to spawning, the female develops a mottled appearance; her background color lightens and dark blotches develop. Once a pair bond has formed, the male gently nudges and bites the female, and then the pair settle down side by side over the nest, usually facing the same direction. The female turns on her side, discharges eggs next to the vent of the male, and he simultaneously emits milt (Coble 1975). Fertilized eggs attach to polished stones in the nest (Hubbs and Bailey 1983). After spawning, the male discontinues cleaning of the nest (Pflieger 1966).

After spawning, females lose their color and leave the nests. Males remain and actively guard offspring until the fry disperse up to 28 days later (Hubbs and Bailey 1938). Pflieger (1966) observed males spawning twice in the same season. The second nesting period may occur after adverse weather conditions such as floods or low water temperature, or after initial nest failure (Mraz 1964). Brynildson (1957) reported that males deserted nests when water temperature dropped from 18.3°C to 7.2°C.

Fecundity ranges from 2,000–20,825 eggs, depending on age, size and weight of the fish (Emig 1966). Average egg diameter is 2.2 mm (Latta 1963). Initially, eggs are pale yellow, adhesive and highly visible. As they develop, eggs become transparent and settle into the gravel. Densities of 2,000–10,000 eggs per nest are common. Incubation time is dependent on temperature: ten days at 54°F and two days at 77°F (Coble 1975). After hatching, typical fry densities are 1,000–5,000 per nest (Pflieger 1966).

Newly hatched fry are transparent and 51 mm long. Eight to eleven days after hatching, fry absorb their yolk and slowly rise above the nest, and the male herds them into schools (Doan 1940). Fry begin feeding on Dipterous larvae and turn black. About 19–28 days after hatching, schools diffuse and fry range further from their nest. When smallmouth bass reach 84 mm or more, they change into the green color of adults and permanently disperse to shallow waters near shore (Hubbs and Bailey 1938).

Movements. Smallmouth bass are essentially nonmigratory and maintain restricted home ranges. They rarely venture even moderate distances in lakes or streams. Capture and release studies found that 97 percent of tagged fish remained within a 40 km area (Funk 1957). Smallmouth bass appear to occupy home territories in rivers, and in streams, they may occupy a single pool throughout an entire season (Paragamian and Coble 1975). In large lakes, smallmouth bass are often in several discrete populations (Forney 1961).

During the winter, smallmouth bass descend into deeper water and seek dark places devoid of current, such as holes, submarine caves, hollow logs and crevices between rocks (Munther 1970). This movement begins when water temperatures reach 3.5–10°C. In spring, when temperatures rise, smallmouth bass return to shallow water and resume feeding. Under warmer conditions, smallmouth bass often swim at the surface during the daytime; but at night, they rest on the bottom.

Food Habits. Smallmouth bass progressively feed on larger food items as they grow. Young smallmouth bass forage on zooplankton such as copepods, *Cladocera* and entomostracans. When bass

grow to about 38 mm, they feed increasingly on insects such as midges and mayflies. Fish and crayfish become important as smallmouth bass reach 76 mm in length. Older bass feed primarily on fish, crayfish and insects. Important fish prey includes members of the minnow family and other centrarchids (Becker 1983).

Smallmouth bass begin active feeding in early spring when water temperatures reach about 18°C (Bennett 1938). Studies in Maine showed that adults feed mainly on larval and adult insects through the warmer months, especially June and September. In late July, young yellow perch, sunfish, chubs, shiners and suckers dominate their diet; and in August, smallmouth bass consume three times more fish than insects. Feeding apparently ceases in the fall when cool temperatures retard their metabolism (Langlois 1936).

Age and Growth. Smallmouth bass exhibit a wide range of growth rates throughout North America. Growth is influenced greatly by temperatures and food supply. Males and females grow at similar rates; usually, they both mature in four to six years (Turner and MacCrimmon 1970). The maximum age attained by smallmouth is probably about 18 years (Forney 1972).

Coble (1974) calculated growth data for several populations across North America; average total lengths for smallmouth bass were 94 mm in their first year, 170 mm in their second, 234 mm in their third, 279 mm in their fourth, 326 mm in their fifth, 358 mm in their sixth, 381 mm in their seventh, 404 mm in their eighth, and 429 mm in their ninth year. In the Ozarks, Missouri, the following length–weight relationship was determined for smallmouth bass in the middle section of streams:

$$\log W = -5.0540 + 3.0765\ TL \text{ (Lowry 1953)}$$

Mortality in smallmouth bass can be quite substantial during the spawning season and in warmer growth periods. Robbins and MacCrimmon (1977) reported an average mortality of 10 percent for breeding smallmouth bass in Lake Simcoe, Canada. Clady (1977) found natural mortality to be high in the summer season when growth was most rapid. In two Michigan lakes, 23.8 percent natural mortality was observed in June. Clady also estimated that about 60 percent of annual natural mortality occurs in 3–4-year-old bass (smallmouth and largemouth) between June and August.

Smallmouth bass may also sustain substantial mortality from angling. In Lake Oneida, New York, angling mortality was 18 percent in 1955, 21 percent in 1956, and 5 percent in 1957. Marinac–Sanders and Coble (1981) found total annual mortality from angling and natural mortality exceeded 50 percent.

E3.2.6 Yellow Bullhead (*Ictalurus natalis*)

Description. Yellow bullhead are basically stream dwellers with a solitary nature and voracious feeding habits. In general, the bullhead family can live in water with extremely low oxygen concentration; however, the yellow bullhead is least tolerant of low oxygen levels. They feed primarily on fish and crayfish. Preferred habitats are warm, permanent streams with clear, well vegetated inshore areas (McGinnis 1984). Typically, yellow bullhead are yellow, olive or black on the dorsal region and lighter on the ventral sides, and measure 165–235 mm SL (Moyle 1976).

Distribution. The native range of yellow bullhead extends throughout eastern and central United States: from Vermont to Florida, west to central Texas, north to South Dakota and east to New York. Yellow bullhead have also been introduced into various parts of the United States. In California, they are

confined to the Colorado River (Wydowski and Whitney 1979). Yellow bullhead also occur in Arizona, in the East Verde River, Verde River and Salt River (Minckley 1973).

Habitat. Yellow bullhead can endure severe environmental conditions. This species survives oxygen levels as low as 0.3–0.1 ppm (Cooper and Washburn 1949). In Arizona, yellow bullhead are most abundant in clear, rocky-bottomed, intermediate-sized streams. Small populations persist in quiet, weedy sections of reservoirs (Minckley 1973). They frequently inhabit water at depths of 0.6 to 1.5 m with substrates of sand, mud and gravel.

Spawning. In Arizona, yellow bullhead spawn in spring and early summer (Minckley 1973). After pairs form, both male and female may cooperatively build nests. At water depths of 0.5 to 1.2 m, a pair builds either nest depressions, or occupy cavities between rocks. Nests are usually located beneath undercut banks, logs or trees (Moyle 1976). Nests are also found under boards, in cans, under crockery and in entrances of deserted muskrat burrows (Adams and Hankinson 1926). In lakes, nests are constructed in heavy banks of weeds. Egg production varies with fish size; Wydowski and Whitney (1979) reported an average fecundity of 2,334 eggs for females measuring 210–218 mm in length. Eggs hatch in 5–10 days depending on water temperature. Both parents guard the larvae and juveniles until young reach about 50 mm (Mansueti and Hardy 1967). Young yellow bullheads school in compact groups on the surface in quiet waters. The guardian parent remains approximately 0.3–0.6 m away from fry and wards off all predators (Harlan and Speaker 1956). In the autumn, juveniles disperse and seek shelter under logs and stones (Adams and Hankinson 1926).

Movements. In marking studies in Michigan Lakes, yellow bullhead demonstrated no apparent homing or territorial tendencies (Fetterolf 1952).

Food Habits. Yellow bullhead are opportunistic feeders, but are apparently more selective and nocturnal than other species of bullheads (Harlan and Speaker 1956). Characteristic of ictalurids, yellow bullheads are chemosensory feeders (Keast 1984) and can detect prey up to 25 body lengths away by smell alone (Bardach 1967).

As juveniles, yellow bullhead are food generalists, but they become specialized piscivores and crayfish feeders as adults. Young yellow bullhead forage primarily on endomostracans and insect larvae. In their fourth year, they begin feeding more on fish, decapods and insect larvae. In general, adults may feed on a wide variety of living and dead material: insect larvae and adults (amphipods, cladocerans), crustaceans (including crayfish), molluscs, plant material, and live and dead fish (Becker 1983, Wydoski and Whitney 1979).

Age and Growth. Typically, yellow bullhead do not exceed five years of age. They grow faster than the black bullhead (Moyle 1976). In Wisconsin, average length was 206 mm in their second year, 226 mm in their third, and 272 mm in their fourth (Priegel 1966). The maximum reported length is 465 mm (Mansueti and Hardy 1967). In Wisconsin, lengths of juvenile bullheads were 15–20 mm and 22–29 mm in July, 32–50 mm and 53–60 mm in August, and 35–63 mm in September (Paruch 1979). Yellow bullheads mature when they are 2–3-year-olds (Harlan and Speaker 1956).

E3.2.7 Channel Catfish (*Ictalurus punctatus*)

Description. Channel catfish are strong swimmers with streamlined bodies and deeply forked tails. They are well-adapted for inhabiting main channels of large streams and rivers. When not feeding, they prefer

to lurk under banks or beneath root tangles. Channel catfish are unable to reproduce unless undercut banks, rootwads or other cave-like environments are present; this limitation has led to unsuccessful introductions in many reservoirs (Moyle 1976). Other distinguishing characteristics include pointed lobes on the forked tails and conspicuous black spots scattered lightly on the sides (Becker 1983).

Distribution. Channel catfish have been so widely transplanted that uncertainty exits in defining their original range (Lee *et al.* 1980). Apparently, channel catfish are native along the Atlantic coast from Virginia to Florida, along the Gulf Coast to central Texas north to North Dakota and to eastern Montana and east to the Appalachians (Lee *et al.* 1980, Scott and Crossman 1973). They have been introduced into essentially all drainage systems of the United States (Minckley 1973).

Habitat. Channel catfish are tolerant to a wide range of conditions. They thrive at water temperatures averaging 21.1°C but survive extreme conditions of 36–38°C depending on acclimation temperature (Allan and Straun 1968, Scott and Crossman 1973). Channel catfish can withstand low dissolved oxygen levels; lethal oxygen levels for this species were determined as 0.95, 1.03 and 1.08 ppm at temperatures of 25°C, 30°C and 35°C, respectively (Moss and Scott 1961). Salinities of up to 10 ppt are tolerated by channel catfish inhabiting the waters along the Gulf of Mexico (Wang 1986).

Preferred habitat for these fish are streams and rivers with cool, clear, well-oxygenated water. However, channel catfish also proliferate in sluggish streams, lakes and reservoirs. In flowing water they may be found over mud bottoms as in the lower Colorado (Wydoski and Whitney 1979, Moyle 1976). Unlike bullheads, they seldom associate with dense, aquatic vegetation. During the day, channel catfish are most often found in deeper holes, in the protection of rocks or logs.

Young, yearlings and subadults remain in fairly shallow water in streams (Wydoski and Whitney 1979). Young-of-year live in riffles and turbulent areas near sand bars, taking advantage of rocks that break the current. Juvenile channel catfish prefer warmer waters than adults; and in Indiana, their optimum temperature range was determined as 30–32°C (Gammon 1973).

Spawning. In Arizona, reproduction begins in the spring, typically from April through early June (Minckley 1973). Water temperatures of 23.9°C stimulate spawning activities, and optimum temperatures for peak breeding periods are 27°C. Depending on habitat, breeding individuals may or may not migrate into rivers at spawning time (Scott and Crossman 1973). Channel catfish require cave-like sites for their nests, preferring to breed in old muskrat burrows, under ledges with rock strata outcroppings in the channel, or beneath roots of trees undercut by current (Becker 1983).

Prior to spawning, the male clears the nest site by vigorous fanning of fins and body, and then waits for a gravid female (Davis 1959). Largest fish spawn first followed by smaller fish. Pairing may occur before the female is actually ripe and she may remain nearby while the male cleans the nest. Breeding males manifest thick lips and a bright blue or deep blue-black color on their back and sides (Minckley 1973). The region above and behind the male's eye also becomes swollen (Becker 1983).

Male and females pair up by characteristically nipping on potential partners. If fish are going to pair, the bites of the male become progressively less severe until only gentle nudges are given in the region of the vent. Prior to spawning, the female "runs" over the nest in a wiggling motion. The pair then head in opposite directions to one another. The male wraps his tail around the female's head and covers her eyes with his caudal fin. The female in turn wraps her tail around the male's head; they then quiver

and spawn in unison (Becker 1983). Spawning periods may last from four to six hours, with eggs released about nine times each hour (Clemens and Sneed 1957). Eggs are deposited in a large, flat gelatinous mass (Wang 1986). Clemens and Sneed (1957) determined that females of weights 0.45 to 1.81 kg generally deposited 8,800 eggs/kg of body weight. Channel catfish may also breed more than once per year (Carlander 1969).

After spawning, the male drives the female away and vigorously defends the nest. The male presses and packs the eggs with his pelvic fins for one to two days; later in the incubation period, he moves the eggs with his mouth. Eggs are light yellow, demersal, adhesive, and average 3.2 mm in diameter. Incubation periods range from 5–10 days at water temperatures between 21.1–29.4°C (Becker 1983).

At hatching, larvae are a minimum of 6.4 mm in length. Guarded by the adult male, fry mass on the bottom and later make excursions to the surface. In California, small juveniles (20 to 60 mm TL) were found at all levels of the water column (Wang 1986). Fry may travel in schools for several days or for weeks (Mansueti and Hardy 1967). After dispersal, juveniles feed singly in quiet shallow water over sand bars, around drift piles, and among rocks; some juveniles winter under boulders in fairly swift water (Becker 1983).

Movement. Although channel catfish are largely sedentary animals, local movements in lakes have been recorded as well as upstream and downstream movements. Extensive upstream migrations are common during the spawning season. Two upstream movements were noted in South Dakota: in April through June, and September to October (Elrod 1974). In a tagging study in Wisconsin, general downstream migrations were observed during the late summer and autumn (Brynildson *et al.* 1961). Record movements include a catfish recaptured 78 km upstream from the release site in the lower Wisconsin River, and a 190-km downstream movement in the Mississippi River (Brynildson *et al.* 1961). Channel catfish travel the farthest before sunrise and sunset (Scott and Crossman 1973). Lastly, they exhibit only a weak homing instinct (Hubley 1963).

Food Habits. Channel catfish are considered omnivorous, although the plant and detritus material ingested may be incidental to their feeding on invertebrates and fish (Moyle 1976). Channel catfish are fairly indiscriminate in their diet and forage on a wide variety of organisms. Young fish less than 20 cm FL tend to feed on bottom arthropods and the larvae of aquatic insects; after they reach 100 mm, their diet usually becomes more piscivorous (Carlander 1969). Fish and crayfish become increasingly important, although aquatic insects are still consumed when abundant (Moyle 1976). In food preference studies, Lewis *et al.* (1965) found that channel catfish selected crayfish over fathead minnows, and fathead minnows over bluegills, green sunfish and golden shiners. Fingerling carp and bullheads were poorly utilized and tadpoles were killed but not eaten. Stomachs of channel catfish from Wisconsin contained insects (including Diptera, Coleoptera, Hymenoptera, Trichoptera, Orthoptera, and Hemiptera), annelids, seeds, plant materials and detritus (Becker 1983).

Adult catfish typically forage on the bottom in a random manner, detecting food by touch and smell. The eyes of channel catfish are proportionately larger than those of other catfish species and may be adapted for sight feeding (Davis 1959). This hypothesis is consistent with channel catfish behavior of foraging on minnows in clear water (Bailey and Harrison 1948).

Channel catfish feed most actively from sundown until about midnight when water temperatures range between 10–34.4°C. They rarely feed during the winter or the breeding season.

Age and Growth. On average, channel catfish is the fastest growing catfish species, although considerable variation occurs from population to population (Moyle 1976). Growth is rapid in early years; in Ohio, young catfish were 51–102 mm long by October and 89–190 mm by their first year (Scott and Crossman 1973). Age-length relations from the Mississippi River in Iowa were reported as follows: channel catfish averaged 75 mm in their first year, 161 mm in their second, 231 mm in their third, 299 mm in their fourth, 361 mm in their fifth, 423 mm in their sixth, 488 mm in their seventh, 536 mm in their eighth, 610 mm in the ninth, 658 mm in their eleventh, and 709 mm in their twelfth (Appleget and Smith 1951).

The tremendous variability in growth is temperature dependent, and growth rate significantly increases in southern waters (Scott and Crossman 1973). Average length in the tenth year is 356 mm in the St. Lawrence River, 363 mm in the Ottawa River, 432 mm in Lake Erie, and 676 mm in the Mississippi River in Iowa. The length-weight relationships of these populations further expresses growth differentiation. Those expressions for the St. Lawrence River, Lake Erie and the Mississippi River were as follows:

$$\log W = -4.012 + 3.039 \log FL$$

$$\log W = -4.910 + 2.956 \log TL$$

and

$$\log W = -6.759 + 3.66 \log TL \text{ (weight in g; FL, TL in mm)}$$

The age of maturity is also variable in different waters. In the Iowa region of the Mississippi River, channel catfish reached sexual maturity between five and nine years old. Studies in the south showed that channel catfish matured in the second to third year (Davis 1959). Few catfish live longer than eight years, although large individuals from 15 to 40 years old are occasionally found (Finke 1964, Scott and Crossman 1973). The largest fish recorded was caught in the Santee-Cooper Reservoir in 1964 and weighed 26.31 kg (Becker 1983).

E3.2.8 Flathead Catfish (*Pylodictis olivaris*)

Description. Flathead catfish is one of the larger species of its family. The world record sport fishing size is 36 kg which is second only to the blue catfish. Flathead catfish are fairly solitary, with mature individuals taking up permanent residence in deep pools of medium and large-sized rivers (McGinnis 1984). As the name implies, they have an extremely large, flat head, with small eyes and mouth.

Distribution. Flathead catfish are considered native to the large rivers of the Mississippi, Missouri and Ohio basins, as well as the Rio Grande and rivers in northeastern Mexico (Lee *et al.* 1980, Moyle 1976). They have been sparingly introduced outside their original range. In Arizona, flathead catfish were stocked in the Gila River system prior to 1950, and currently large populations occur in the San Carlos Reservoir. In the 1960s, the Arizona Game and Fish Department introduced them into the Lower Colorado River and they have successfully expanded their range west into California waters (McGinnis 1984). They are presently found throughout the Verde and Salt rivers and in the associated reservoirs.

Habitat. Flathead catfish prefer riverine habitats with summer temperatures ranging from 31.5–33.5°C (Gammon 1973). They primarily reside in highly oxygenated water in major streams and large rivers, become less abundant in small streams, and are virtually absent in intermittent streams.

Young flathead catfish under 100 mm are often found among rocks in riffles. As they reach 100 to 600 mm in length, they disperse throughout the river. Individuals of 600–800 mm inhabit areas with cover (logs, brush-piles and rocks) at intermediate depths. Large adults over 800 mm are solitary; they live in deeper pools near large cover, especially logs and felled trees (Minckley and Deacon 1959). Pflieger (1975) noted that adults have favorite resting places that they reliably visit every day unless disturbed.

Spawning. In Arizona, flathead catfish spawn from spring to early summer. Appropriate water temperatures for breeding are 22.2–23.9°C (Becker 1983). Flatheads choose spawning sites with a cave-like environment such as muskrat burrows, undercut banks, log jams or rocks. Both sexes participate in constructing large nests. They remove substrate with their tails and mouths to build a silt-free nest with a bare gravel and rock bottom. Cross (1967) described a typical flathead nest as dug into a steep clay bank with a 355-mm diameter entrance that widened to 813 mm inside the nest chamber.

Courtship for flathead catfish begins when the male approaches the female. He swims alongside and over the female and gently rubs her belly. The male eventually rests on the bottom and wraps his caudal peduncle and fin around the head of the female. This activity continues for almost two weeks until the female deposits her eggs and the male fertilizes them. The actual spawning lasts up to 4.5 hours (Fontaine 1944). Unlike many other fish species, coloration remains the same during spawning. After spawning, flathead males guard and vigorously defend the eggs until they hatch.

Egg production of an Oklahoma population showed a range of 4,076–31,579 eggs for females weighing 1.05–11.66 kg (Summerfelt and Turner 1971). Eggs average 3.7 mm in diameter. Incubation time for flathead catfish eggs is six to seven days at temperatures of 23.9–27.8°C, and nine days at 24–25.9°C (Giudice 1965, Snow 1959). Emerging larvae may measure about 11 millimeters. Larvae school for several days after hatching. After absorbing their yolk-sac, fry leave the nest and move mainly into shallow, swift riffles and beneath stones or cover (Cross 1967).

Movement. Flathead catfish are generally classified as semi-mobile (Minckley and Deacon 1959). Tagging studies in Missouri reported 48.9 percent of tagged flatheads were recaptured less than 1.6 km away and 90.7 percent less than 40.2 km away from the point of tagging (Funk 1957). A strong homing tendency is also apparent. In telemetry studies, flathead catfish were displaced 1.3 to 2.7 km and subsequently homed actively in the direction of their point of capture (Hart 1974).

Flathead catfish move to different habitats with increasing size, possibly as a result of population pressure (Minckley and Deacon 1959). Young-of-year move from their nesting site to swift riffles with rubble bottoms. When juveniles reach approximately 102 mm TL, they distribute evenly in the stream. Some remain in the shallows; however, more move into pools and deeper riffles. Larger flathead catfish usually locate in or near deep holes in the stream bed or near massive logs and drift piles (Becker 1983).

Flathead catfish move more at nighttime than during the day. Koster (1957) and Trautman (1957) indicated that large flatheads often move from deeper waters into riffles or shallow areas near swift currents at night.

Food Habits. Flathead catfish are primarily bottom feeders that forage on the most available organisms. Unlike channel catfish, flatheads rarely scavenge on dead and dying material but feed mostly on fish and crayfish. Flathead catfish gradually become more piscivorous with increasing size. Reportedly, individuals under 100 mm TL feed mainly on fish, and the stomach volume of large flatheads (over

250 mm) is 80 percent fish, such as suckers, minnows, channel catfish, madtoms, darters, sunfish and freshwater drums (Minckley and Deacon 1959).

Although they feed at all hours, the most extensive feeding is at night and in the early morning. At night, flathead catfish actively feed in very shallow riffles with their dorsal fins exposed out of the water. Passive feeding also occurs; catfish lie on the bottom and wait for prey to dart into their wide open mouths (Trautman 1957). Foraging behavior changes over the seasons. Flathead catfish feed most intensively in May through September. They feed less during the spawning season and in winter (Becker 1983).

Age and Growth. Habitat largely influences growth rates of flathead catfish. Growth rates are reportedly fastest in individuals residing in turbid, relatively shallow areas as opposed to clear, rocky areas. Purkett (1958) found that flathead catfish also tend to grow more rapidly in downstream locations than in headwater areas. Rapid growth is also more common on shallow mudflats than clear, rocky areas (Carlander 1969).

Growth is usually greatest during the first three to four years of life, and then decreases in later years. In Iowa, mean lengths for flathead catfish were 142 mm in their first year, 269 mm in their second, 393 mm in their third, 469 mm in their fourth, 550 mm in their fifth, 600 mm in their sixth, 674 mm in their seventh, and 714 mm in their eighth year (Mayhew 1969). The length-weight relationship for this population was determined as follows:

$$\log W = -5.5819 + 3.2597 \log TL \text{ (weight in g, TL in mm)}$$

Males mature at 3-5 years old and at lengths of 800-1,200 millimeters. Females mature at 4-6 years old and at lengths of 457-508 millimeters.

E3.2.9 Largemouth Bass (*Micropterus salmoides*)

Description. Largemouth bass are the principal warmwater predatory fish in most lakes and reservoirs and consequently of considerable ecological importance. When first introduced into smaller lakes, ponds and reservoirs, a population explosion initially occurs. As a result, all forage species are decimated and largemouth bass subsequently experience stunted growth (Robbins and MacCrimmon 1974). However, little evidence exists to support that introduction of largemouth bass into large bodies of open water has resulted in appreciable declines of prey species (Heidinger 1975). Largemouth bass have been implicated in the destruction of a number of Arizona populations of endemic fish species, including the Gila chub and *Cyprinodon* species from a pond at Monkey Springs; also, a substantial proportion of the last natural population of Gila topminnow in the state was depleted as a result of largemouth bass predation (Minckley 1973).

As the common name implies, they have a large mouth with the maxillary extending beyond the center of the eye, even in small specimens (Wydoski and Whitney 1979). Largemouth bass are dark green to light on the back and head, with a prominent lateral stripe from the snout to tail. Lengths are typically 229-305 mm TL (Becker 1983).

Distribution. The native range of largemouth bass was widely distributed. They originally inhabited waters east of the Rocky Mountains, north to southern Quebec and Ontario and throughout the Great Lakes and Mississippi Valley. The southern limit included the Gulf of Mexico extending to northeastern Mexico, Florida and up to the Carolinas (Robbins and MacCrimmon 1974). Currently, largemouth bass are distributed nearly worldwide: North America, Central America, South America, Africa, Europe, Guam, Hawaii, Japan, Lebanon, New Zealand and the Philippines (Becker 1983).

In the United States, the range of introduced and native populations extends across the continent from the Atlantic to the Pacific coasts, and northward from the Gulf States to the Great Lakes basin and along the Canadian border. The first introduction of largemouth bass to Arizona was in 1892 by the United States Fish Commission (Robbins and MacCrimmon 1974). In recent years, a southern form, *M. s. floridanus* (LeSuer), has been introduced in Arizona because it purportedly grows faster and achieves larger sizes as an adult (Bailey and Hubbs 1949). However, in similar environments, growth between the two subspecies is not substantially different (Minckley 1973).

Habitat. The typical habitat of largemouth bass is warm reservoirs, ponds and lakes with low turbidities and beds of aquatic plants. Optimum temperatures for growth are 20–30°C with a minimum oxygen requirement of 1.5–2.0 ppm (Emig 1966). Upper lethal limit for largemouth bass is 37°C (Moore 1942). They are suited to slightly alkaline waters with a total alkalinity of less than 900 ppm, carbonate alkalinity less than 250 ppm and K + Na less than 200 ppm. Largemouth bass are also frequently found in brackish water, up to 24.4 ppt salinity (Carlander 1977).

Largemouth bass are primarily a lake species although they have developed populations in medium to large rivers. Bass primarily inhabit shallow areas with dense vegetation beds. They are seldom found deeper than the deepest areas where rooted plants grow; commonly in depths to 1.5 m but seldom below 6 meters. Largemouth bass prefer clear to slightly turbid waters, but are capable of surviving in permanently turbid water (Miller 1975). Preferred substrates include mud, sand and organic material; these provide the best substrate for aquatic vegetation. Usually, largemouth are found in association with objects that provide cover, such as brush, logs, pilings, submerged trees, reeds and lily pads (Wydoski and Whitney 1979).

Spawning. Breeding activity begins as water temperatures reach 14–16°C; the critical temperature for initial nest selections is 15.6°C (Breder and Rosen 1966). In Arizona, the spawning season peaks from April through May or June at water temperatures of 18°C or higher (Minckley 1973). Males select nest sites in shallow, cove areas with vegetation (Scott and Crossman 1973). Preferred substrate for spawning is sand and gravel (Hubbs and Bailey 1938). Nests are constructed in water depths between 0.2–1.8 m but average depth is 0.6 m (Breder and Rosen 1966). Largemouth bass do not nest in colonies like most sunfish; they generally construct nests at least 9 m apart (Becker 1983). Males may construct nests almost anywhere in a lake but commonly select sites near shorelines or in coves. Protected sites near rocks, stumps and slopes are often selected as well (Miller and Kramer 1971).

Males begin nest construction by fanning out huge basins with their fins, typically 1 m in diameter and 0.3 m deep. Nests are circular and about twice the diameter of the parent bass. Courtship begins as the male attracts a female to its nest. Both fish undergo vivid color changes. The couple swim over the nest with both vents in close contact and simultaneously emit eggs and sperm. This process is repeated several times with resting periods in between. Males will spawn with more than one female in a nest. Apparently, no mortality is associated with the stress of reproduction (Becker 1983).

Nests contain an average of 5,000 eggs. Fertilized eggs are demersal, adhesive, 1.5 to 1.7 mm in diameter, and amber to pale yellow (Scott and Crossman 1973). Males continuously fan nests to keep eggs in contact with fresh water and free of silt. Males also actively guard the nest from predators such as bluegill. If a large population of bluegill is present, predation pressure may be too intense for males to successfully protect their nests; such predation can eliminate entire year-classes (Bennett 1971).

Egg incubation time ranges from three to seven days depending on temperature. Merriner (1971) recorded the following hatching times and temperatures: 317 hours at 10°C, 55 hours at 18°C and 49 hours at 28°C. At hatching, fry are transparent and 3 mm in length; typically 3,000 fry emerge per nest (Becker 1983). Fry remain in the bottom of nests until they absorb the yolk in six to seven days. Afterwards, fry measuring 5.9–6.3 mm rise from their nests and begin schooling. Fry may remain in a brood for up to 31 days, and the male closely guards the school for part or all of the time. Young bass usually school as a single nest, but two to five schools may join and the respective parental males accompany the group (Becker 1983). As fry grow, the schools begin to disperse into shallow weedy waters. Juveniles remain associated with vegetation, typically schooling near the edge of the shoreline (Wang 1986).

Movement. Investigators have reported variable data on largemouth movement. A strong tendency to remain in a home area was found by Lewis and Flickinger (1967); bass remained within 91 m of their point of capture. However, longer wanderings were observed in other studies: 3.1 km for a radio-tagged bass and 2.7 km for a tagged and recaptured fish (Larimore and Dufford 1976, MacKay 1963). Schaumer and Eschmeyer (1942) found that 90 percent of their recovered bass had moved 25.6 km in one year. In Florida, home ranges varied from 0.01–5.16 hectares (Mesing and Wicker 1986). Actual migration and movement of largemouth bass is not clearly understood.

In the Florida study, largemouth bass underwent spawning migrations to areas as far as 3 km outside their home range. They moved into protected areas near shorelines with vegetation. However, 36 percent of the largemouth bass population remained offshore. Daily movements generally increase as mean monthly water temperatures increases from 20–28°C. As water temperatures approach 30°C in July and August, daily movements declined. In the winter, limited afternoon movements were noted in December and January when water temperatures were less than 18°C. Warden (1973) reported similar results: diurnal movement decreased at temperatures above 27°C and nocturnal movement increased, and all movement decreased below 10°C. Generally, largemouth bass inhabit deeper waters during the winter and migrate into early warming bays in the spring (Lewis and Flickinger 1967).

During the day, largemouth bass cruise above aquatic plants at depths of 1–3 m, or lie under lily pads, or in the shade of overhanging trees, piers or brush. Bass move into shallow water in the evening to feed. After a peak of intense foraging activity at dusk, largemouth bass move back into deeper water and become quiescent (Moyle 1969). Unlike other bass species, small and medium-sized largemouth bass aggregate in schools (5–10 fish) and cruise the shorelines while feeding. However, the larger mature bass are usually solitary.

Food Habit. Largemouth bass are the dominant carnivore in many North American lakes and reservoirs. Their large mouth and elastic stomach are well adapted for predation on fish. Fingerlings feed primarily on microcrustaceans such as copepods, cladecerons and ostracod. Young bass (51–76 mm in length) forage on insects and insect larvae, and fish begin to appear in their diet. Insect prey is commonly dragonfly nymphs. Larger individuals eat fish, crayfish, frogs and larger insects (Mraz *et al.* 1961).

Fish prey items for adults in descending order of importance are: bluegill, tadpole madtoms, brown bullheads, yellow perch, black crappies, minnows and smaller largemouth bass (Becker 1983).

Bass may passively feed by waiting for prey and then sucking in the organism; or they may actively pursue and capture prey. Largemouth bass are sight feeders. They feed at all hours, but most intensely in the early morning or late in the day (Becker 1983). Prey is only swallowed whole, and therefore their forage is limited by the size of the prey. Largemouth bass feed intermittently on large fish; once a fish is ingested, they characteristically do not feed for about 40 hours. However, this feeding pattern does not apply when foraging on small fish and crayfish (Lewis *et al.* 1974). Largemouth bass grow more rapidly on a diet of fish than on a diet of insects, regardless of whether the same amount was ingested (MacKay 1963).

Age and Growth. Largemouth bass have variable growth rates. Greatest increases in length occur during the first two years of life; thereafter, weight gains are greater. After one year, largemouth bass may be 5–35 cm long. In Wisconsin, largemouth bass averaged 91 mm in their first year, 170 mm in their second, 229 mm in their third, 272 mm in their fourth, 305 mm in their fifth, 345 mm in their sixth, 411 mm in their seventh, 452 mm in their eighth, and 467 mm in their ninth year (Becker 1983).

Mature fish are generally 3–4 years old and 254–305 mm long. Females tend to be longer and heavier than males in similar age groups, but differences between the sexes is slight. However, differential mortality is apparent; females reach a maximum age of nine years and males reach a maximum age of only six years (Padfield 1951). The oldest largemouth bass recorded was 16 years old and measured 541 mm in total length (Carlander 1977). Most largemouth do not exceed 0.9–1.4 kg in weight, but occasionally a 2.7-kg fish is taken. A maximum record fish was collected in Georgia that was 819 mm long and weighed 10.09 kg (Becker 1983).

E3.2.10 Yellow Bass (*Morone mississippiensis*)

Description. Yellow bass is primarily a lake species. They are fast growing and relatively short lived, often producing populations which are unstable and cyclical in nature. Adult yellow bass are basically pelagic, school closely, and thrive in rich, eutrophic lakes abundant with zooplankton and fish fry. They are golden yellow throughout most life stages, with dark stripes along the sides. Typical lengths for yellow bass are 152–203 mm TL (Becker 1983).

Distribution. Yellow bass is a southern species; it was originally confined to the lower Mississippi Valley (Lee *et al.* 1980). The range has since extended up the Mississippi River to the lower Chippewa River basin; other areas include the lower Wisconsin River, the Lake Michigan drainage basin and the Rock River basin (Becker 1983). In Arizona, yellow bass were introduced into Roosevelt Reservoir between 1929 and 1932. Although large populations never developed in the lake, this species is currently present in all the reservoirs on the Salt River and downstream from Roosevelt Dam (Miller and Lowe 1964).

Habitat. Yellow bass inhabit lakes and connecting sloughs, reservoirs and large rivers. They prefer wide expanses of open water that is free of weeds. Yellow bass are found in clear to turbid waters and at depths up to at least 7 meters. Suitable substrates include sand, gravel, rubble, silt and firm substrates overlaid with a thick layer of mud (Becker 1983). They reportedly tolerate water temperatures of 32.2°C and higher (Burnham 1909).

Spawning. Yellow bass spawn in late spring to early summer. Smaller males ripen in early winter and larger females are ripe by April (Minckley 1973). Spawning activity begins as water temperatures approach 15°C, after a rapid rise of 3.5–4.5°C over several days (Bulkley 1970). Males form large schools at the mouth of inlet streams and near suitable spawning areas in lakes and move to the nesting site before the females. Congregations form in shallow water at night over rocky or gravel substrates at depths of 0.6–1.0 m (Becker 1983).

Males and females pair off and swim side by side; females are usually found 8 cm away from the males (Burnham 1909). Yellow bass are broadcast spawners. During actual spawning, fish swim very slowly or stop for a few seconds to release eggs and sperm. The female lies partly on her right side and the male remains upright. Eggs are laid intermittently, but the pairs continue to swim together between spawnings. Breeding usually takes an hour or more, and is probably most intense at water temperatures of 20–22°C (Shields 1965). No parental care is given to eggs or fry (Becker 1983).

For females measuring 148–168 mm TL, average fecundity is 19,300 eggs (Churchill 1976). Eggs are semibuoyant and sink slowly. Hatching success can be low and the strength of year classes erratic (Shields 1965). A good year class usually occurs in only one out of three years. Eggs hatch in 4–6 days at a temperature of 21.1°C. Fry are colorless, transparent and approximately 3.2 mm long. After about four days, fry have absorbed the yolk and begin swimming upward and schooling. Fry swim vigorously up toward the water surface and sink; when they hit bottom, the young again return to the surface. Swim-up fry inhabit waters about 0.6 m deep. After two to three days, they drift toward the shore into water 3–35 cm deep (Becker 1983).

Movements. After the spring spawning season, yellow bass move from the shallows to offshore waters. In the fall, they return to the shallows when temperatures drop below 10°C; however, yellow bass leave again when temperatures decrease to 4°C (Helm 1964). Yellow bass tend to remain off shore during the day and move in at dusk, following the shoreline to forage. In general, yellow bass are far more active at night than during the day. Kraus (1963) determined that yellow bass are most active between the hours of 20:00 and 04:00. Juveniles prefer the lake bottom during the day but move to surface waters as light intensities decrease.

Food Habits. Yellow bass feed primarily on plankton and are carnivorous. They forage on plankton during the day and chironomids at night. Helm (1964) examined the major foods of yellow bass and reported the following frequency of occurrence: cladocera, 92 percent; copepoda, 92 percent; chironomidae larvae, 68 percent; chironomidae pupae, 52 percent; chaoborinae, 16 percent; fish remains, 20 percent; and ostracoda, 28 percent. This paper also reported that the diet of yellow bass was similar, regardless of their size.

Yellow bass forage in a definite pattern; peak feeding occurs shortly after dark and again at daylight (Helm 1964). Unlike white bass, yellow bass do not regularly feed on the surface, but usually school between mid-water and near the bottom (Helm 1958, Shields 1965).

Age and Growth. Yellow bass grow extremely rapidly. In Wisconsin, average total length for yellow bass was 97 mm at the end of their first year, 136 mm in their second, 153 mm in their third, and 159 mm in their fourth year (Churchill 1976). A particularly fast-growing population in Lake Poygan, Wisconsin had a length–weight relationship of

$$\log W = -4.0289 + 2{,}700 \log TL \text{ (weight in g, TL in mm)}$$

Sexual maturity is reached by the third year (Priegel 1975), and yellow bass seldom live longer than three to four years. Annual survival rate is 20–40 percent after the first year of life (Becker 1983). Perhaps contributing to this high mortality is the severe disease outbreaks that occur during spawning. Such post-spawning mortality has been observed in Illinois.

E3.3 MAMMALS

E3.3.1 Black-tailed Jackrabbit (*Lepus californicus*)

Status. The black-tailed jackrabbit is the most common of two species of jackrabbits found in Arizona; the other is the antelope jackrabbit (*L. alleni*) which occurs in the southern third of the state (Hoffmeister 1986). One other species, the white-tailed jackrabbit (*L. townsendi*) possibly also exists in Arizona, but there have been no confirmed records (Hoffmeister *op. cite*). Three subspecies of *L. californicus* are recognized: *L. c. eremicus*, *L. c. deserticola*, and *L. c. texianus*, but the distinctiveness of these is debatable.

Description. Head and body are 43-53 cm; ears are 15-18 cm. Individuals weigh 1.3-3.1 kg. The body is grayish brown on back and sides and creamy white underneath. The tail shows a distinctive black streak on the dorsal side, extending up the back. This character and the typically large ears with black tips serve to distinguish this species from others (Burt and Grossenheider 1976).

Distribution and Habitat. Black-tailed jackrabbits are present throughout Arizona in open and semi-open arid grasslands, and they occur rarely in the pine forests of higher terrain. The species is also found in mesquite, sage-brush, desertscrub, and open pinyon-juniper habitats, but few jackrabbits occur in thick cover. Grazed rangelands are preferable to those not grazed, and numbers may be higher in areas where coyote eradication programs have been conducted. According to John Phelps (AGF. pers. comm.), jackrabbit survival and reproduction are significantly reduced by drought.

Breeding. Females are of breeding age about one year after birth and can stay in breeding condition throughout the year with as little as two weeks between the birth of one litter and conception of another. Individuals seven years old in captivity continue to breed. Two to four young are typically produced per litter and females may have as many as four litters per year. Nests range from shallow depressions in the earth with little or no preparation to hair-lined, globular, below-ground nests. Young are precocial and reach adult length 28 weeks after birth and adult weight at 32 weeks.

Activity. Individuals are most active during the crepuscular period. During the day, they rest in shallow depressions called "forms" at the base of bushes or clumps of grass. Adults often stand on their hind legs to survey the surrounding area.

Food Habits. The normal diet consists of grasses (nearly all available kinds) and mesquite, with cactus contributing little. However, in dryer years when grass and mesquite production are low, cacti make up a larger proportion of the diet.

E3.3.2 Desert Cottontail (*Sylvilagus auduboni*)

Status. The desert cottontail is the most common of the three species of rabbits found in Arizona, the other two being *S. nuttalli* and *S. floridanus*, the mountain and eastern cottontail, respectively (Hoffmeister 1986). Three subspecies are recognized: *S. a. arizonae*, *S. a. minor*, and *S. a. warreni*. The former is the most prevalent and is found in the western part of the state above and below the Mogollon rim and as far eastward as Roosevelt Reservoir and southward from Arivaca.

Description. Head and body 30-38 cm; ears are 76-102 mm. Individuals vary in weight from 0.6 to 1.2 kg. The body is pale grey washed with yellow. The tail has a narrow band of grey and the rest is white, giving the rabbit its generic name of cottontail (Burt and Grossenheider 1976).

Distribution and Habitat. *S. auduboni* is found throughout Arizona and is common in desertscrub habitats and semiarid grasslands where brush is thickest. In southern Arizona, desert cottontails are often found in mesquite thickets. In central and northern parts of the state, they are common in open stands of juniper where the trees have been thinned by bulldozing and brush piles are present. Cottontail densities are often high in agricultural areas (John Phelps, AGF, pers. comm). Like jackrabbits, cottontail numbers are severely impacted by drought, but when rainfall restores the habitat, cottontail populations may quickly rebound as a result of their high intrinsic reproductive potential.

Breeding. In central and southern Arizona, *S. auduboni* breeds from January through August, but may breed year round in other part of its range. Two to six young are produced per litter, and females may have up to five litters per year, although they normally have less. Young are hairless and altricial. The area where the female gives birth ranges from a shallow depression to a burrow. The female lines the nest with grasses and her own fur. When nesting in a burrow, the female may plug it while she is away foraging.

Activity. *S. auduboni* usually uses burrows abandoned by other mammals, cavities in brush, or rock piles. Forms similar those used by black-tailed jackrabbits are often used as resting places, though the forms are never dug out as is sometimes the case for the jackrabbit. Cottontails are most active at night and during crepuscular hours. These rabbits must make use of available shade during the day as their ability to dissipate heat is insufficient to protect them from high temperatures.

Food Habits. Little is known about the food habits of *S. auduboni* in Arizona. It is assumed that grasses, mesquite, cacti, and sagebrush constitute the bulk of their diet. Desert cottontails apparently do not eat shrubs (Hoffmeister *op. cite*).

Age and Growth. Young begin leaving the nest at two weeks of age but are reliant on the mother for nursing for some time after. Males and females attain breeding age about three months after birth.

E3.4 BIRDS

E3.4.1 Eared Grebe (*Podiceps nigricollis*)

Status. The eared grebe is common in the southern half of Arizona in winter and rare in summer. In the northern half, it is present only during the breeding season which begins in late March and early April.

Description. The eared grebe is about 23 cm long with a 58 cm wingspan (Palmer 1962). The bill is slightly upturned and shorter than the head. During the breeding season the head crest, chin, neck, breast, and wings are black and the sides chestnut colored. A buff colored fan of feathers extends from just behind the eye beyond the back of the head. In the winter, the bird is much more drab, with no crest, dusky black on the head extending below the eye, down the back of the neck, and on the wings. The chin and breast are white and the rest of the neck and sides of the body are grayish. The white on the chin may extend to form a crescent behind the eye. Juveniles resemble the winter plumage of adults.

Distribution and Habitat. Found throughout Arizona, though seasonally in the northern half of the state. Outside its breeding season, eared grebes frequent large bodies of water, often forming rafts in open water of many (>50) individuals. During its breeding season, this bird is found in the sheltered areas of ponds, marshes, lakes, and reservoirs.

Breeding. Birds breed when they are at least one year old, and pairs participate in an elaborate courtship display which serves to establish and maintain the pair bond. Pairs are monogamous for the length of the breeding season and possibly for additional breeding seasons. The floating platform nest usually contains 3-5 eggs. Usually there is only one clutch per year, but possibly two in some areas, and pairs will re-nest if the eggs or young are lost early enough in the season. The young are precocial and often travel on their parents' backs where they are fed and brooded under the wings.

Migration. Eared grebes migrate nocturnally, and their routes cover a wide portion of the western United States. There is considerable overlap between breeding and wintering ranges in Arizona, and many of the birds present in the winter are migrants from farther north. Northward movement begins as early as February and continues into March. Southward movement begins in late August in northern states, peaking in October and November.

Food Habits and Behavior. The diet of eared grebes consists mainly of aquatic insects and larvae. Fish, crustaceans, mollusks, and amphibians contribute to a lesser degree. Grebes eat their own feathers in great amounts, a behavior that apparently helps to protect the stomach from sharp bones which the gizzard is unable to crush. When attacked by a raptor, grebes dive beneath the water's surface and emerge some distance away.

Age and Growth. Young are precocial and are readily able to swim and dive. Young from several broods may join, forming "creches." Fledging takes place approximately 21 days after hatching, and young may breed the following year.

E3.4.2 American Coot (*Fulica americana*)

Status. The American coot is resident in Arizona, and its populations are augmented by wintering migrants.

Description. Length is about 30 cm with a wingspan of 63 cm. Head and neck are black and the body slate colored. The bill is white to near white with a black band near the tip. The forehead shield is reddish brown. The feet are lobate, varying in color from dusky green in juveniles to bright yellow or orange in adults.

Distribution and Habitat. The American coot frequents marshes, ponds and reservoirs throughout Arizona in all seasons. It often forages in mud-bottomed shallows and grazes on shore and on golf courses.

Breeding. Birds probably breed when one year old. Male and female participate in a courtship ritual and are monogamous at least for the duration of the breeding season. The pair builds up to nine floating platform nests. Eggs are laid only in one, the others serving as sites for displaying and copulation. Eight to twelve eggs are usually laid, with incubation usually beginning after the laying of the fifth egg. Incubation lasts 21-25 days, and both adults participate. Young are precocial and fledge in 49-56 days. The coot may be subject to brood parasitism by other females. One or possibly two broods may be raised each year. Young are precocial and ride on a parent's back.

Migration. Birds from more northern areas leave in March and April and return to Arizona in late fall or early winter.

Food Habits and Behavior. The majority of the diet consists of aquatic vegetation and algae. Coots also eat fish, tadpoles, crustaceans, snails, worms, aquatic and terrestrial insects, and the eggs of other marsh nesting birds. Adults and juveniles may pirate aquatic vegetation from diving ducks and swans. The American coot's defense against attack is to dive below the surface of the water, but it often walks away from water to graze in areas far from shore, a behavior that renders it especially vulnerable to predation. Coots must run on the water to take flight, and compared to ducks, coots are very slow flyers.

E4 DDE AND PCB'S IN UNHATCHED EGGS OF ARIZONA BALD EAGLES: AN ASSESSMENT OF POSSIBLE EFFECTS ON PRODUCTIVITY

Prepared by Robert Risebrough
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The productivity of Arizona bald eagles is about 0.9 young fledged per occupied nest (Section C2). Productivity in 1987-1989 averaged 0.83, 1.04, and 0.52, respectively, (Table E4-1) the low value in 1989 was attributed to excessively hot weather. A mean productivity of approximately 0.9 is above the estimated critical level of 0.7 that would maintain population stability of bald eagle populations in eastern North America (Sprunt *et al.* 1973) but below the 1.0 level estimated by Wiemeyer (1984) to characterize a "healthy population." Stalmaster (1987) gives a continent-wide mean of 0.9 young which equals that observed in Arizona during the last two decades (see Section A2). This report addresses the hypothesis that in spite of this "normal" productivity of the population as a whole, the productivity of selected pairs may be depressed by DDE (p,p'-DDE, 1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethylene, a metabolite of DDT: p,p'-DDT, 1,1,1-trichloro-2,2-bis(*p*-chloro-phenyl)ethane). Such a pattern has been observed among bald eagles in California (R.W. Risebrough and D. Garcelon, unpublished) as well as among species such as the prairie falcon, *Falco mexicanus*, and merlin, *F. columbarius* (Fyfe *et al.* 1988).

Table E4-1. Productivity of all known and documented bald eagle nesting sites in Arizona, 1987–1989. Young fledged per occupied nest.

Year	Occupied Nests	Successful Nests	Young Fledged	Nest Success (%)	Productivity
1987	24	11	20	46	0.83
1988*	23	15	24	65	1.04
1989	25	9	13	35	0.52

* The 1988 report lists 23 active sites, but the summary report lists 26.

The bald eagle population of western Florida provided the first documented example of a pattern of reproductive failures and population decline that was later linked with the DDT compound DDE (Broley 1958). Charles Broley banded the fledgling eagles in this region over the period 1939-1958. In 1947, 41 percent of the nests visited by Broley produced no young; the percentage of failed nestings increased to 48 in 1948, 77 in 1949, and 78 in 1950. Over the period 1952–1957 only 20 percent of the active nests produced young, and the numbers of active nests declined. Human disturbance, an increasingly important factor affecting the availability of nesting sites, could not explain the apparent sterility of the eagles. Broley's banding activities had shown that Florida bald eagles disperse northwards after the breeding season; the percentage of immatures among the bald eagles passing over the Hawk Mountain

sanctuary in eastern Pennsylvania declined during these years (Broun 1931-1960). A comparable pattern of reproductive failure was later documented in bald eagle populations in other areas of eastern North America; invariably the depressed productivity resulted in population decline (Sprunt 1963; Sprunt and Ligas 1966; Sprunt *et al.* 1973; Stickel *et al.* 1966; Abbott 1967; Postupalsky 1968, 1971; Grier 1972; Wiemeyer *et al.* 1972).

Because of the national importance of the species, bald eagles found dead and recovered unhatched eggs were sent to the national analytical facility at the Patuxent Wildlife Research Center for analysis of organochlorines and other environmental contaminants. A large data base of contaminant levels in bald eagles and their eggs was thereby obtained (Reichel *et al.* 1969; Mulhern *et al.* 1970; Belisle *et al.* 1972; Cromartie *et al.* 1975; Prouty *et al.* 1977; Kaiser *et al.* 1980).

Invariably, the declining bald eagle populations experienced eggshell thinning (Hickey and Anderson 1968; Anderson and Hickey 1972; Wiemeyer *et al.* 1984). The cases for which data on organochlorine residues in eggs, shell thickness, and productivity over a 3-5 year interval were available were analyzed by Wiemeyer *et al.* to determine relationships among these parameters. Both depressed productivity and shell thinning were associated more with DDE than with any other contaminant, and an effect caused by a contaminant other than DDE could not be demonstrated in this data base.

A relationship between shell thinning and DDE levels was first demonstrated by Hickey and Anderson (1968) in herring gulls, *Larus argentatus*. Correlations between decreasing shell thickness and increasing DDE levels have since been demonstrated in a number of species and thinning has been induced in the laboratory by DDE levels comparable to those measured in the environment. A recent review (Risebrough 1986) found no evidence that any compound other than DDE has contributed to the shell thinning observed.

The relationship derived by Wiemeyer *et al.* between productivity and DDE residues (Figure E4-1) shows a very sharp decrease of productivity with very low levels of DDE. These data have been re-analyzed by Nisbet (1989) who found that a model which shows a range of low DDE values with no or very little depressed productivity, and above which productivity rapidly declines, provides a better fit to the data (Nisbet 1989; Figure E4-1). This model is moreover consistent with field observations of species experiencing shell thinning and population declines; there is a range of lower DDE concentrations and smaller reductions of shell thicknesses that are not associated with a significant depression of productivity.

Interpreted with either model, this data set shows that productivity of bald eagles becomes significantly depressed at relatively low levels of DDE, in the range of 3-5 ppm wet weight. The bald eagle is therefore one of the most sensitive species to the effects of DDE contamination.

Like other species showing DDE-caused reproductive failures, bald eagle populations have responded to the ban on DDT use in North America. In northwestern Ontario, productivity increased from a low of 0.46 young per breeding area to 1.12 in 1981. Simultaneously, shell thickness increased and DDE levels in unhatched eggs declined (Grier 1982).

In the present study, seven unhatched eggs were obtained for analysis (Table E4-2). Egg contents were homogenized and an aliquot was ground with anhydrous sodium sulfate; lipid extracts were obtained by soxhlet extraction with methylene chloride. After removal of the methylene chloride by rotary evaporation, the lipids were weighed and dissolved in hexane, and weighed. For clean-up, up to 0.1 g lipid was

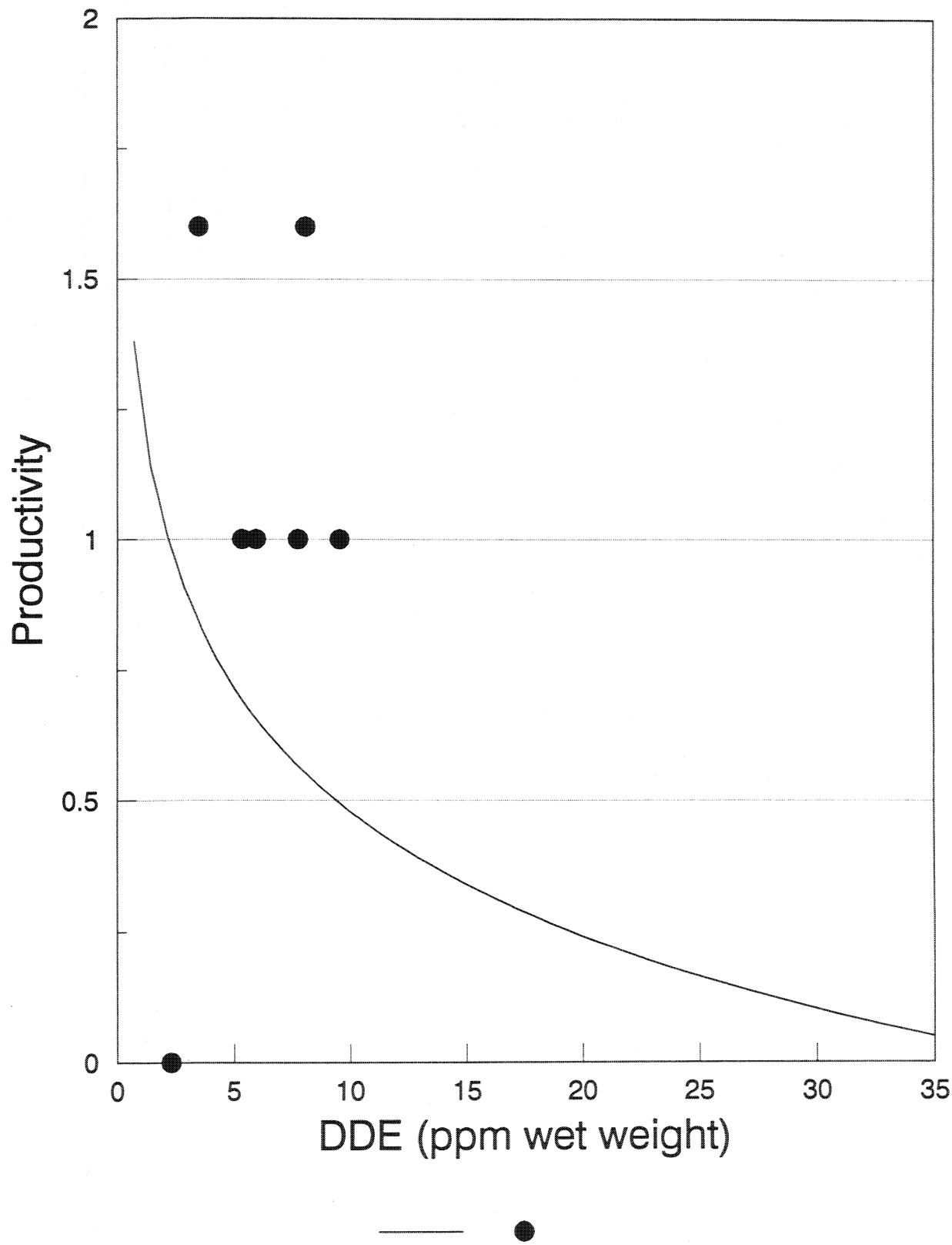

Figure E4-1. Productivity vs. DDE content for Arizona bald eagle eggs (●) compared to curve derived by Wiemeyer *et al.* (1984) for productivity vs. DDE relationships among a larger sample of North American bald eagle nest sites. Productivity is mean number of fledged birds for a territory (*see* Table E4-2).

Table E4-2. Productivity of breeding areas of Arizona bald eagles over 1985–1989 from which an unhatched egg was taken for analysis.

Site	Year	Status	Eggs	Young	Fledged	Estimated Productivity	DDE (ppm lipid)	Comments
Cedar Basin	1985	Failed	1+	0	0			
	1986	Failed	1+	0	0			
	1987	Failed	3	0	0			
	1988	Failed	2	0	0			
	1989	Failed	1+	0	0	0.0	31	Egg collected for analysis.
Chino	1985	Successful	2+	2	2			
	1986	Failed/Foster	1	0 (2)	0 (2)	1.0	110	Egg infertile, analyzed. Two young fostered into nest and fledged.
	1987	Failed	2+	0	0			New female or pair. Old pair (banded female) moved to Alamo breeding area.
	1988	Unoccupied						
	1989	Unoccupied						
McDowell	1985	Successful	3	3	3			
	1986	Successful	2+	2	2			
	1987	Successful	1+	1	1			
	1988	Failed	2+	0	0	1.6	94	First clutch failed, probable disturbance; egg collected for analysis from second clutch which was incubated past term.
	1989	Successful	2+	2	2			
Cliff	1985	Successful	2	2	2			

Table E4-2. (Continued)

Site	Year	Status	Eggs	Young	Fledged	Estimated Productivity	DDE (ppm lipid)	Comments
Cliff	1986	Failed	1+	0	0			
	1987	Occupied	-	-	-			
	1988	Successful	2+	2	2			
	1989	Failed	3+	1	0	1.0	120	Young disappeared during first week; other eggs incubated past term; one collected for analysis.
Horseshoe	1985	Successful	2+	2	2			
	1986	Successful/ foster	2+	2	2			Nest inundated, young fostered to Chino and fledged.
	1987	Successful	3	3	3			
	1988	Successful	1+	1	1			
	1989	Failed	2+	1	0	1.6	74	Young decapitated, apparent great horned owl predation; egg collected for analysis.
Alamo	1987	Occupied	0	0	0			Adult female banded, possibly 1986 Chino pair.
	1988	Successful	1+	1	1			New adult female.
	1989	Successful	2+	1	1	1.0	130	Egg collected for analysis.
Horse Mesa	1985	Failed	1+	0	0			
	1986	Successful	3	2	2	1.0	100	Egg taken for analysis; Sample information lists 1987 date.
	1987	Successful	2+	2	2			
	1988	Successful	1+	1	1			
	1989	Failed	1+	0	0			

placed on a florisil column that had been pre-rinsed with hexane (florisil activated at 400°C, cooled, deactivated with 0.5% H_2O, 18 g florisil). Two fractions were collected, eluting with hexane (F1), and 50 percent methylene chloride in hexane (F2). Volumes were adjusted such that DDE but not p,p'-DDT eluted in F1, and both p,p-DDT and dieldrin eluted in the F2. For this report only the F1 fraction was analyzed, by packed column electron capture gas chromatography with a Hewlett-Packard 5790 gas chromatograph; 1.5 percent SP-2250, 1.95 percent SP-2401 on Supelcoport, 100/120 mesh; injection temperature 250°, detector 325°, and the oven 215°. The runs were isothermal.

Several of the eggs contained DDE at concentrations greater than 100 ppm on a lipid basis, or approximately 5 ppm wet weight (Table E4-3), the level found to be associated with depressed productivity by Wiemeyer *et al.* (1984) and by Nisbet (1989). The low productivity of the Cedar Basin site can not be attributed to these contaminants, since the Cedar Basin egg contained the lowest levels of DDE and the second lowest level of PCBs (wet weight), and the DDE level is below the expected effect level. The relatively high productivity of the sites from which the other eggs were obtained (Table E4-2, Figure E4-1) indicates no or only a very small effect of contaminants. A threshold level of DDE effects on productivity would appear to be in the order of 8 ppm wet weight or higher, more than twice the level predicted by the Wiemeyer/Nisbet relationships.

A hypothesis that could explain this apparent discrepancy derives from a feeding experiment with mallard ducks, *Anas platyrynchos*, in which the ducks were fed DDE, PCBs, or a mixture of DDE and PCBs. Birds on the mixed diet produced fewer eggs and lost more eggs to egg-eating (Risebrough and Anderson 1975). Although the statistical analyses undertaken by Wiemeyer *et al.* (1984) and by Nisbet (1989) showed that only DDE had a demonstrable effect on productivity, this analysis could not distinguish an effect caused only by DDE and a DDE effect enhanced by PCBs. In this sample the geometric mean PCB concentration, 2.0 ppm wet weight, is lower than the mean level of 7.2 ppm (n = 21) recorded in eggs from successful nests and the level of 13 ppm (n = 56) recorded in eggs from unsuccessful nests in the data set analyzed by Wiemeyer *et al.* In this data set, PCB levels were approximately twice those of DDE, whereas in the Arizona eggs DDE levels are higher than those of the PCBs (Table E4-3).

National monitoring programs for organochlorines in wildlife have consistently recorded higher levels of DDE in Arizona than in almost all other sampling sites (Martin 1979; Martin and Nickerson, 1972; Nickerson and Barbehenn, 1975; White, 1976, 1979; Clark and Krynitsky, 1983; Cain and Bunck, 1983). In part these residues may derive from the mixtures of technical dicofol used in the past as a miticide in cotton cultivation (Hunt *et al.* 1986; Risebrough *et al.* 1986) are significant sources of present DDT contamination.

Although the studies of bald eagle productivity vs. contaminant relationships undertaken elsewhere in North American would suggest that the DDE levels measured in the Arizona eggs would cause depressed productivity, such a depression was not observed. The previous studies could not distinguish, however, between an effect caused only by DDE and a DDE effect enhanced by another contaminant, such as the PCBs. The Arizona population, with moderate DDE and low PCB levels may therefore be useful in sorting out the relative contributions of these contaminants to the documented depression of productivity in the past elsewhere in North America, as well as the depressed productivity presently observed in southern California and the Great Lakes. Since the productivity of the Arizona population is relatively high, the present effect of contaminants is minimal; monitoring of organochlorine residues as potential threats to the population would not therefore appear to be a high priority. Nevertheless, the scientific value of any unhatched eggs from sites where productivity data are available is considerable. Such eggs

Table E4-3. DDE and PCBs in eggs of Arizona bald eagles. Parts per million of the lipid weights.

Site	Development	Date	Percent Water	Percent Lipid	DDE	PCBs
Cedar Basin Breeding Area Nest 4, Upper Salt River	None visible,* contents uniform, dull yellow	12 May 89	77.8	7.5	31	18
Chino Breeding Area, Nest 1, Big Sandy River	None visible,* contents uniform, dull yellow	21 Mar 86	64.3	8.6	110	25
Ft. McDowell Breeding Area, Nest 5, Verde River	None visible,* contents uniform, grey	30 May 88	77.1	8.5	94	46
Cliff Breeding Area, Nest 4, Verde River	None visible,* contents uniform, dull yellow	16 May 89	78.0	6.4	120	45
Horseshoe Breeding Area Nest 6, Verde River	None visible,* contents uniform, dull yellow	3 Apr 89	78.5	4.6	74	23
Alamo Breeding Area, Nest 2, Bill Williams R.	Embryo, 1/3 developed	25 Mar 89	80.0	4.1	130	30
Horse Mesa Breeding Area Nest 1, Salt River	Embryo, 3/4 developed	10 Apr 86	65.9	5.9	100	55

* Small decomposed embryo would probably not be detected in this sample.

should therefore be preserved, preferably frozen, for use in continuing studies of contaminant effects on bald eagles.

E5 ULTRASTRUCTURE OF BALD EAGLE EGGSHELLS FROM ARIZONA AND ITS RELATIONSHIP TO EGG QUALITY

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From an evolutionary perspective, the development of the amniote egg represents a major advance in the transition from an aqueous to a terrestrial environment (Gilbert 1985). This concept is exemplified by the avian egg where an aqueous environment surrounded by a hard shell allows species to exploit a greater range of environments than their reptilian ancestors.

The avian egg has long been the subject of scientific studies: the chicken egg because of its importance in the diet of man, and more recently the eggs of wild birds adversely affected by man-made chemicals. Eggshells have been studied with light microscopes for over 160 years (since Purkinje first described the layers of the shell in 1830), with polarizing light microscopes for approximately 90 years, and with the electron microscope for over 20 years (Simons 1971).

Our study, using electron microscopy, is the first to describe the ultrastructure of the bald eagle eggshell. Our results provide baseline data to be used in future studies in conjunction with Dr. Risebrough's chemical analyses (Section E4). A brief description of eggshell formation is followed by a detailed comparison of our findings with previous studies on other species with regard to changes in ultrastructure associated with organochlorine contamination.

One of our goals was to compare the ultrastructure of Arizona eggs with those from more humid climates with the idea that adaptations for extreme xeric conditions in Arizona might have evolved to reduce water loss. Studies have shown that eggs of species with dry nest conditions have low porosity shells (Vleck *et al.* 1979) and eggs of species with wet nest conditions have high porosity shells (Tullett 1984). One of several factors that affects eggshell porosity is the number of pores. We attempted to compare surface pore density among several eggshell samples, but results were inconclusive. The problem is that organochlorines and possibly other contaminants affect shell morphology in unknown ways. At this time, variation in pore density as an adaptation is inseparable from variation due to contamination. As more information is obtained on these relationships, a picture of adaptive differences may emerge. For now, we can provide no information on this issue.

Eggshell Formation

The following description is taken mainly from Gilbert (1979). Most birds have only one functional ovary and oviduct, usually on the left side of the body. The ovary produces the egg, deposits on it the yolk protein formed in the liver, and delivers the egg to the oviduct. The oviduct is a muscular tube extending from near the ovary to the cloaca, and is divided into five regions: infundibulum, magnum, isthmus, shell gland, and vagina (Figure E5-1).

The funnel-shaped infundibulum engulfs the egg shed from the ovary, and fertilization takes place here. As the egg moves further into this region, the first layer of albumen is deposited on it. The remaining layers of albumen are deposited on the egg while it is in the magnum. In the isthmus, two eggshell membranes are formed around the albumen, and proteinaceous cores are deposited on the outer membrane.

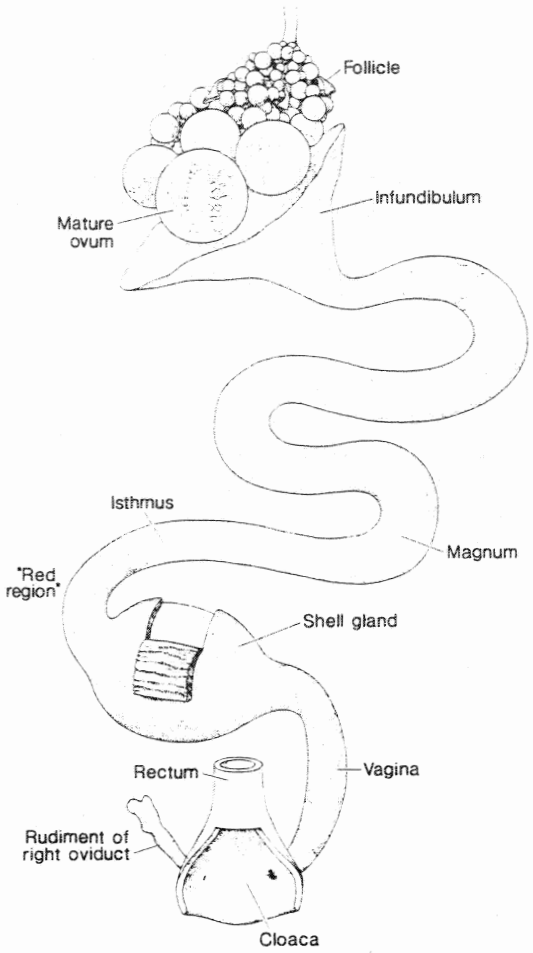


Figure E5-1. The avian female reproductive tract, from Taylor (1980).

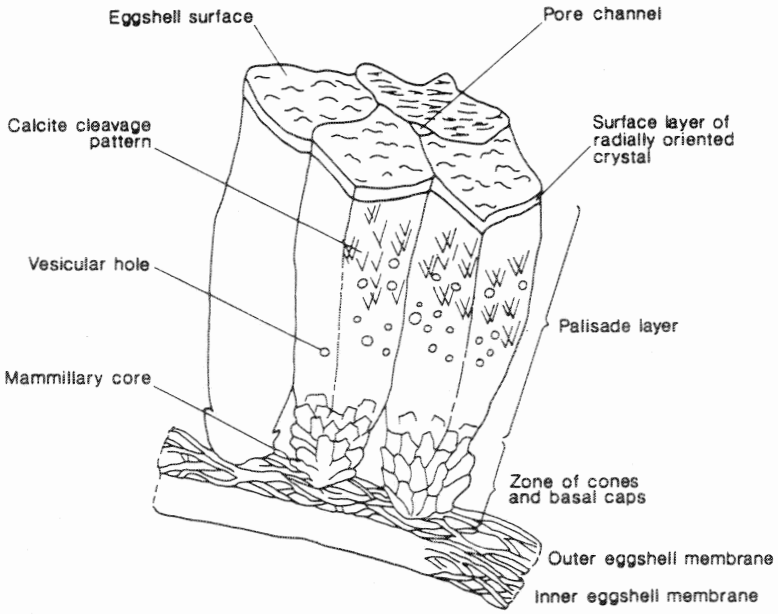


Figure E5-2. Layers of the avian eggshell, from Becking (1975).

The posterior portion of the isthmus is called the "red region." Some authors considered this region to be part of the shell gland (e.g., Fuji and Tamura 1970) and have thus referred to it as the "tubular shell gland;" however, recent studies have shown the red region is histologically identical to the isthmus, and distinct from the shell gland. When the egg enters the red region, the first calcite crystals are deposited on the outer membrane around the organic cores (Stemberger *et al.* 1977).

The egg spends 80 percent of its total time in the oviduct in the eggshell gland. Here a secretion of water, electrolytes, and glucose is absorbed by the albumen, a process called "plumping," causing the egg to swell. The main portion of the calcified eggshell and its coverings are formed in the shell gland.

The vagina is a duct connecting the shell gland to the cloaca. Once the egg enters the vagina, oviposition takes place in anywhere from seconds to hours, depending on the species. The vagina also has sperm host glands which store sperm for later egg fertilization.

Eggshell Structure

Avian eggshell structure is divided into three main components: membranes, calcified shell, and cuticle (Becking 1975). The general structure of an eggshell is shown in Figure E5-2, and the structure and function of each component is discussed in detail below.

E5.1 METHODS

Cross-sections of bald eagle eggshells from seven whole eggs and 19 fragments were prepared by making a fresh break in the shell and mounting it vertically so that the break faced up. Sections for studying the calcified structure were soaked in household bleach (sodium hypochlorite) for two hours at room temperature to remove organic matter; sections for studying the organic cores were decalcified in 1.0 N HCl for 15 minutes and the membrane was then pulled off of the calcified portion. All specimens were washed in distilled water, mounted on aluminum stubs, sputter-coated with gold-palladium at 15 Ma in an argon atmosphere, and studied with a Model WB-6 International Scientific Instruments scanning electron microscope at an accelerating voltage of 10 kV.

Five measurements on the micrograph of each eggshell cross-section were averaged to determine the eggshell thickness, excluding membrane, for each egg. For comparison of our thickness data with other published data, I added 0.111 mm to the mean eggshell thickness to account for membranes (L. Kiff pers. comm.). Percent thinning was calculated by dividing the total thickness by the pre-DDT historical thickness of 0.591 mm, which is the mean of the closest bald eagle population to Arizona, located in Baja California, Mexico, for which historical thickness data is available (L. Kiff pers. comm.).

After the contents were removed from the seven whole Arizona eggs, four remained intact. I candled these four eggs to look for the irregularities, termed "holes," which were first noticed in some California bald eagle eggs (*see* discussion below). While holding the eggshell under a light source, the diameter of each "hole" was measured to the nearest 0.1 mm using a caliper. The total eggshell area was calculated using the formula:

$$A = 4.83\ (\pi\ LB^2/6)^{2/3}$$

where A is area, L is length, B is breadth (Peakall *et al.* 1973). The total area of "holes" was calculated as a percent of the total surface area.

E5.2 RESULTS AND DISCUSSION

The thickness data for all Arizona bald eagle eggshell samples and the ultrastructure for the whole egg samples is given below and discussed with regard to previous studies on the effects of organochlorines on bird eggs.

Eggshell Thickness

The average thickness of all Arizona bald eagle eggshell samples is 0.562 mm (SD = 0.042, range of 0.455–0.651 mm), which is 4.9 percent thinner than the pre-DDT mean of 0.591 mm from the Baja California population (Table E5-1). This thickness is identical to the mean thickness of 0.561 mm obtained by measuring eggshell fragments with a manual gauge at the Western Foundation of Vertebrate Zoology (L. Kiff pers. comm.). Grubb *et al.* (1990) found a mean eggshell thickness of 0.539 mm for Arizona bald eagle eggs collected from 1977 to 1985. This is not significantly different than our mean ($P > 0.05$, t-test).

Studies of many bird species, both in laboratory experiments and in wild populations, have demonstrated that organochlorines, particularly DDE, induce eggshell thinning. Hickey and Anderson (1968) first demonstrated such a correlation in bald eagle eggs. Wiemeyer *et al.* (1984) found that 10 percent thinning in bald eagle eggs was associated with 5.6 ppm DDE (wet weight). Four of the 26 samples we measured showed thinning greater than 10 percent (Table E5-1). Of the whole eggs measured, the egg from Horse Mesa territory showed the highest percent thinning. This was also the egg with the most developed embryo (see Table E4-3 in Section E4). Although eggshells are thinned during incubation by withdrawal of calcium for the developing embryo's skeleton, Bunck *et al.* (1985) concluded that thinning due to embryonic development was insignificant with regard to thinning due to organochlorine contamination, and thus correction for stage of incubation is not necessary when making thickness comparisons.

Eggshell Ultrastructure

The general structure of an eggshell is shown in Figure E5-2. Fox (1976) found that abnormal ultrastructure resulting in embryonic mortality can be induced by DDE, independent of shell thinning. Each component of the bald eagle eggshell is discussed below with regard to various studies of abnormal eggshell ultrastructure in other birds.

Cuticle and Cover. The surface of the shell is enclosed in a thin proteinaceous cuticle (Tyler 1966). The cuticle aids in prevention of bacterial infection (Gilbert 1979), reduces evaporation and contributes to shell strength (Simons 1971), and makes some shells water repellant (Board 1974). In some species there is an additional calcified layer either on top of the cuticle or under it, called the cover (Tyler 1969). I did not observe a cuticle or cover in any of the Arizona bald eagle shells examined. Tyler (1966) examined 25 other species of the order Falconiformes and found (by staining) that all had a very thin cuticle (1 to 10 μm), but none had a cover. The whole eggs we examined were washed before we

Table E5-1. Thickness of bald eagle eggshells and percent thinning from pre-DDT mean thickness of 0.591 mm.

Egg Number	Breeding Territory	Photo Number[1]	Average Thickness (mm)	Percent Thinning[2]
86-02	Cibicue	8602	0.541	8.5
86-03	CCIFF	8603	0.563	4.7
86-04	Redmond	8604	0.601	−1.7
86-05	East Verde	8605	0.601	−1.7
86-06	Redmond	8606	0.567	4.1
86-08	Cedar Basin	8608	0.641	−8.5
87-03	Blue Point	8703	0.571	3.4
87-04	Pinal	8744	0.527	10.8
87-05	Pinal	8705	0.537	9.1
87-09	Chino	8709	0.531	10.2
87-10	Horse Mesa	8710	0.541	8.5
87-12	Horseshoe	8712	0.553	6.4
87-15	East Verde	8715	0.533	9.8
87-18	Sheep	8718	0.623	−5.4
87-20	76	8720	0.455	23.0
88-10	Sheep	8810	0.535	9.5
—[3]	Hecho, Mexico 1987	0188	0.581	1.7
—[3]	Hecho, Mexico 1988	4148	0.571	3.4
—[3]	Redmond 1987	0000	0.613	−3.7
90-002	Cedar Basin	9002	0.651	−10.2
90-003	Chino	9003	0.551	6.8
90-004	Ft. McDowell	9004	0.537	9.1
90-005	Cliff	9005	0.599	−1.4
90-006	Horseshoe	0007	0.537	9.1
90-007	Alamo	9007	0.545	7.8
90-008	Horse Mesa	0008	0.517	12.5
	Mean Thickness (+/− 1 S.D.)		0.562 (+/− 0.042)	

[1] Photo number refers to the scanning electron micrograph from which the measurements were made.
[2] A negative percent thinning indicates that the egg was thicker than the pre-DDT mean.
[3] Sample did not have an egg number assigned.

received them, and both whole eggs and fragments were exposed to weather and mechanical abrasion in their nests for several months before they were collected. It is therefore likely that the very thin cuticle on the freshly laid eggs was removed by desiccation and abrasion.

Patches of cuticle have been observed on California bald eagle eggs which were incubated at the Santa Cruz Predatory Bird Research Group (D. Bland unpubl. data). Garrett (1973) found that brown pelican eggs with high DDE and severe thinning did not completely lack a cuticle, and concluded by this that premature termination of eggshell formation was not an effect of DDE contamination. Studies of other species which have pigment on the outside of the cuticle revealed that, even in thinned shells, pigment was present (e.g., Fox 1976). In summary, it is therefore unlikely that the level of DDE in the Arizona bald eagle eggs contributed to the lack of observable cuticle.

Studies on common terns (Fox 1976), Coturnix quail (McFarland *et al.* 1971), American kestrels (Peakall *et al.* 1973), and brown pelicans (Erben and Krampitz 1971) showed globular projections on the outer surface of the eggshell resulting from the disruption of the cuticle and/or cover formation that were associated with organochlorine contamination. I observed no such projections on the Arizona bald eagle eggshells, but have seen them on some highly contaminated bald eagle eggs from California; these had up to 1100 ppm DDE (D. Bland unpubl. data).

Calcified Shell Layers. The calcified portion of the eggshell provides the embryo with mechanical protection, is the source of skeletal calcium, and controls gas exchange and water loss (Taylor 1980). Ninety-eight percent of the calcified portion of the eggshell is composed of $CaCO_3$ in the form of calcite crystals; the remaining two percent is an organic protein matrix (Lundholm 1987).

The calcified shell has several layers: mammillary, palisade, and the surface crystal layer (Figure E5-2). The basal caps and cones, referred to collectively as the mammillary layer, are adjacent to the outer shell membrane. The spongy or palisade layer is outside the mammillary layer. The basal caps are formed of calcite crystals radiating out from the mammillary cores and are partially embedded in the outer shell membrane (Bunk and Balloun 1977). The cones are formed when the laterally-growing crystals make contact (Gilbert 1979). The palisade layer is a continuation of the mammillary cones and is columnar in appearance, each column roughly corresponding to one cone. The outermost palisade consists of a thin layer of compact, radially oriented crystals called the surface crystal layer (Becking 1975). A very fine network of organic matrix is embedded throughout the calcified portion of the eggshell (Simons 1971).

The calcified layers of bald eagle eggshells generally correspond to Becking's description, with the exception that there is no surface crystalline layer (Plate 1). Tyler (1966) found that the 25 other species of Falconiformes he studied also lack this layer. The appearance of the palisade layer varies between species. In bald eagles, as in some other Accipitridae (Tyler 1966, D. Bland and R. Risebrough unpubl. data), there is a distinct outer palisade layer with large spaces or clefts perpendicular to the outside of the shell (Plate 2). Cooke (1979) called this the "resistant surface layer" due to its resistance to etching with acid, probably due to its relatively high content of organic matter; Board (1982) refers to this portion of the palisade as the "reticulate layer" which is the term we will use here. It appears that, in at least some instances, the clefts are branches of the pores (Plate 3, see discussion below under Pores).

The cones of a normally-formed mammillary layer are compact and hemispherical in shape (Plate 1). In bald eagles and some other Accipitridae, there is a distinct demarcation between the mammillary and

palisade layers (Plate 2), whereas in some other species the two layers are indistinguishable (e.g., Roseate Terns, D. Bland and I. Nisbet unpubl. data). Cooke (1979) found that the ratio of cone height to mammillary layer thickness was increased for recent eggs compared to pre-DDT eggs for two Falconiformes species. He related this to a decrease in water vapor conductance. An elongated, abnormal cone structure with exaggerated clefts between cones is depicted in Plate 4. Closely spaced, compact cone structure is associated with stronger eggshells (Simons 1971, Parsons 1982).

The inside of the basal caps covering the cones are visible when the membranes are removed (Plate 5). The number of basal caps per square mm for the seven whole Arizona bald eagle eggs is given in Table E5-2. There is considerable variance between samples, and one egg shows high variance even within samples. The embryo utilizes calcium from the shell for skeletal development (Gilbert 1979). Plate 5B shows eroded basal caps on the inside of a shell which contained a three-quarters-developed embryo. Fox (1976) and Greenburg *et al.* (1979) found that the number of mammillae or basal caps per square mm was decreased by DDE, hence the caps were enlarged and fewer caps per area were present. The eggshell from Cliff territory has the most obvious deformations among the Arizona eggs, with some cones completely lacking basal caps and with many small, fragmented basal caps (Plate 6). However, in our sample, there appears to be no correlation between DDE (wet wt) and number of basal caps.

Pores. The calcified shell has openings called pores, originating between some of the cones and penetrating the palisade layer as roughly cylindrical channels opening to the outside (Tullet *et al.* 1975). Some kinds of birds have branching pore channels, others are funnel shaped and some straight (Tullett 1984, Rahn *et al.* 1980, Tyler 1966, 1969). Bald eagles have pore systems classified as the "reticulate" type by Tullet (1984). The pores allow gaseous exchange between the developing embryo and the atmosphere (Rahn *et al.* 1980). The shape of the pores is one of the factors that affect the egg's loss of water vapor to the atmosphere. Eggshells with the reticulate pore structure have a high resistance to water vapor conductance because of the many narrow channels in the outer palisade layer and therefore have a relatively low porosity (Board and Scott 1980). The inner opening of a pore channel is shown in Plate 5 and complete pore channels in Plates 3 and 4. Tyler (1966) considered the pores of the Falconiformes he studied to be unbranched. He held that the channels ended at the junction of the palisade with the reticulate layer. However, his studies with dye indicated that the pore channels were directly connected to the clefts of the reticulate layer. Our data conflicts with Tyler's interpretation; Plate 3 indicates a branching of channels.

The outside of the Arizona bald eagle eggshells shows the "innumerable tiny pits" mentioned by Tyler (1966) (Plate 7). In a severely thinned California bald eagle eggshell, which lacked the reticulate layer, the tiny pits are lacking and pores appear as large, roundish holes (Plate 8).

Several studies have investigated the effect of organochlorine contamination on eggshell porosity. Cooke (1979) found water vapor conductance and functional pore area reduced in modern peregrine falcon eggs. Fox (1976) found reduced water loss and fewer pores in DDE-contaminated common tern eggs which failed to hatch. These effects were independent of eggshell thinning. Peakall *et al.* (1973) found water loss (permeability) and thickness were reduced in eggs from white Pekin ducks, American kestrels, and ring doves fed DDE. A theory to explain the reduction of porosity in thin eggshells relates to the pore shape. Most of the resistance to water vapor conductance of funnel shaped pores occurs across the narrow, inner section (Simkiss 1986). Therefore, if the wide funnel part of the pore were reduced in length by a thinning in the outer layers of the shell, all that would remain of the pore is the narrow

Table E5-2. Number of basal caps and percent of surface area covered by "holes" for whole eggshells from Arizona.

Breeding Territory	Number of Basal Caps/mm^2	Mean per Egg (variance)	Percent of Total Surface Area Covered by "Holes"[a]
Cedar Basin	111		
	95		
	94	100 (9.5)	NA
Chino	68		
	63		
	71	67 (4.0)	0.005
Ft. McDowell	98		
	77		
	102	92 (13.4)	<0.005
Cliff	110		
	118		
	122	117 (6.1)	0.012
Horseshoe	72		
	67		
	64	68 (4.0)	NA
Alamo	76		
	75		
	75	75 (0.6)	0.015
Horse Mesa	79		
	77		
	80	79 (1.5)	NA
	Mean (N=7)	85 (18.5)	

[a] NA = Not analyzed.

portion and thus the overall resistance of the shell would increase and water vapor conductance would decrease. However, this does not explain the reduced water loss which is independent of shell thinning.

In contrast to the above studies, incubation of DDE-contaminated California bald eagle eggs at the University of California, Santa Cruz Predatory Bird Research Group, showed water loss two-to-three times greater than the 15 percent which Rahn et al. (1980) found was normal during incubation (B. Walton unpubl. data). During routine candling of some of these eggs, certain irregularities in the eggshells were observed (J. Linthicum pers. comm.). These appeared as numerous "holes" in the shell or points through which the light penetrated (Plates 9 and 10). These "holes" are much larger than pores and may be related to the increased water loss observed since the rate of water loss increases with increasing pore diameter (Simkiss 1986). The diameter of these "holes" on the inside of the shell ranges from 0.5 mm to more than 1 mm, whereas the inside diameter of pore openings is approximately 0.025 mm.

The percent of total surface area covered by these "holes" for four Arizona bald eagle eggs is given in Table E5-2. From the outside, the "holes" are delineated by a roughly circular fissure (Plates 9A and 10A), and from the inside they lack any basal caps or cones (Plate 10B). The lack of organized structure in "holes" of Arizona bald eagle shells is shown in Plate 11. Haywood and Ohmart (1983) noted the presence of "a small pinhole" in the 1982 Bartlett bald eagle egg. The egg was apparently buried in the bottom of the nest and may have sustained mechanical damage. We are currently evaluating the relationship of these "holes" to organochlorine contamination and their affect on hatching success. Although all eggs have some slight irregularities, potentials for detrimental impact of a large percentage of "holes" are several: desiccation due to increased water loss and increased egg breakage due to less organized shell structure.

The calcified shell is also permeated by smaller holes, called by various names such as globular inclusions (Erben and Krampitz 1971), gas inclusions (Schmidt 1962), pit-like holes (Heyn 1963), and vesicular holes (Becking 1975). The vesicular holes in the Arizona Bald eagle eggs are 1 μm or less in diameter (Plate 12). Simons (1971) found that vesicular holes are lined with organic matter and connected by very fine organic strands or fibers. Becking (1975) found the vesicular holes were larger and more numerous in eggs of tropical birds than those from temperate regions, speculating that the function of these structures is related to gas exchange. Erben and Krampitz (1971), Fox (1976), and Peakall *et al.* (1973) found that vesicular holes were more numerous in DDE-contaminated birds.

Membranes. Two soft proteinaceous layers surround the egg albumen. These are commonly referred to as the "inner" and "outer" shell membranes, although neither are true cytological membranes, and are separated from the chorioallantois of the embryo by a thin "film" (Rahn *et al.* 1980). The membranes are slightly elastic fibers composed of a central proteinaceous core surrounded by a glycoprotein (Gilbert 1979).

The shell membranes have several functions. The inner membrane imparts the typical oval shape to the egg and is attached to the albumen by a "ligament" (Gilbert 1979). The outer membrane and its associated organic cores serve as nucleation sites for shell crystallization (Stemberger *et al.* 1977). Both membranes are involved in regulating gas exchange between the embryo and the environment, although to a lesser extent than the calcified portion of the shell (Rahn *et al.* 1980). The two membranes at the blunt end of the egg separate after the egg is laid to form the air sac (Gilbert 1979). In the later stage

of development, the embryo's head lies adjacent to this air sac, and when the embryo breaks through the sac its lungs begin functioning.

The outer membrane with its associated organic cores is shown in Plate 13. Robinson and King (1970) found abnormal distribution and shape of organic cores in eggshells with reduced breaking strength. Greenburg *et al.* (1979) found that DDE reduced the number of organic cores in mallards, along with a linear relation between core and basal cap densities. They concluded that DDE affects the formation of the organic portion of the eggshell. This effect takes place in the isthmus in a manner different than the thinning of the calcified shell, which occurs in the shell gland. Erben and Krampitz (1971) found that the total organic matter in the shell portion of DDE-contaminated brown pelican eggs was increased, and that the composition of the amino acid pool was altered, suggesting that protein synthesis is affected by DDE.

The bald eagle egg from Cliff territory, Arizona, shows an unusual abnormality in structure possibly related to organic biosynthesis. The inside of the shell, between the outer membrane and the calcified portion, is covered with numerous bumps (Plate 14) up to 2 mm in diameter which are visible without magnification. Since the bumps are removed when a shell sample is soaked in bleach (Plate 15) but not when decalcified in acid (Plate 16), it appears the bumps are composed primarily of organic matter. The bumps are firmly attached to the calcified portion of the shell with numerous fibers (Plate 17). Attempts to remove the membrane intact from an area of bumps were not entirely successful since the membrane around the bump tore apart, leaving the outermost membrane layer still attached to the calcified shell. It appears that the bumps are giant organic cores, formed by some unknown disturbance in the isthmus. There are no corresponding giant basal caps under the bumps, but this shell had the highest number of abnormal, fragmented basal caps, which may be a result of such enlarged cores. A few of these bumps were also seen on the shell of the egg from Cedar Basin territory, but not to the extent of those on the egg from Cliff territory.

E5.3 SUMMARY

Mechanical protection and regulation of gas exchange with the developing embryo are the two most important functions of an eggshell (Gilbert 1979). Disruptions in the formation of an eggshell can effect its integrity, and consequently the hatching success of the embryo and productivity of the adults. Organochlorines, particularly DDE, are known to disrupt processes during the formation of both the organic (Greenburg *et al.* 1979) and inorganic (Lundholm 1987) components of the shell, resulting in abnormalities, such as thin shells, that can be detrimental to the embryo.

The ultrastructure of the Arizona bald eagle eggshells we studied generally corresponds to that described for other species, particularly for other members of the Falconiformes (Tyler 1966). Mean percent thinning for all samples (4.9%) is well below the 10 percent level associated with reduced productivity in other bald eagle populations (Wiemeyer *et al.* 1984, Nisbet 1989). Only one egg (from the Cliff breeding territory) showed disruptions in structure in both the organic and inorganic portions of the shell, although this egg showed only 1 percent thinning.

Recently, numerous, large "holes" were observed in some California bald eagle eggs with high DDE levels and excessive water loss (B. Walton unpubl. data). We observed such "holes" in four Arizona eggs, but densities of the holes were one or two orders of magnitude less than in the California eggs. The possible impact such "holes" may have on water loss from bald eagle eggs from an arid climate such as Arizona is unknown.

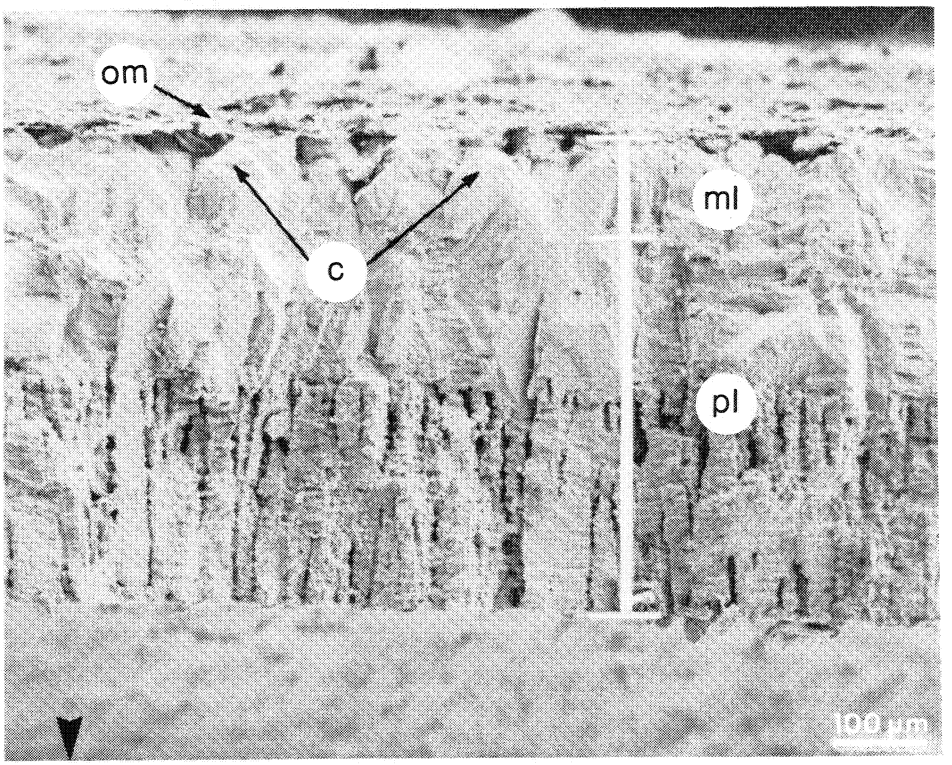


Plate 1. Cross-section of a bald eagle eggshell from Sheep territory, 1987, showing the layers: om = outer membrane; ml = mammillary layer; c = cones; pl = palisade layer. Note the compact, closely spaced cones of the mammillary layer. Outside of shell indicated by arrow.

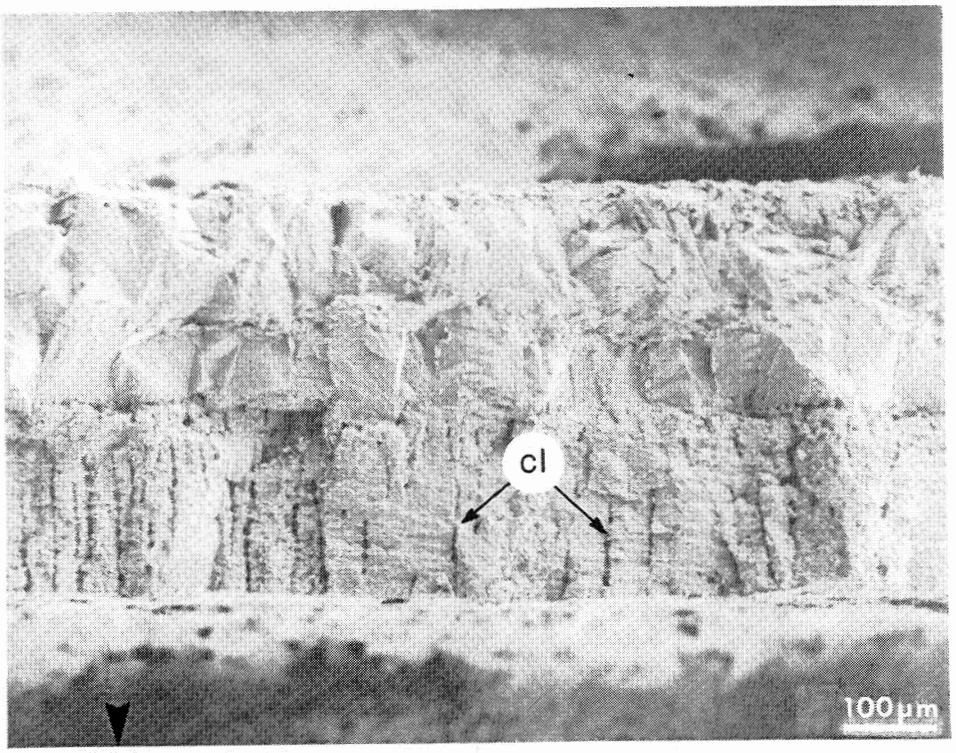


Plate 2. Cross-section of a bald eagle eggshell from Pinal territory, 1987, showing the numerous clefts (cl) in the outer palisade layer. Note the distinct demarcation between the mammillary and palisade layers. Outside of shell indicated by arrow.

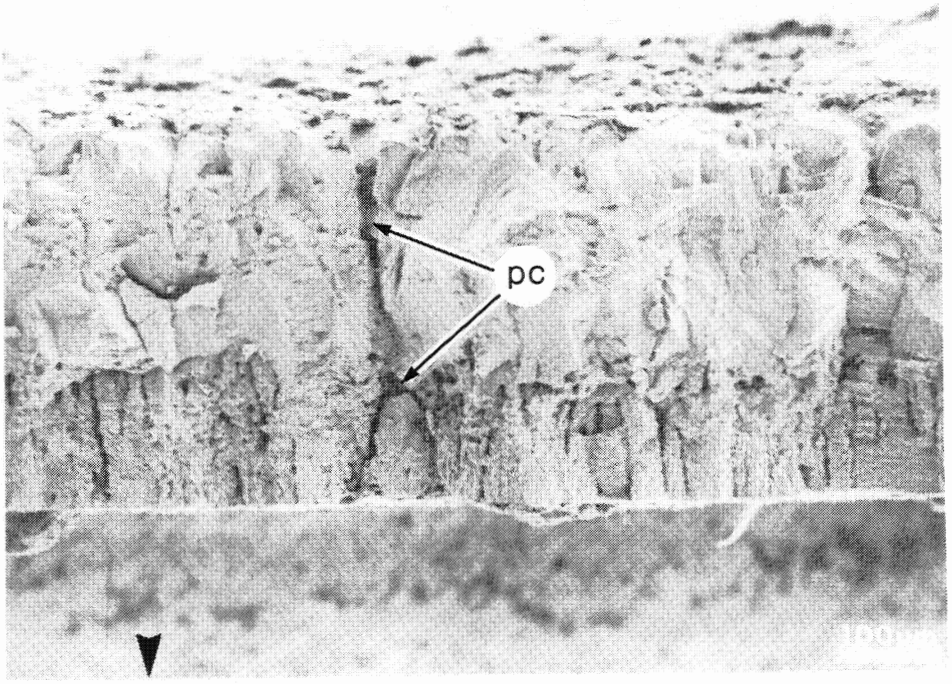
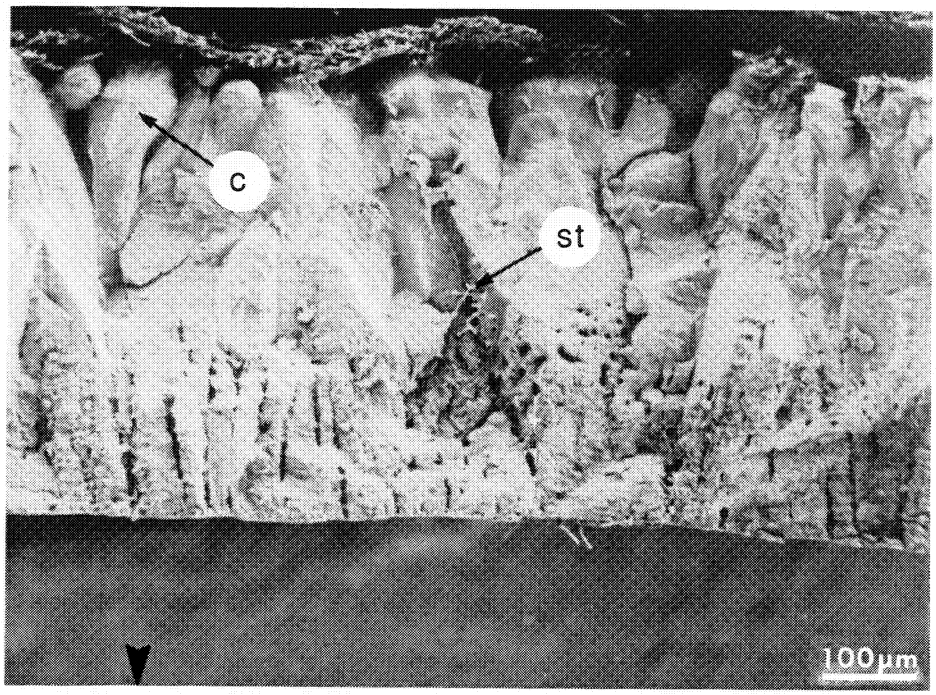


Plate 3. Cross-section of a bald eagle eggshell from Chino territory, 1987, showing a pore channel (pc) that branches. Outside of shell indicated by arrow.

Plate 4. Cross-sections of bald eagle eggshells from Cliff territory in 1989. **4A**: Note the elongated cones (c) with intercone spaces penetrating deep into the calcified shell and the large strands (st) of organic matter in the palisade layer. **4B**: Note loosely arranged, irregularly shaped cones (c); pc = pore channel. Outside of shell indicated by arrow.

4A



4B

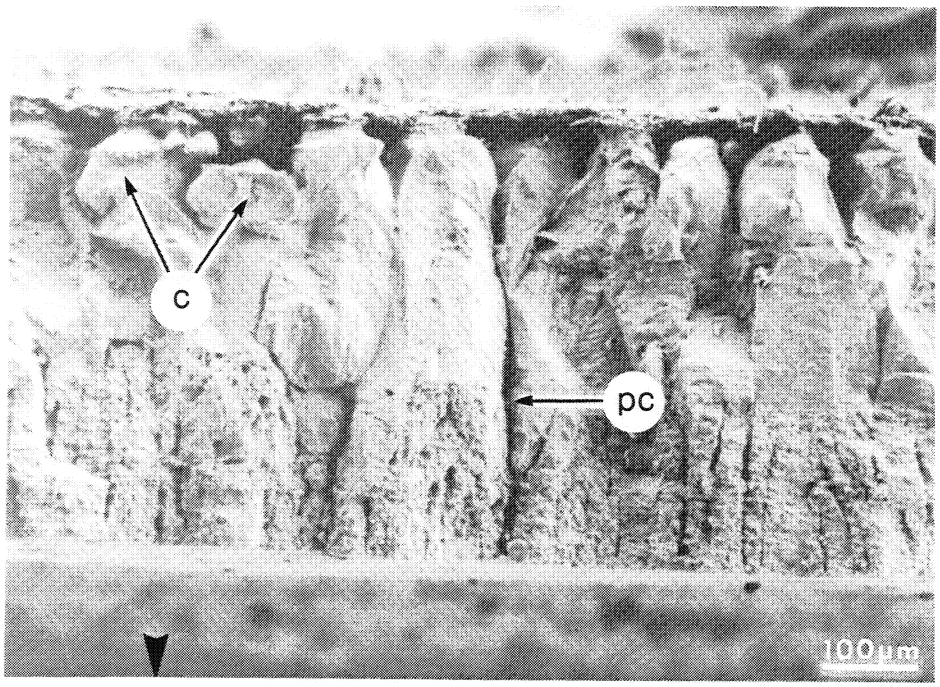
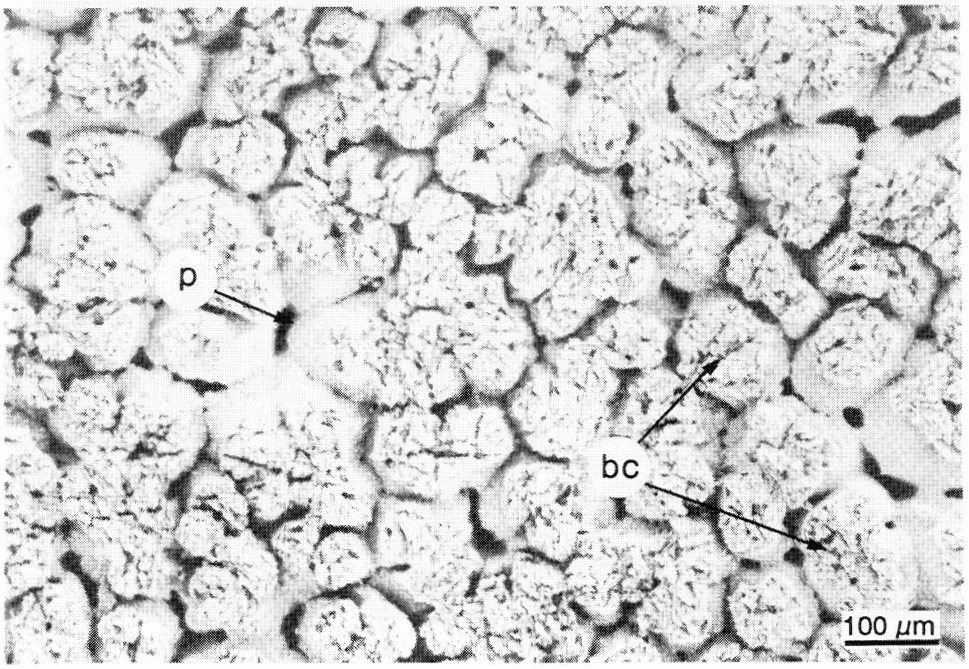
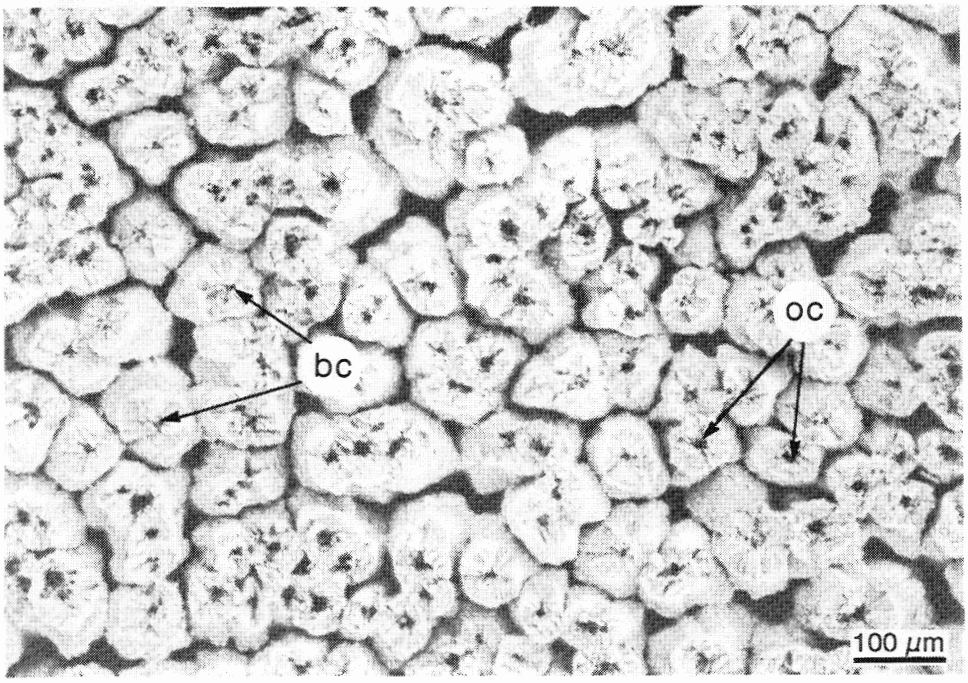


Plate 5. Inside of bald eagle eggshells with membranes removed. **5A**: Egg from Horseshoe territory, 1989. The outline of fibers from the outer shell membrane are visible in the basal caps (bc) where they were enmeshed. The typical arrangement of basal caps around a pore opening (p) is shown, although this view does not indicate if this opening penetrates the shell. **5B**: Egg from Horse Mesa territory, 1986. The basal caps (bc) have been eroded from resorption of calcite by the 3/4-developed embryo. Holes in the centers of the basal caps indicate where the organic cores (oc) were located.

5A



5B



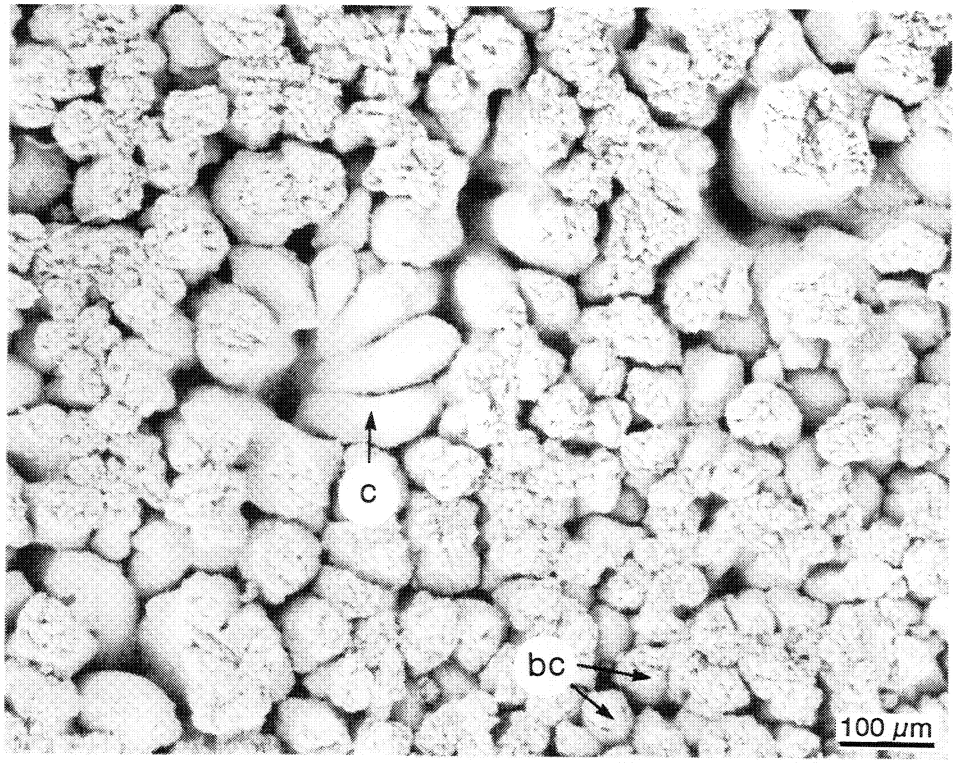


Plate 6. Inside of a bald eagle eggshell from Cliff territory, 1989, with membranes removed. Note the numerous fragmented basal caps (bc) and some cones (c) completely lacking basal caps.

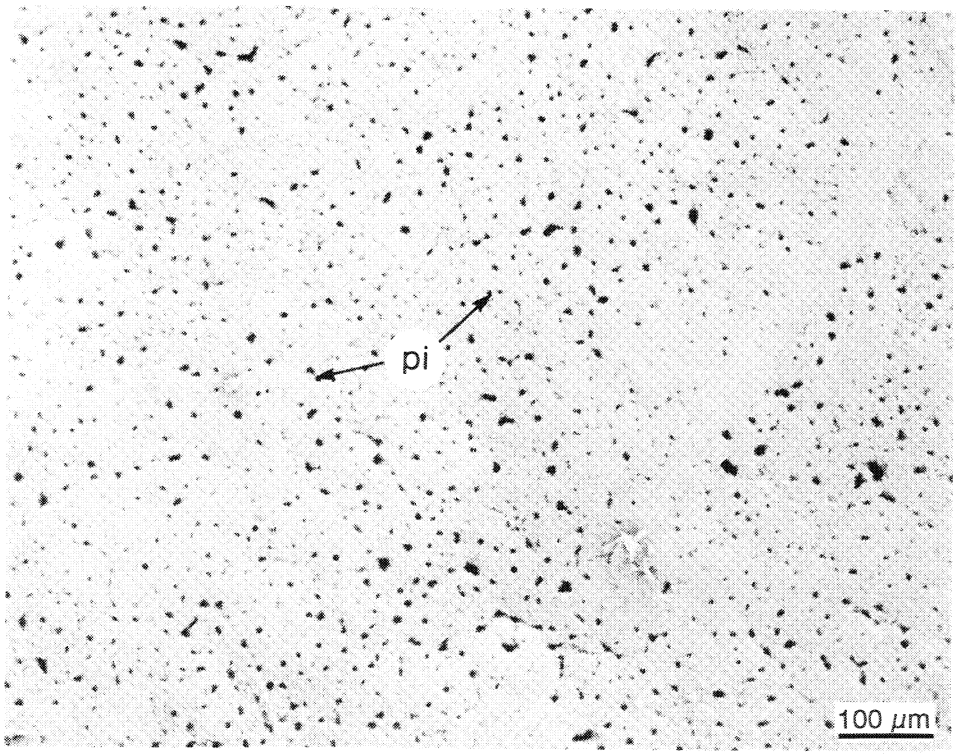
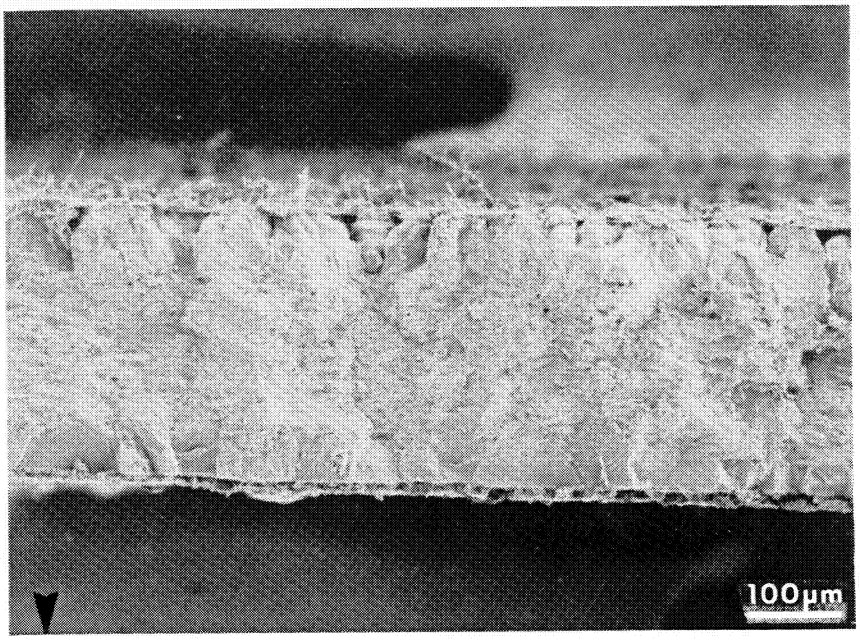


Plate 7. Outside of a bald eagle eggshell from Horseshoe territory, 1989, showing the tiny pits (pi) on the surface of the egg.

Plate 8. Bald eagle eggshell from Cool Springs territory, Plumas County, California, 1987, which is 31 percent thinner than the pre-DDT historical thickness of eggshells from this region (Anderson and Hickey 1972). **8A:** Cross-section of eggshell; note complete lack of outer palisade layer. Outside of shell indicated by arrow. **8B:** Surface view showing large, circular pore opening (p). Compare with Plate 7.

8A



8B

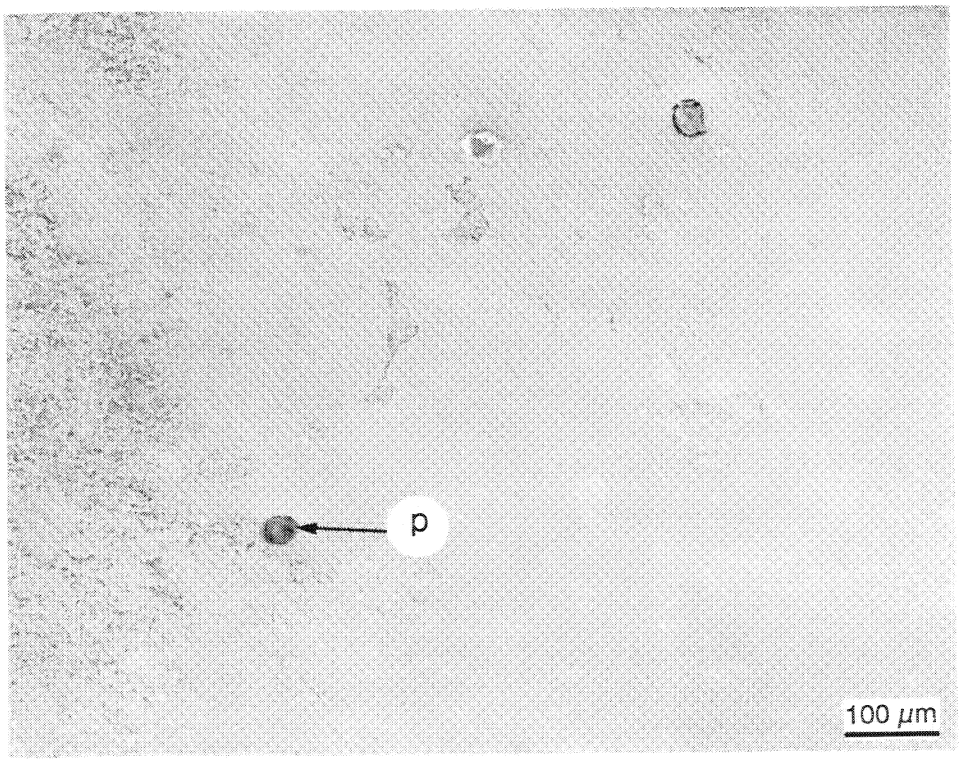
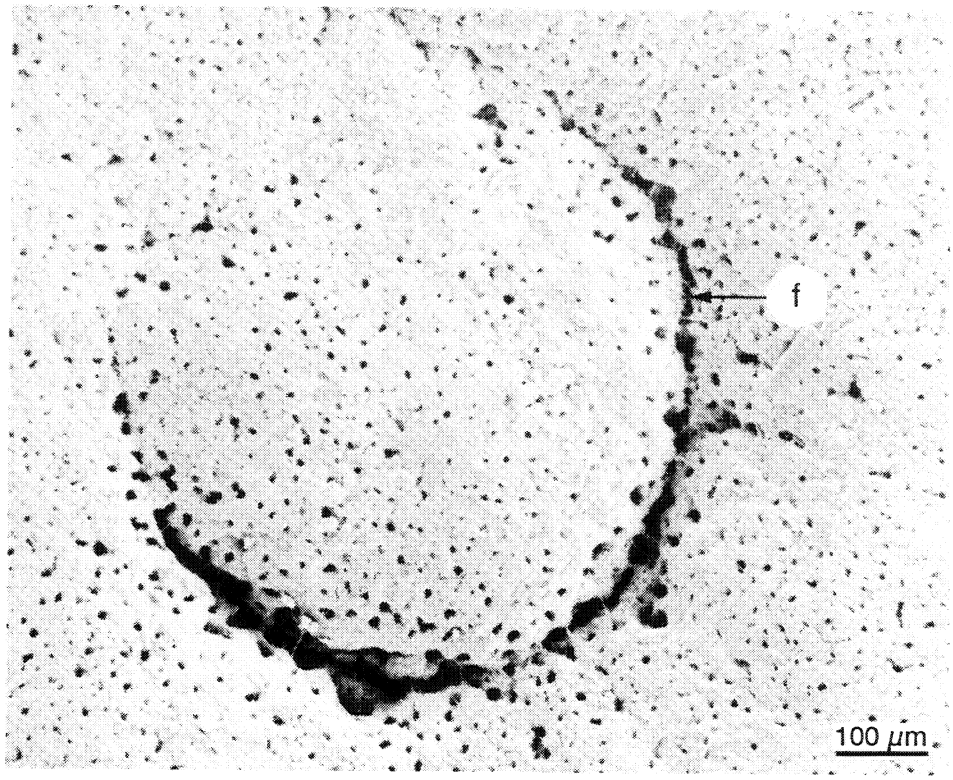


Plate 9. Bald eagle eggshell from Rocky Point territory, Plumas County, California, 1986. **9A**: Surface view of eggshell showing a large "hole" (~0.6 mm diameter) delineated by a circular fissure (f). **9B**: Cross-section of a large "hole" showing the lack of organization in the calcified layers. Outside of shell indicated by arrow.

9A



9B

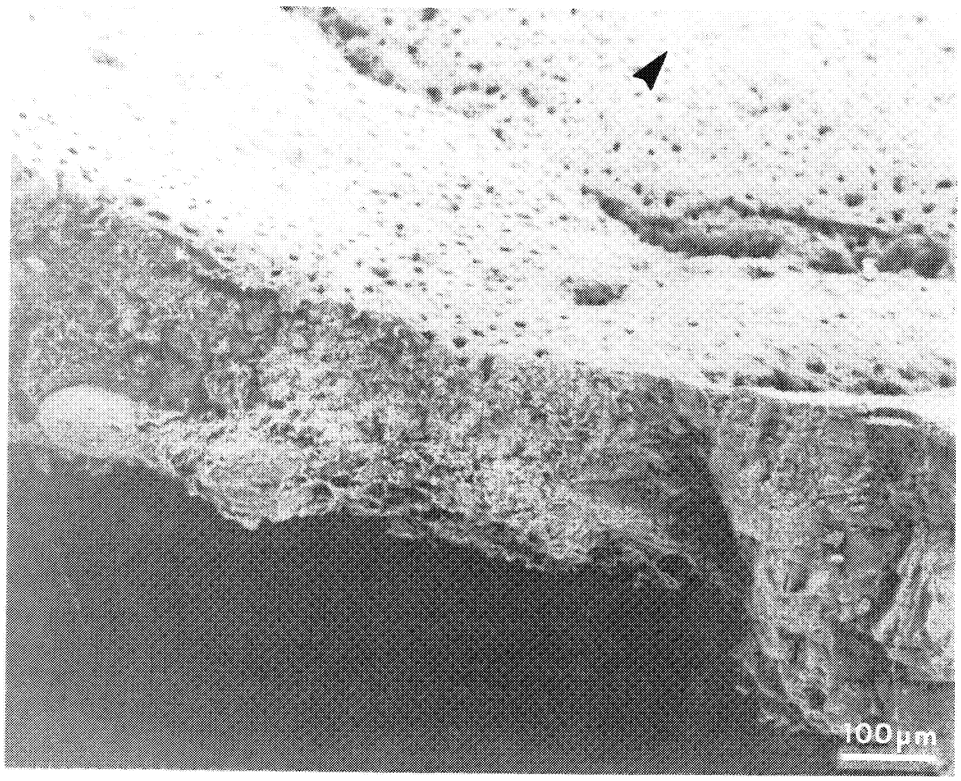
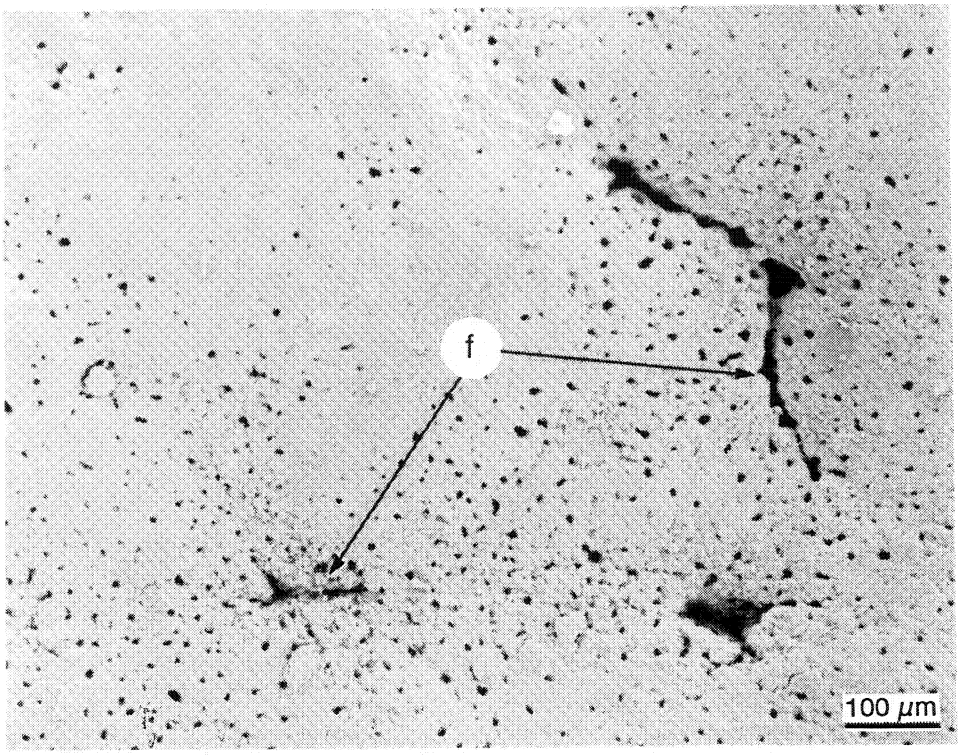


Plate 10. Bald eagle eggshell from Santa Catalina Island, California, 1990. **10A**: Surface view of eggshell showing a large "hole" (~0.65 mm diameter) delineated by fissures (f). **10B**: Inside of the same "hole" showing lack of basal caps and cones in the area of the hole.

10A



10B

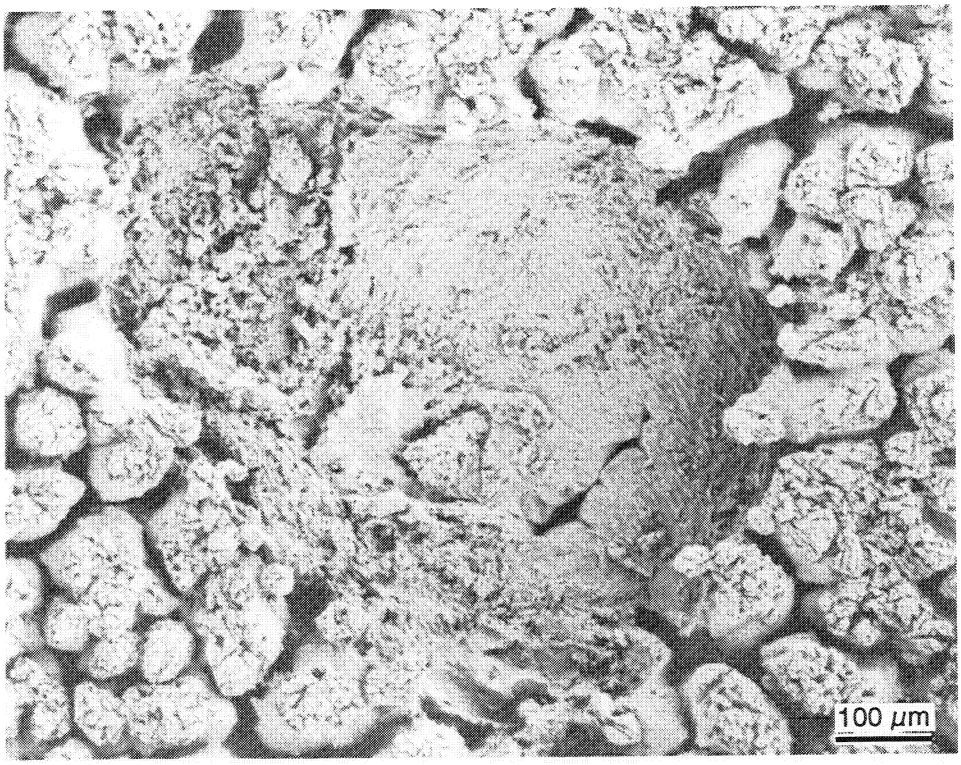
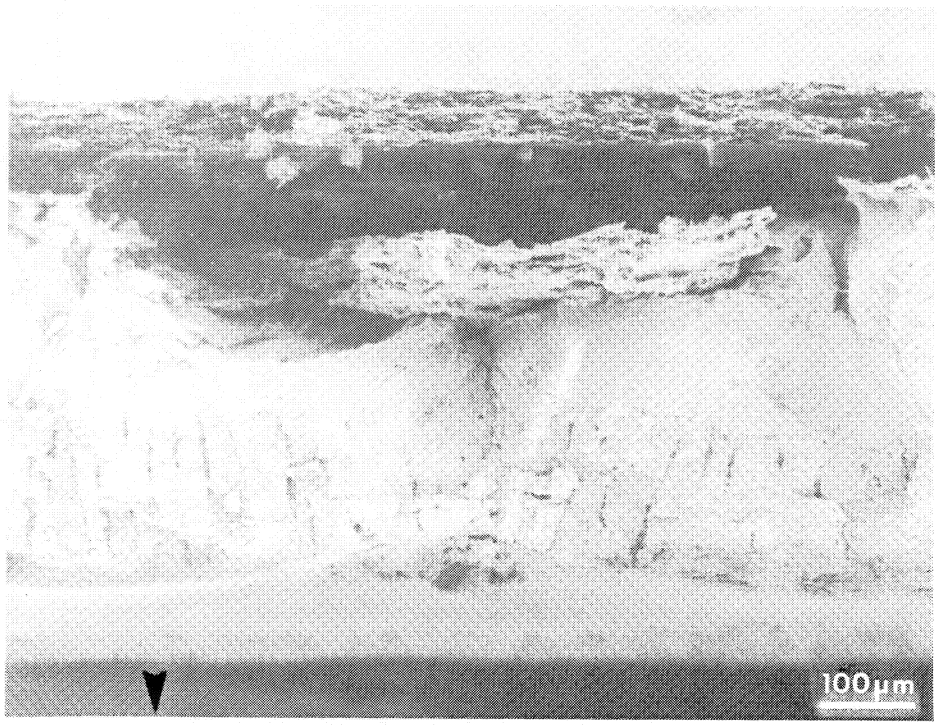
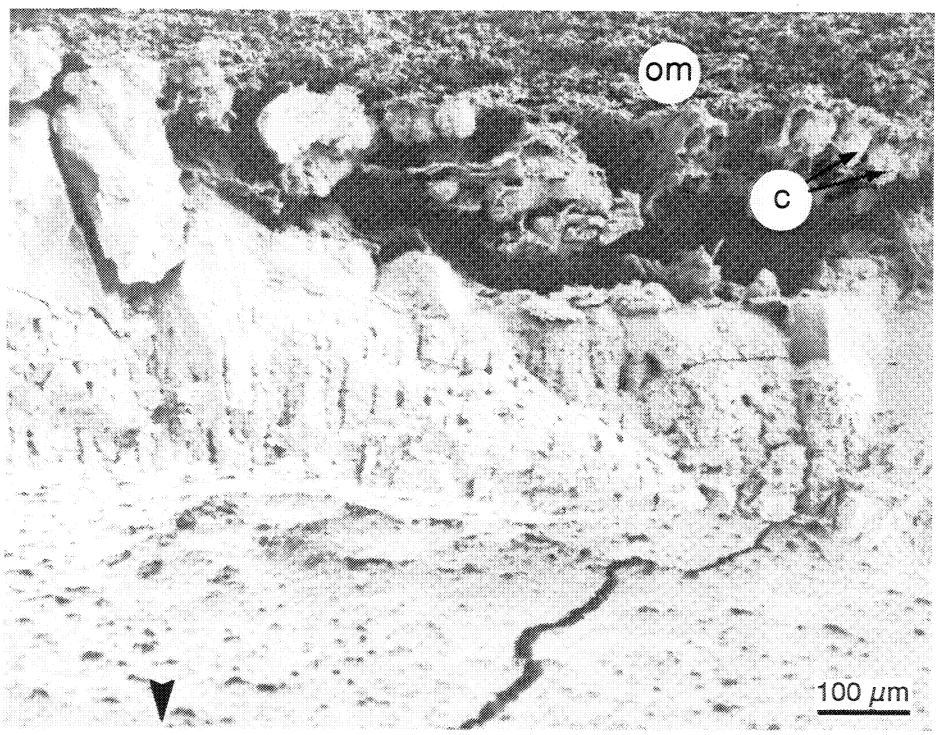


Plate 11. Cross-sections of bald eagle eggshells from Arizona. **11A**: Egg from Horseshoe territory, 1989, depicting complete lack of mammillary layer in the area of a "hole." **11B**: Egg from Alamo territory, 1989, showing rudimentary mammillary layer with small cones (c) embedded in the outer shell membrane (om) in the area of a "hole." Outside of shell indicated by arrow.

11A



11B



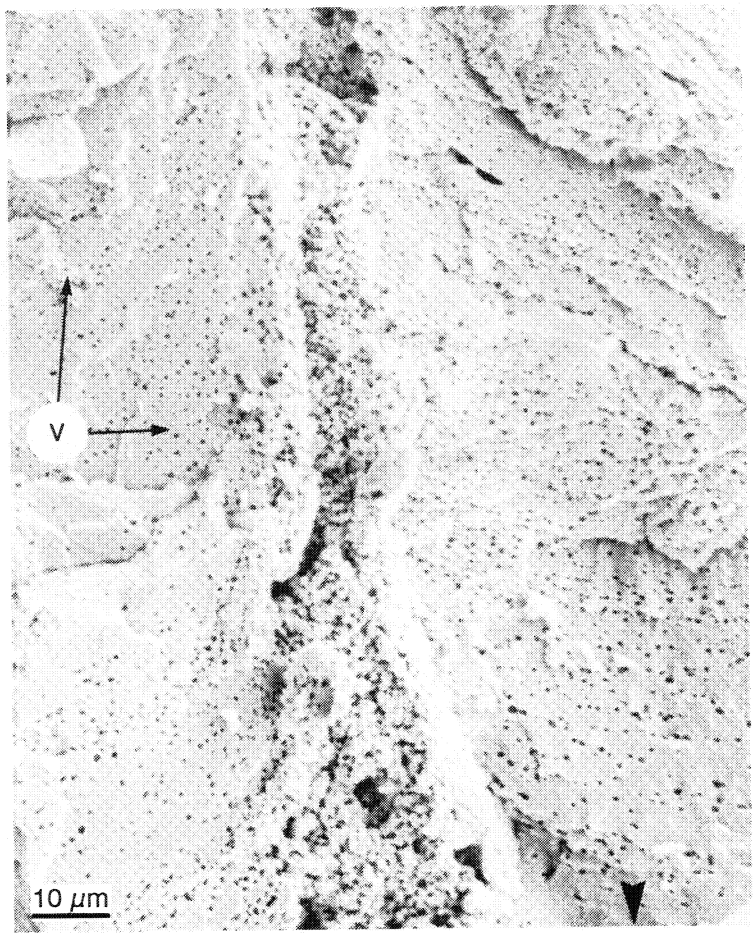


Plate 12. Cross-section of a bald eagle eggshell from Pinal, 1987, showing vesicular holes (v) that occur through the calcified layers of the shell. Outside of shell indicated by arrow.

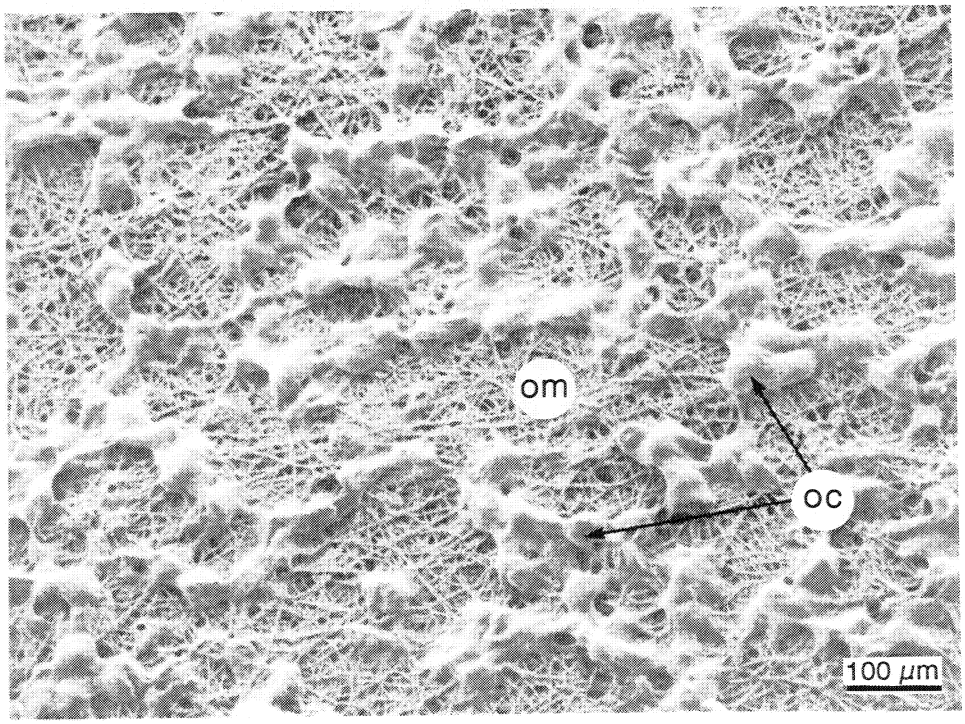
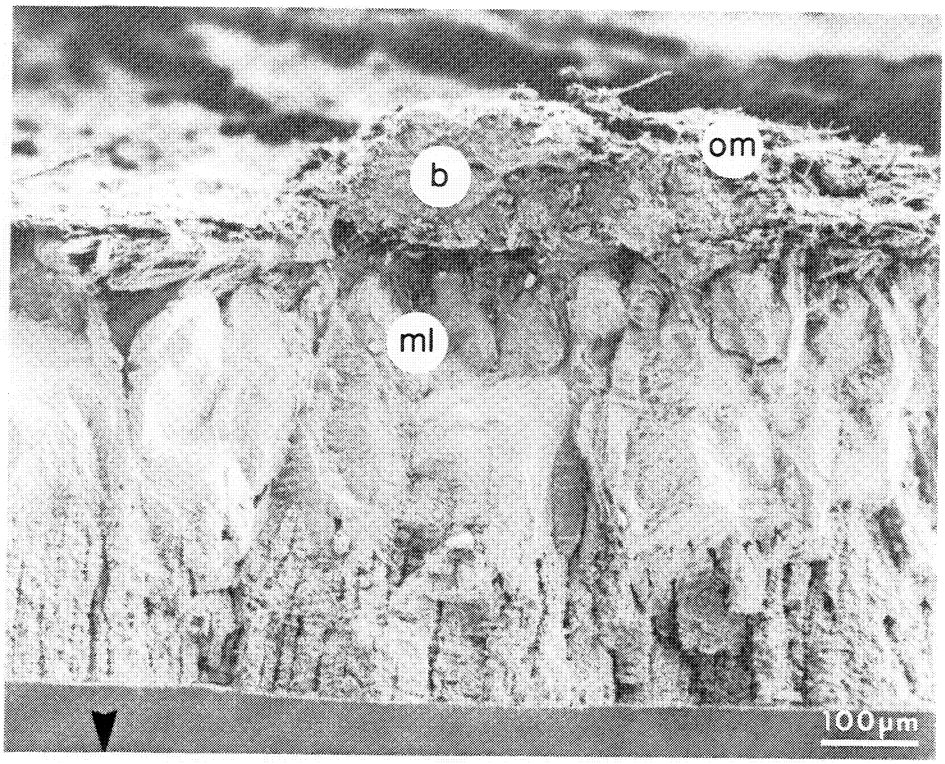


Plate 13. View of the outer surface of outer eggshell membrane (om) of bald eagle egg from Cedar Basin territory, 1989, showing organic cores (oc) which are the nucleation sites for calcite crystallization.

Plate 14. Cross-sections of bald eagle eggshell from Cliff territory, 1989. In both **14A** and **14B**, note large bumps (b) located between the outer shell membrane (om) and the mammillary layer (ml). Outside of shell indicated by arrow.

14A



14B

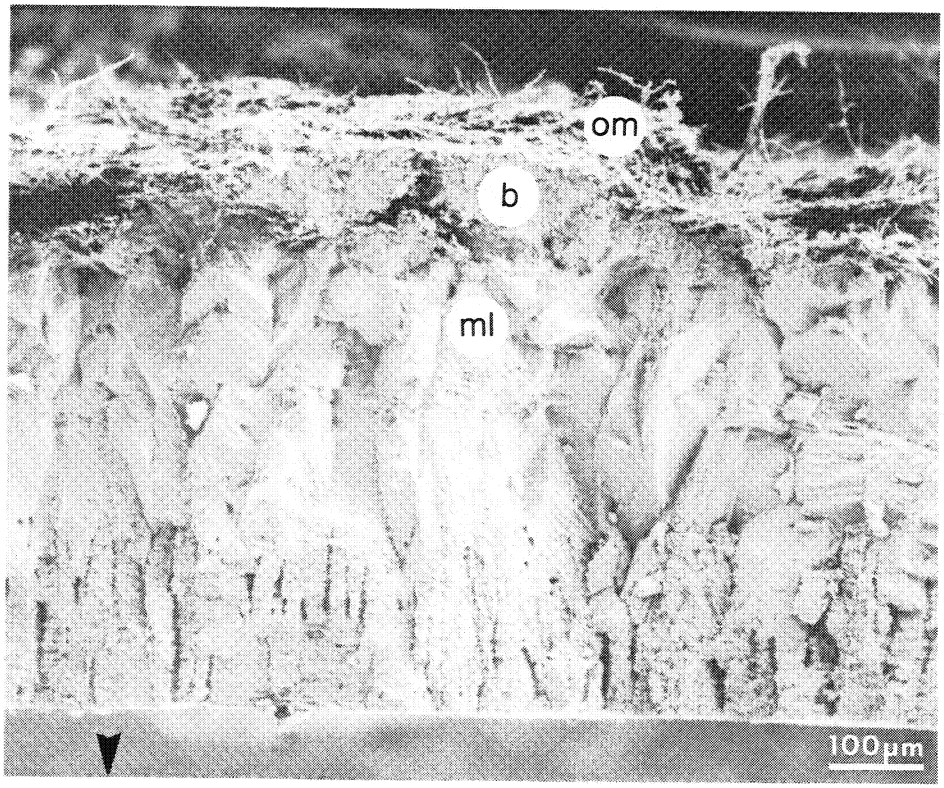
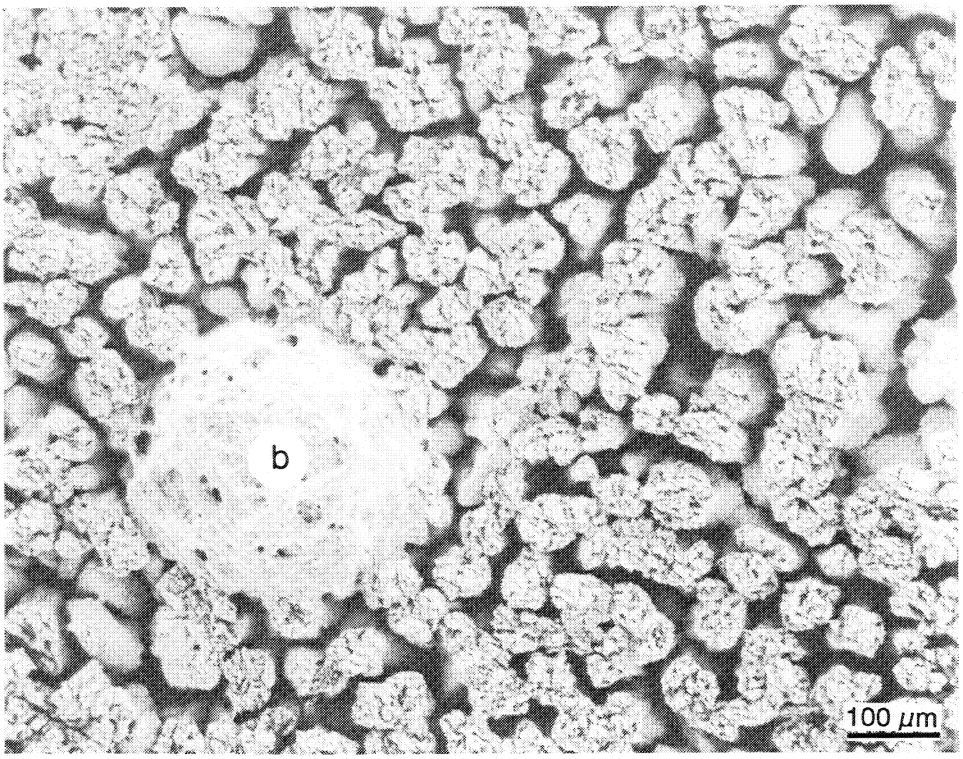
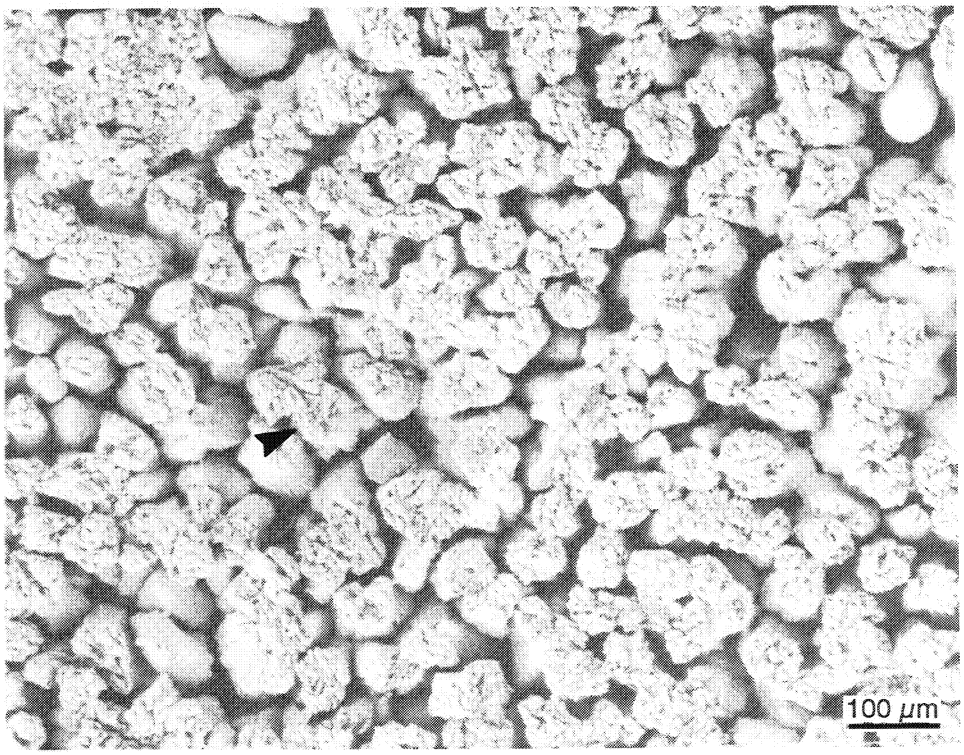


Plate 15. Inside of bald eagle eggshell from Cliff territory, 1989. **15A**: Bump (b) is visible after soaking the shell in bleach for 0.5 hr, but the outer shell membrane has been dissolved. **15B**: After soaking the same sample in bleach for a total of 1.5 hr, the bumps are completely dissolved. Arrow indicates where bump was previously located.

15A



15B



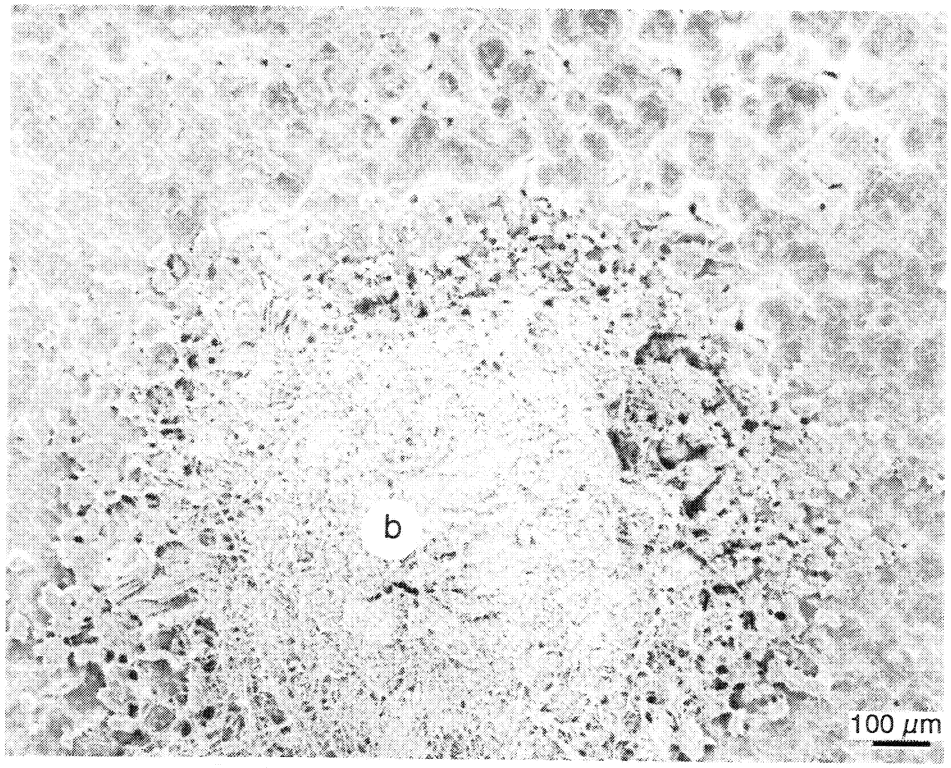


Plate 16. Inside of bald eagle eggshell from Cedar Basin territory, 1989, after partial decalcification in HCl, showing large bump that remains (b).

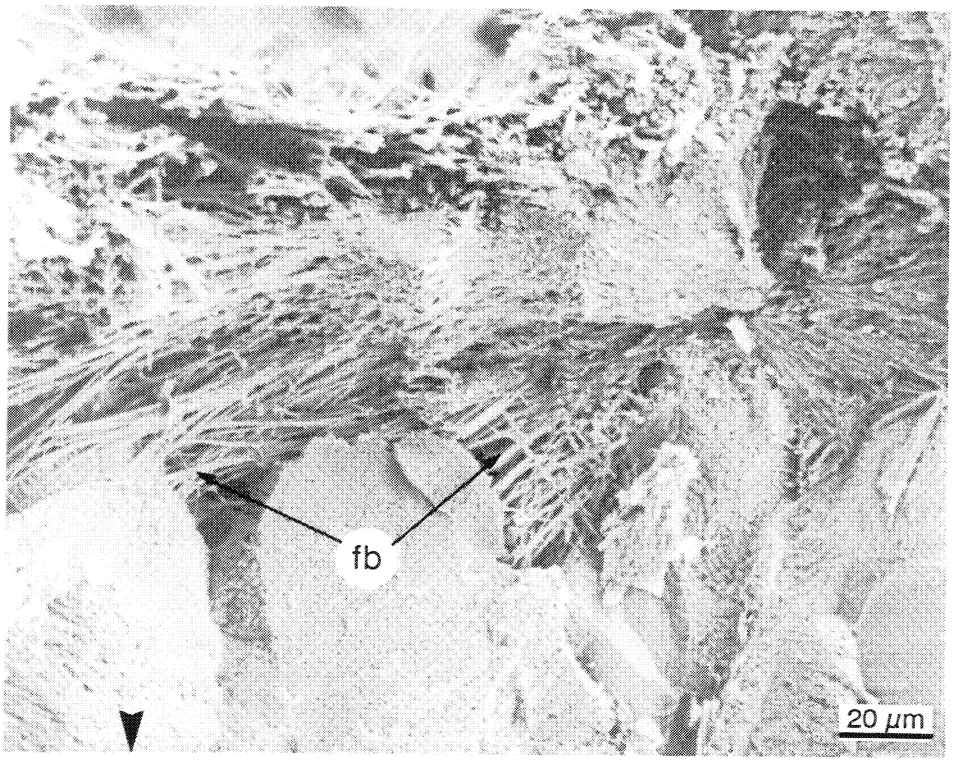


Plate 17. Cross-section of bald eagle eggshell from Cliff territory, 1989, showing the numerous fibers (fb) by which the bumps are attached to the calcified layer. Outside of shell indicated by arrow.

E6 AN ANALYSIS OF BALD EAGLE POPULATION GENETICS USING DNA FINGERPRINTING

Prepared by E.R. Vyse
Montana State University

E6.1 INTRODUCTION

Conservation of endangered or threatened species has usually involved the preservation of habitat or the maintenance of a few remaining organisms in zoos or preserves. Until the advent of the use of variable number of tandem repeat loci (VNTR), sometimes called mini-satellite or DNA fingerprinting, estimating genetic variability depended on protein electrophoresis, which samples only a small fraction, at best, of the genome largely composed of conserved gene coding sequences. The genetic resources of endangered species has only recently been considered. The neglect of genetic resources was due largely to the difficulty of estimating genetic variation rather than a lack of awareness of the potential hazards of the restriction of genetic resources (Schonewald-Cox *et al.* 1983). Small populations often have low levels of heterozygosity and show signs of inbreeding depression, resulting in observable physiological problems including: increased juvenile mortality; morphological asymmetry; reduced reproductive capacity; and, increased population susceptibility to pathogens (Yuhki and O'Brien 1990).

The potential of molecular techniques in pursuing genetic analysis of endangered species was brought to the attention of conservationists by the dramatic results of O'Brien in the cheetah. They reported that cheetahs are not only homozygous but, astonishingly enough, that they accept reciprocal skin transplants (O'Brien *et al.* 1985). Protein electrophoresis and skin transplants as employed by O'Brien, although well documented and state-of-the-art at the time, have been supplanted by recombinant DNA techniques.

The newer techniques of restriction fragment-length polymorphism (RFLPs) analysis of cytoplasmic DNA, coupled with RFLPs and mini-satellite probes of nuclear DNA, has enabled conservation biologists to apply genetic analysis to a variety of biological problems, including the question of genetic diversity in endangered species. The absence of genetic variability in populations is usually attributed to a history of inbreeding, resulting from a drastic reduction in population size. Recent publications (of studies that employed DNA fingerprinting techniques) have reported low levels of genetic variability in California Channel Island foxes (Gilbert *et al.* 1990), the African cheetah and the Asiatic lion (Yuhki and O'Brien 1990).

The potential of DNA fingerprinting has been most fully realized in birds where the presence of nucleated erthyrocytes allow the isolation of DNA from a few drops of blood. DNA fingerprinting in birds has been used to identify brood multiple paternity (Burke *et al.* 1989), to establish extra pair matings (Wetton *et al.* 1988), to identify population specific polymorphisms, and to detect reduced levels of heterozygosity (Longmire *et al.* 1988).

In this study, we compare the genetics of three bald eagle populations using DNA fingerprinting techniques to estimate inter- and intra-population genetic variability. Specifically, we apply these techniques to the following questions: (1) Are there population-specific restriction fragments that can be used as markers to identify individual populations? (2) What are the relative amounts of heterozygosity

(i.e., genetic variability) between populations? and, (3) What are the relative amounts of relatedness between the populations under investigation?

E6.2 MATERIALS AND METHODS

E6.2.1 Samples

Bald eagle blood samples were sent by various field workers to J. Longmire at Los Alamos National Laboratory, Los Alamos, New Mexico. These samples had been frozen as whole blood or frozen after dilution in buffer; they were subsequently shipped to our laboratory under dry ice.

E6.2.2 DNA Extraction and Blotting

Frozen blood samples were thawed at room temperature and DNA extracted, following the procedure of Mullenbach *et al.* (1989) with minor modifications. Approximately 300 μl of sample diluted with an equal volume of SE buffer (Tris-HCl pH 8.0, 25 mM EDTA, 75 mM NaCl) plus 100 μl of Proteinase K (10 mg/ml) and 100 μl of 10 percent SDS. Then samples were incubated at 37°C overnight in a rotating drum. One-quarter volume of a saturated NaCl solution was added and this was incubated at 37°C in a rotating drum for one hour. They were then extracted once with phenol:chloroform and the DNA precipitated from the transferred aqueous layer with an equal volume of isopropanol. After washing with 200 μl of 70 percent ethanol the pelleted nucleic acids were dried in air and then dissolved in 200 μl water.

Five to eight μg DNA was digested with 40 units of HinfI or HaeIII using the 10× buffer supplied by the manufacturer in a total volume of 100 μl. Digests were incubated from 3 hr to overnight at 37°C and then extracted with phenol:chloroform, DNA precipitated from the extract with isopropanol and the precipitate collected by centrifugation at 13,000 g for 25 minutes. The precipitate was dissolved in 10–15 μl water, mixed with loading buffer and loaded into wells 1.5 mm × 1.2 cm in a 20-cm × 25-cm 0.8-percent agarose gel. Electrophoresis to separate the restriction fragments by size was performed at 3 V/cm for 18–20 hr, when fragments less than 1 kb were run off the gel in 0.5 × TBE (5 × TBE = 0.225 M Tris-Borate, 0.005 M EDTA pH 8.3).

Gels were stained with ethidium bromide, photographed with UV light and then blotted onto Zetabind membrane, using the ammonium acetate procedure of Westneat *et al.* (1988). Prehybridization and hybridization was carried out, according to the methods of Westneat *et al.* (1988).

E6.2.3 DNA Hybridization and Autoradiography

Mini-satellite variable bands were detected on blots by three different probes using the restriction endonucleases HaeIII and HinfI. M13 virus, mp18 (Vassert *et al.* 1987), was purchased from BRL, Life Technologies, Inc. Jeffreys' human probe 33.6 (herein, 33.6) was a gift of Cellmark Diagnostics.

Probe M13 was labeled using a random primer kit (BRL Life Technologies), probe 33.6 was labeled using the protocol supplied with the DNA. Blots were washed, following the procedures of Westneat *et al.* (1988), usually three times at room temperature in 2 × SSC, O.1 percent SDS for 15 minutes, then washed once at 60°C in 0.1 × SSC, 0.1 percent SDS for 15–30 minutes. After washing, excess liquid was removed and they were wrapped in plastic and autoradiographed for 1 to 10 days using Kodak XAR-5 film with intensifying screens. Figure E6-1 shows autoradiograms from each of the enzyme-probe systems utilized.

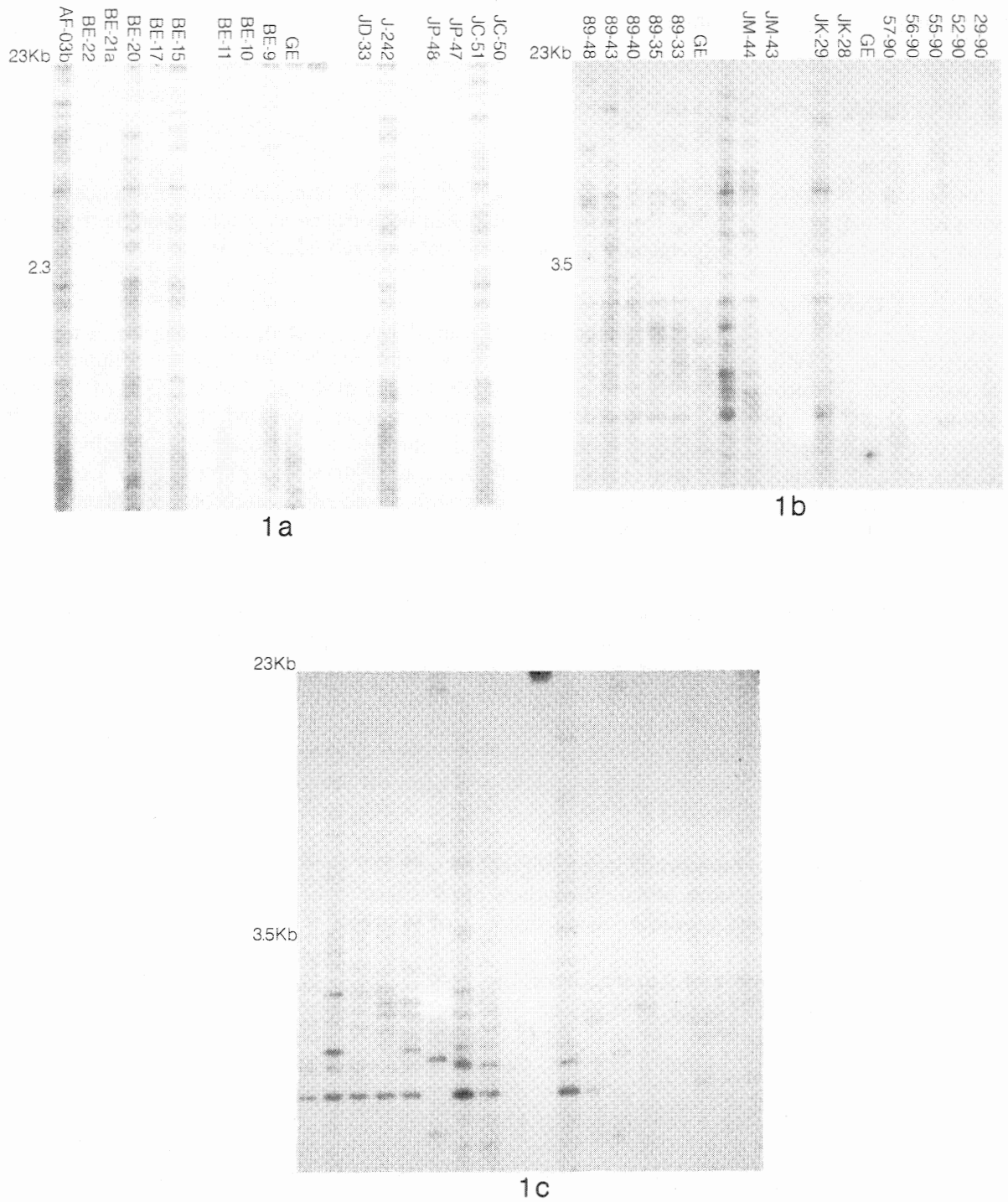


Figure E6-1. Autoradiograms from the three enzyme/probe systems used in this investigation. **1a**: HaeIII/PV-47; **1b**: HinfI/M-13; **1c**: HinfI/33.6. Individual labels on each autoradiogram are the sample labels provided with the blood samples.

E6.2.4 Analysis of Autoradiograms

Restriction fragments on autoradiograms were scored as either present or absent. A golden eagle DNA sample and three molecular weight standards (derived from digested lambda DNA) were run on each gel to insure equal mobility across electrophoretic gels. To further ensure that identical fragments were scored for each individual, comparisons were made only for individuals represented within a single autoradiogram (sensu, Gilbert *et al.* 1990).

These presence and absence matrices were used to calculate the similarity coefficient (x), of Jeffreys' *et al.* (1985). These calculations were performed on an IBM-PC with a program kindly provided by Graham Mark, Los Alamos National Laboratory. This output represented both inter- and intra-population similarity coefficients. These x-values were averaged over all individuals and summary statistics calculated. We report a standard error of the mean (s.e.m.), for mean similarity coefficients; this value was calculated following the equation of Gilbert *et al.* (1990). PC-SAS (Version 6.0, SAS Institute, Cary, N.C.) was used to calculate population-level statistics for x-values. Mean similarity values were clustered using the algorithm UPGMA (Sneath & Sokal 1973). The program NTSYS (Version 1.5, Exeter Software, Setauket, N.Y.) was used to generate phenograms of the mean similarity coefficients.

E6.3 RESULTS AND DISCUSSION

We limit our discussion to the three populations under primary consideration in this study, namely, those of California, Arizona, and Florida. We have analyzed birds from the other locations and give data for those birds where available.

We were unable to identify population-specific restriction fragments in this study (Figure E6-1). This is not surprising due to the extremely high levels of variability revealed with this technique, coupled with the high dispersal potential of bald eagles. Some studies using DNA fingerprinting have revealed population-specific restriction fragments (e.g., Longmire *et al.* 1988; Gilbert *et al.* 1990), but these have mostly been found in populations that are very isolated and have had little gene flow in the recent past. However, we did find that combinations of fragments patterns were, in most cases, useful to correctly classify individuals into the proper population when individual similarity values were clustered using UPGMA. A species-specific marker band was detected for bald eagle samples; this fragment was absent in golden eagle DNA. In summary, we found no constant, population-specific markers for bald eagles, but were able to correctly classify individuals into their respective populations a majority of the time. This indicated that our methods do have the ability to classify individuals when used in a multi-variate manner.

The average numbers of bands per individual are given in Table E6-1. The Florida birds have a consistently higher number of bands/individual than the other populations under all enzyme/probe combinations analyzed. Arizona birds have more bands/individual than do California birds with the exception of HinfI digests probed with the 33.6 probe. This could be an artifact of the small number of individuals analyzed with this probe, and at present, the results from the 33.6 probe should be taken with some caution.

Mean intra-population similarity values are listed in Table E6-2. The most consistent findings are that the Florida eagles have higher similarity values than do California or Arizona. This would indicate that Florida birds are more closely related to one another (and, perhaps, more inbred) than are those birds

Table E6-1. The average number of restriction fragments per individual for all populations from the three restriction enzymes and probes evaluated in this study. The sample size (*n*) is given in parentheses.

	Enzyme/Probe System		
Location	HaeIII M-13	HinfI M-13	HinfI 33.6
AZ	5.4 (17)	4.6 (42)	13.1 (11)
CA	5.2 (4)	4.2 (11)	11.8 (6)
FLA	7.8 (3)	5.3 (16)	16.2 (8)
CAN	4.0 (8)	6.3 (20)	8.1 (10)

Legend: AZ—Arizona; CA—California; FLA—Florida; CAN—Canada.

from either of the other populations. The ranking of California and Arizona populations differs depending on which enzyme/probe system was used to analyze these populations. The California birds appear more closely related (or inbred), than do Arizona individuals with HaeIII/M-13, and HinfI/33.6 combinations, while the opposite is the case with HinfI/M-13 combination. In most cases, the values for California and Arizona are closer to one another than either is to Florida populations, indicating that they are less similar in relation to the Florida population. These findings must be assumed to be preliminary (and treated with due caution), because of a lack of information concerning sampling procedures.

Table E6-2. Intra-population similarity coefficients *x* (Jeffreys *et al.* 1985b). The standard error of the mean (Gilbert *et al.* 1990) for each value is given in parantheses.

Location	HaeIII M-13	HinfI M-13	HinfI 33.6
AZ	0.351 (0.031)	0.246 (0.047)	0.441 (0.006)
CA	0.390 (0.023)	0.216 (0.052)	0.497 (0.000)
FLA	0.500 (0.000)	0.289 (0.038)	0.506 (0.000)
CAN	0.423 (0.024)	0.259 (0.031)	0.463 (0.006)

Legend: AZ—Arizona; CA—California; FLA—Flordia; CAN—Canada.

The results we have obtained could easily be explained by sampling procedures. We know nothing of the sampling regimes, and have no way of determining the potential for relatedness among samples, with the exception of a few samples from Arizona that appear to be nestlings. We also have no way to determine the natal origin of samples taken from adult and subadult individuals; the location of their capture may not be indicative of their natal origin.

The standard error of the mean (s.e.m.), of the intra-population similarity coefficients is also given in Table E6-2. This value indicates the amount of variation of similarity coefficients between individual within the populations. They yield a similar pattern to the *x*-values themselves. The Florida birds are consistently less variable than are those from California and Arizona.

The matrix of inter-population similarity coefficients is given in Table E6-3. Phenograms produced from these similarity matrices are illustrated in Figure E6-2. The similarity values indicate that there is a large difference between Arizona and Florida birds, which suggests that they are the most distantly related. The California population is most similar to the birds from Florida suggesting that they are more closely related to California birds than to birds from Arizona. Although the absolute values of the similarity coefficients between California and Florida differ, the overall pattern of variability is similar and they produce similar phenograms.

When included in clustering analyses, birds from Canada are well set off from the other three populations, indicating that they are only distantly related to any of the three populations being considered. In our analyses, samples from golden eagles proved to be the most distantly related (having the lowest similarity values); confirming that our methods were reliable, and that the powers of resolution were at least, at the species level. In addition, the overall patterns of relatedness obtained with either the HaeIII/Mi3 or HinfI/M13 enzyme/probe system converge, further confirming the accuracy of our methods (Table E6-3, Figure E6-2).

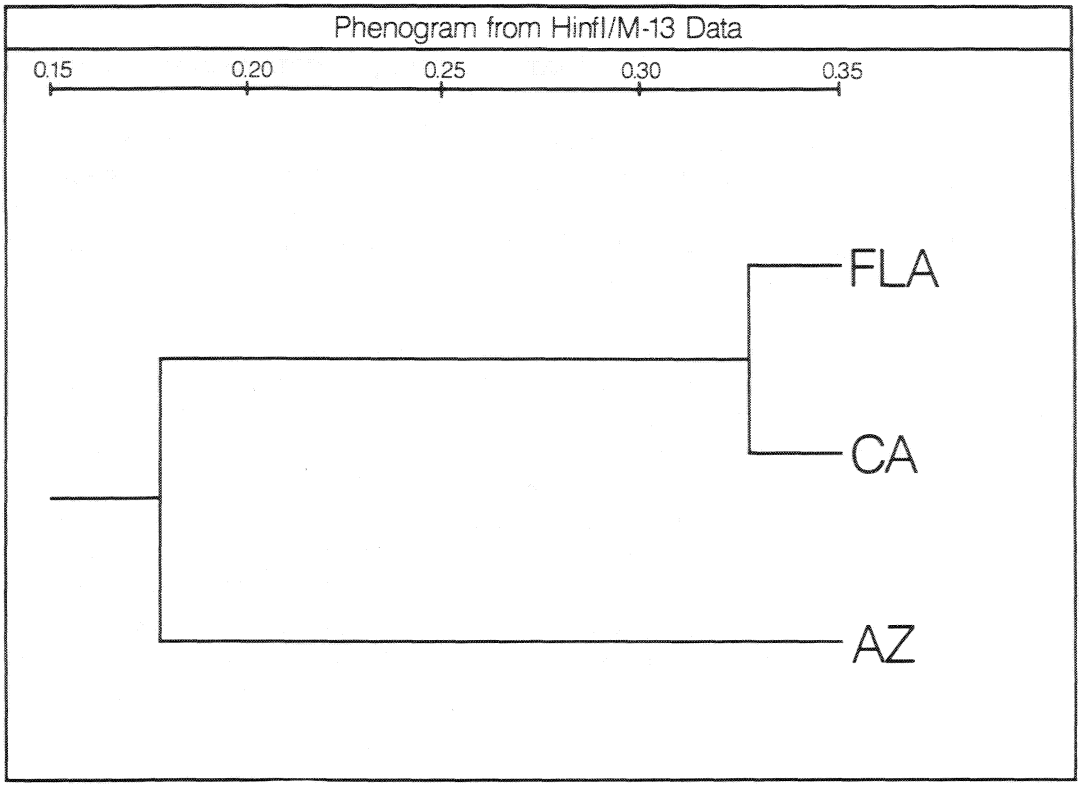
Preliminary results from HinfI/33.6 also produces a phenogram that couples California birds to Arizona birds; this group remains distinct from Florida birds. At present, these data (HinfI/M-13) are too incomplete to be considered further. The APD values within each enzyme/probe combination are very similar but the California-to-Florida comparisons consistently have lower values than the California-to-Arizona or Florida-to-Arizona comparisons (Table E6-4). Suggesting that the phenograms based on the similarity index are valid.

E6.4 CONCLUSIONS

1. No population specific restriction fragments have been found, but patterns of fragments will identify eagles to a specific population.

2. Within populations, Florida eagles have the highest similarity with Arizona and next highest with California, depending on the enzyme/probe combination used.

3. Surprisingly, California and Florida populations group together as being more closely related to each other than to the Arizona population.



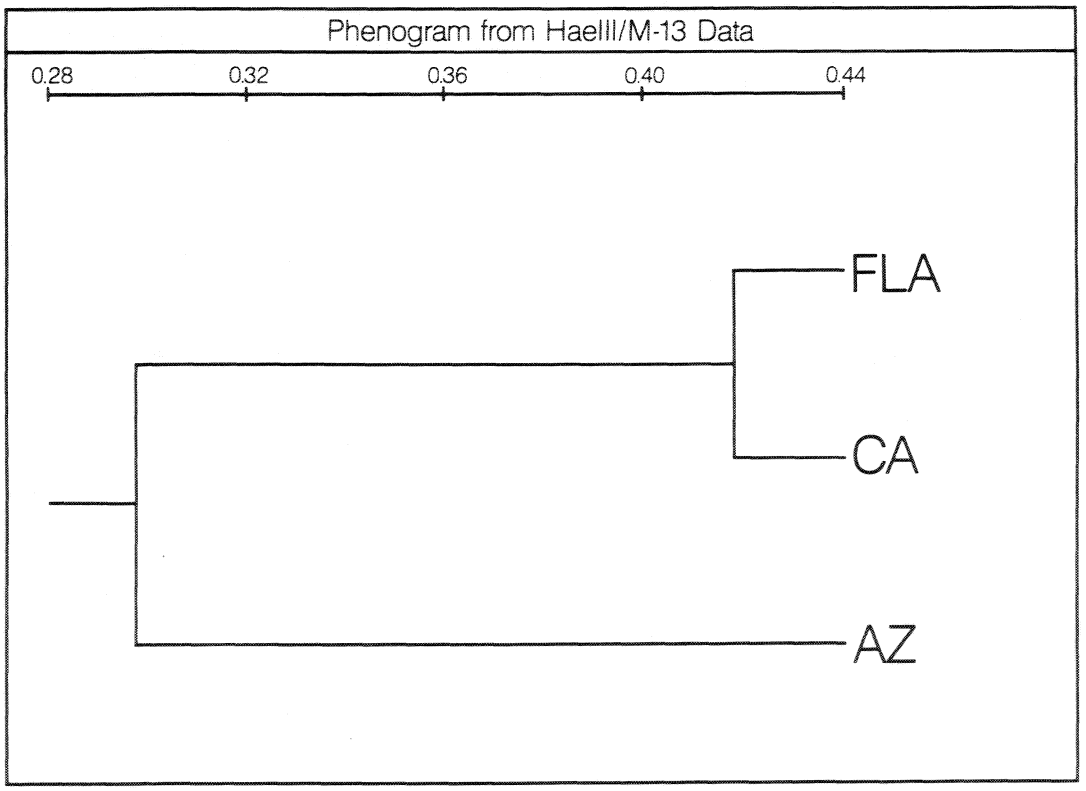


Figure E6-2. UPGMA clustering analysis of the mean similarity coefficients given in Table E6-3. Clustering was carried out using the programs available in NTSYS-PC. The data used to generate each phenogram is labeled on the figure.

Table E6-3. Interpopulation similarity coefficients (Jeffreys *et al.* 1985), for two enzyme/probe systems. The values above the diagonal are from HinfI/M-13 and those below the diagonal are from HaeII/M-13. UPGMA-derived dendrograms of these data are located in Figure E6-1. Missing values are represented by a dashed line. Sample size (*n*), is given in parentheses.

	HinfI/M-13			
	FLA	CA	AZ	CAN
FLA	0.289 (51) 0.500 (5)*	0.326 (29)	0.181 (99)	0.281 (28)
CA	0.417 (10)	0.216 (31) 0.397 (10)	0.172 (121)	—
AZ	0.312 (22)	0.281 (16)	0.246 (104) 0.351 (30)	0.231 (7)
CAN	—	—	0.422 (8) 0.281 (16)	—
	HaeIII/M-13			

Legend: AZ—Arizona; CA—California; FLA—Florida; CAN—Canada.
* This value represents an inter-atoradiogram comparison from a small sample size; its validity may be suspect.

E6.4 SUMMARY

We were unable to isolate population-specific restriction fragments that could be used singly to identify population membership of individual birds. We were able to identify combinations of restriction fragments that were unique to certain populations, and these combinations can be used to correctly identify population membership of individuals in most cases. Eagles from Florida were found to have the highest number of restriction fragments per individual. Although Florida eagles had the largest number of fragments/individual, they were more similar to one another than were individuals from the other populations. Florida birds also showed the lowest variation among intra-population similarity values.

Florida and Arizona birds were found to be the least similar. California birds were found to be more similar to Florida than to individuals from Arizona. This pattern may be accepted as a preliminary estimate, as more samples are needed to validate this relationship.

Table E6-4. Average Percentage Difference (APD) Matrix (Gilbert *et al.* 1990) between four Eagle populations using HaeIII/M13, HinfI/M13 and HinfI/33.6 enzyme/ probe combinations (in that order). APD = above the diagonal; SEM = below the diagonal.

	Arizona	California	Florida	Canada
Arizona	—	62.9	57.4	61.3
California	3.9	—	55.0	59.3
Florida	3.3	3.3	—	53.8
Canada	4.5	1.3	3.6	—
Arizona	—	76.9	73.2	74.7
California	3.7	—	74.7	76.2
Florida	3.8	3.7	—	72.6
Canada	3.0	3.2	3.1	—
Arizona	—	53.1	52.6	53.3
California	1.7	—	49.8	52.0
Florida	1.4	1.5	—	51.5
Canada	2.0	2.1	1.7	—

E6.5 ACKNOWLEDGMENTS

Bruce Neill contributed to all aspects of this study. Kitty Brown provided laboratory assistance throughout this study. Ric Roche, Graham Mark, and Dan Gustafson provided computational assistance. Without their combined efforts, completions of this project would not have been possible; I am thankful for their help.

E7 ENZYME GENETICS OF BALD EAGLES IN ARIZONA

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E7.1 INTRODUCTION

Arizona's nesting population of bald eagles is small enough to raise questions about the probability of its persistence. In the light of the genetic problems of small populations discussed in Section A5.4, we ask the following questions regarding the Arizona population:

1. Are overall levels of genetic variation in the Arizona population suggestive of inbreeding?

2. Are there any genetic differences between the Arizona population and other populations (not simply specific differences but general trends)?

3. Which population is most closely related to the Arizona population?

4. How does a larger data sample compare with similar data collected in 1985?

Questions 2 and 4 are directly relevant to the possibility of a genetic bottleneck and the consequences of small population size. Morizot and coworkers (1985) emphasize the importance of knowledge of genetic information in management decisions, because of the possibility of adaptation to local environmental conditions in the Arizona population. The third question is relevant to this possibility as well as to the general considerations of small populations.

Starch gel electrophoresis offers the opportunity of studying gene frequencies controlled by single loci with no environmental component in the variance of phenotypes. The system, involving comparisons of the mobilities of metabolic enzymes in electric fields, enables us: (1) to estimate within populations the degree of overall variation (heterozygosity), an important clue to inbreeding problems; (2) to detect alleles apparently unique to a population, possibly suggesting evolutionary adaptations to local conditions; and, (3) to contrast the genetics of different populations in order to trace evolutionary affinities and patterns of dispersal.

In this report, we provide the results of an electrophoretic analysis of six enzyme polymorphisms from seven populations of bald eagles in the United States and Canada. This interpretation was written by Ellen Holstert and Jerry Zegers (University of California). Laboratory analysis and gel scoring was performed by M.E. Schmidt of Genetic Analysis, Inc. (under contract with BioSystems) and with consultation from D.C. Morizot. Blood samples from Arizona were collected by Daniel Driscoll (BioSystems) and Robert Mesta (USFWS); additional samples were provided by James Seegar (Maryland), Robert Anthony (Washington/Oregon), David Mabie (Texas), Steve Sherrod (Florida), and John Aiken (California).

E7.2 MATERIALS AND METHODS

The analysis of the genetic status of Arizona bald eagles is based on the following data sets: the results of a 1985 study on clinal genetic variation of bald eagles from the western United States (Morizot *et al.* 1985), and the current study. Morizot and coworkers report gene frequencies from four populations—Alaska, Washington, Oregon, Arizona—and five enzymes—glucosephosphate isomerase (GPI), adenosine deaminase (ADA), peptidase-A (PEPA), glyoxalase-1 (GLO), and esterase-D (ESD). Sample sizes ranged from 5 to 21 birds, depending on the population and the enzyme sampled.

The current study includes eagles from seven populations: Arizona (AZ), Maryland (MD), Florida (FL), Washington–Oregon (WA), California (CA), Texas (TX), and Michigan (MI). The enzymes surveyed are: mannose-phosphate isomerase (MPI), nucleoside phosphorylase (NP), ESD, PEPA, GLO, and GPI. Sample sizes for this study are considerably larger, ranging from 3 to 138, again, depending both on the population and the enzyme sampled.

The genotypes of the birds were determined by vertical starch gel electrophoresis (Morizot *et al.* 1985).

E7.3 RESULTS

To answer Question 2 (Is there any genetic difference between the Arizona population and other populations?), refer to Figure E7-1 (a–f).

These are histograms of gene frequencies of the A allele for six enzymes, the seven 1990 population samples, and the 1985 Alaska sample. In all populations some frequencies differ, but are there any populations that are more different in character from the others?

We used Friedman's test for the two way classification (Steel and Torrie 1980), a non-parametric test based on the ranks of each population for each enzyme (Alaska is excluded from this test because the current study includes two enzymes not surveyed in 1985). The test statistic "f" is distributed as Chi-Square with six degrees of freedom ($\chi^2 = 3.744$, df = 6, $p < 0.075$), *no population stands out in terms of excess fixation or loss of alleles.*

One problem that can occur after genetic bottlenecks is a loss of variability due to a loss of alleles. This would lead to lower mean heterozygosity per locus (MHL). The MHL are: AZ = 0.211, MD = 0.067, FL = 0.135, WA = 0.097, CA = 0.033, TX = 0.143, and MI = 0.108. Arizona actually has the highest heterozygosity for the genes surveyed.

Question 4 (Has there been any change in the Arizona population since 1985?) is difficult to answer with precision because of the different sample sizes between 1985 and 1990. Figure E7-2 shows the gene frequencies for the four loci sampled both in 1985 and 1990. The population remained fixed for GPI A and PEP B, and GLO did not significantly change (0.6 to 0.636). Clearly, the only frequency that may have changed is ESD (0.4 to 0.882). This difference is possibly an artifact of the many fewer samples in 1985.

Which population is most closely related to the Arizona population? Nei's genetic distance, based on no information other than the six alleles surveyed, indicates MD is the most similar (Table E7-1, but six loci

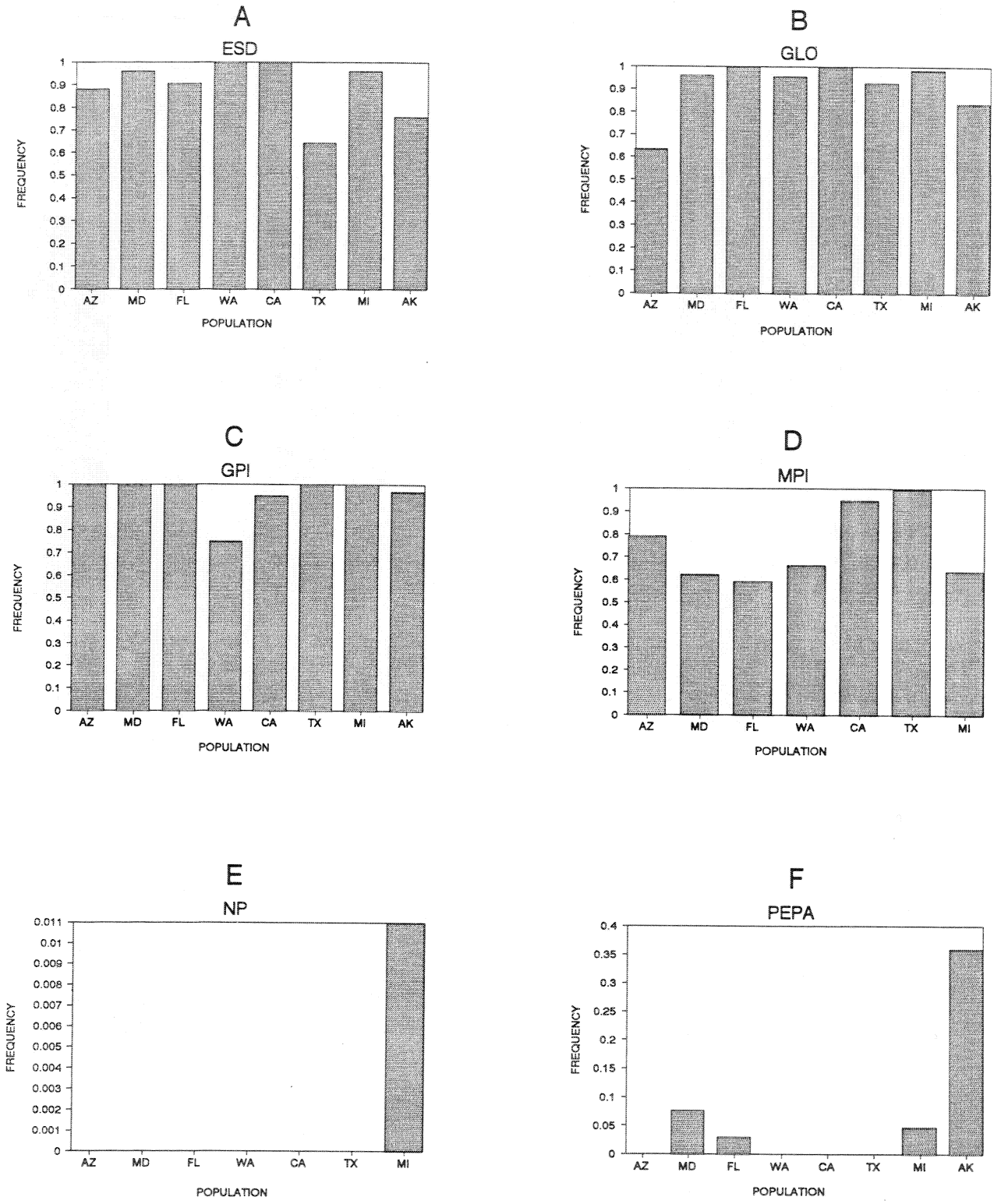


Figure E7-1 (A-F). Geographic variation in allele frequencies. Allele frequencies for six enzyme polymorphisms as revealed by electrophoresis.

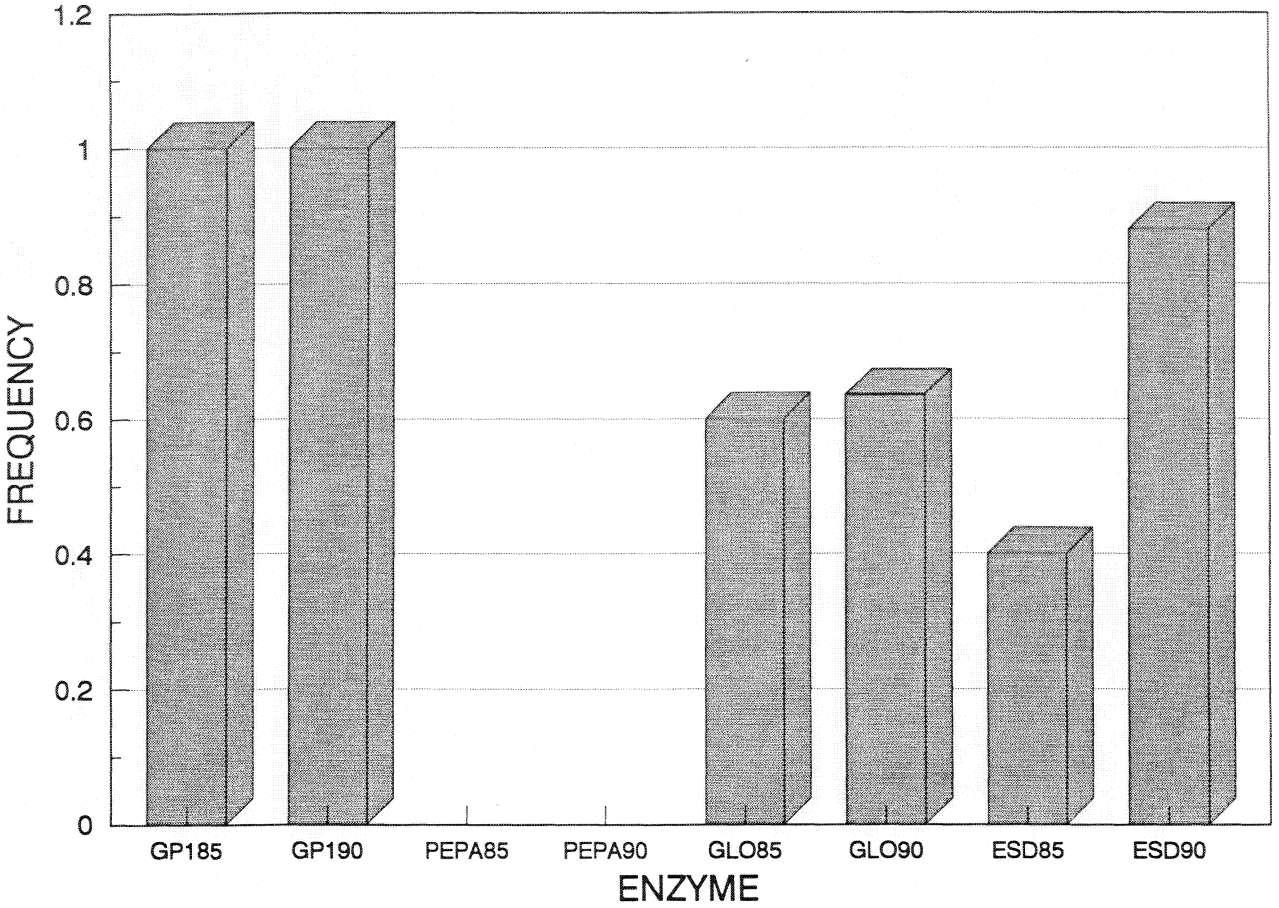


Figure E7-2. Isozyme frequencies in the Arizona bald eagle population.

may not be enough to give a reliable estimate of the true genetic distance). Nei's genetic distance (Hartl and Clark 1989) between the populations can also be used to investigate the "uniqueness" of the Arizona population (Table E7-1). Distances ranged from 0.0003 (MD vs. MI) to 0.0587 (TX vs. WA). The mean distance was 0.026 +/− 0.016. The most similar population to AZ is MD, and the most diverged (excluding AK) is WA. Alaska was not compared to the 1990 samples because only four loci were sampled both in 1985 and 1990. The genetic distance between AZ and AK, based on the five loci surveyed in 1985, is 0.0926.

E7.4 DISCUSSION

Although the bald eagle population in Arizona may have some genetic uniqueness, it is not significantly different from any other population in the ranks of allele frequencies. The mean heterozygosity per locus is highest for the Arizona population. This indicates that there has been little (if any) genetic differentiation of this population as a result of bottlenecks, inbreeding, or random genetic drift.

Table E7-1. Nei's genetic distance.

	MD	FL	WA	CA	TX	MI	AK
AZ	0.0288	0.034	0.0396	0.0297	0.0354	0.0299	0.0926
MD		0.0015	0.0139	0.0200	0.0478	0.0003	
FL			0.0153	0.0242	0.0458	0.0011	
WA				0.0206	0.0587	0.0129	
CA					0.0242	0.0176	
TX						0.0449	

Comparing allele frequencies of this population from the current study and the 1985 study (Morizot *et al.* 1985), the only locus which might have undergone a change in frequency is ESD. The difference seen between the two studies is probably due to the difference in sample sizes (only five individuals in 1985 and 55 individuals in 1990) rather than to random genetic drift.

Nei's genetic distance reflects the amount of divergence (or the divergence time) between two populations. Table E7-2 presents examples of Nei's distance for a variety of animal groups at different taxonomic levels (populations, subspecies, etc.). The genetic distances between the populations in this study are well within the range of distances for local populations for a diverse group of animals. The striking point is not that Arizona is closer to Maryland than it is to the other populations, but that Texas is surprisingly divergent from the other populations. The amount of divergence between Arizona and Maryland is comparable to the other distances.

In summary, these data are not consistent with the expected effects of small population size. This population of bald eagles appears to have levels of genetic variability and heterozygosity comparable to other bald eagle populations. It would be valuable to have information on the number of birds that move into the Arizona population from elsewhere and breed. Knowing how many individuals are immigrants, and the frequency with which immigrants successfully breed, would tell us whether the Arizona population is isolated or whether it is a part of a much larger interbreeding population. It is also important to consider the long generation time of this species. Deleterious effects of small population size could manifest themselves if this population ever decreases in size. The long generation time of these birds would make rapid recovery with the retention of high levels of genetic variability unlikely.

We feel caution should be exercised when interpreting these results due to the low numbers of individuals sampled from most states but especially because of the few loci examined. We need more information about the natural boundaries of these populations. Sampling the birds within a state and calling that

Table E7-2. The genetic distance between different taxonomic levels from: Barrowclough, G.F. and K.W. Corbin, 1978. Genetic variation and differentiation in the parulidae. The AUK: 95:691-702.

Taxa	Local Populations	Sub-Species	Semi Species	Sibling Species	Species	General
Drosophila	0.028	0.230	0.226	0.740	1.056	—
Sunfish	0.020	0.174	—	—	0.616	—
Minnows	0.031	—	—	—	—	0.528
Salamanders	0.051	0.174	—	—	0.462	1.170
Mammals	0.056	0.219	—	—	0.302	0.651
BIRDS						
Aplonis	0.003	0.007	—	0.035	—	—
Zonotrichia	0.004	0.009	—	—	—	—
Icteridae	0.002	—	0.003	0.012	—	0.248
Parulidae	—	—	—	—	0.100	0.179

sample a population while the birds from the same population which happen to be in an adjacent state are labelled as a different population based on convenient political boundaries can produce misleading results. Similarly, sampling from two different populations in a large state and lumping all the samples together into what is called a single population can produce equally misleading results.

E8 METHODS FOR STUDYING EAGLES

Numerous diverse tasks were necessary to complete BioSystems' investigation of the ecology of bald eagles in Arizona. To study home range, habitat selection, foraging, and long-range movements, we utilized radio telemetry, and to do so required capturing specific eagles, selecting and properly attaching transmitters, tracking, observing, codifying observations, and interpreting the results. We approached the problem of defining habitat use in space and time by the foraging adult eagles by employing the principle of *time-lines* in which the locations of the telemetered birds were continuously accounted for from dawn through long and uninterrupted periods of the day, and for numbers of days on end. As often as possible, we observed eagles in the act of foraging and subsequently measured the habitat variables at the foraging sites. To match up prey selection with habitat use, we stationed observers at observation points to visually identify and describe prey deliveries while maintaining radio communication with the tracking teams.

In cases in which research methods or schedules were specific to particular territories or other lines of investigation dealt with in the volumes of this report, we have reported such methods therein.

E8.1 EAGLE OBSERVATIONS

The Observation Form ("ObsForm"), as shown in Figure E8-1, was used to record observations of bald eagles either during visual censuses, telemetry surveys, or incidental sightings when carrying out other tasks. The form was used in conjunction with the BioSystems River Map Atlas. During the course of the study, BioSystems accumulated and computerized over 36,000 records of bald eagle movements and activities.

In general, each time an eagle moved to a different location or began another activity regarded as significant to an understanding of foraging, a new data line was entered. Items left blank or given zeros indicated no data. Observers were instructed to go over their forms at the end of the day, checking all entries for accuracy and completeness, and to initial the form when satisfied. After computer entry, two people compared printouts with original forms for accuracy by reading every field of each data record aloud. Codes and instructions for each data field were as follows:

DATE: Month/day/year. *Example*: May 3, 1987 reads 05/03/87.

DATA TYPE: includes the following categories:

- TRK = Includes any bald eagles seen while tracking
- SEC (or SDR) = Enter Secchi disk reading in centimeters under END and water temperature under TEMP
- NEV = Nest observation
- CAS = Carrion survey
- REF = Researcher on foot
- NSC = Nest shade check
- WFS = Waterfowl survey
- FHS = Food habits survey

		ID	TIME	LOCATION	ACTIVITY AND HABITAT	OBSERVER	WEATHER	
LETTER	DATE (MO DAY YR), DATA TYPE	AGE, BIRD NO, SIGHT MODE	TIME, END, BREAK	RIVER, TERRITORY, SEGMENT, KILOMETER, PRECISION, TRIBUTARY, LAKE-LOC, SIDE	ACTIVITY, PREY?, CROP, BE-SAME, PERCH, SHADE, DIST-H2O, ELEVATION, HABITAT	OBSERVER, OBS-LOC, OBS-MODE, DIST-OBS, RESP-OBS	WEATHER, TEMP, WIND SPEED, ENTRY NO	LETTER
A								A
B								B
C								C
D								D
E								E
F								F
G								G
H								H
I								I
J								J
K								K
L								L
M								M
N								N
O								O

COMMENTS:

This Data is correct _____

Computer Records Verified _____

OBSFORM

BioSystems Analysis, Inc.

LETTER		PUR-USER, DIST-PU, RESP-PU, TYPE-PU, MODE-PU, POST-PU, DIST-PU-H2O, SIDE-PU	LETTER
A			A
B			B
C			C
D			D
E			E
F			F
G			G
H			H
I			I
J			J
K			K
L			L
M			M
N			N
O			O

Figure E8-1. Bald eagle observation form—"ObsForm".

DATA TYPE, continued:

HEC = Helicopter census
TRP = Trapping
APS = Airplane survey
BOC = Boat census
TRK = Tracking
INO = Incidental observation
PUC = Public use census
NEC = Nest climb
SEC = Secchi disk reading
ROS = Road survey
FIW = Fisheries work
OTH = Other (see comments)
POB = Prey observation (e.g., spawning, occurrence in shallow water, etc.)
DAY = A comment or measurement pertaining to the entire day (e.g., comments on high off-road vehicle use this day)
TNR = Intensive observation and tracking of non-radioed bald eagle

BIRD NUMBER: There are two categories of bird identification number: (1) Birds with assigned numbers (those with radios or Visual Identification (VID) bands), and (2) non-telemetered birds of known or presumed identity, coded as follows:

1st space = **Territory code letter** for birds hatched or breeding in the territory (see TERRITORY, below);

2nd space = **Sex/age**: M = adult male, F = adult female, Y = young;

3rd and 4th spaces = **Identification number**.

Example: TM01 = adult male at the Pinal Territory.
For unidentified birds we put U in the first space and age in the second space as follows:

J = Juvenile (a recently fledged nestling prior to migration from territory);
I = Immature (a dark eagle with a dark head, probably in its first year);
S = Subadult (any of various plumages (mottled, white belly/bib, etc., head mottled or with eye-stripe; birds in 2nd or 3rd years);
N = Near-adult (almost adult plumage except dirty white head);
A = Adult (white head);
U = Unknown.

SIGHT-MODE: Sighting Mode:

V = **V**isual sighting or seen *before* being picked up on receiver;
T = Located by **T**elemetry, bird never seen;
F = Used telemetry to **F**ind bird visually;
C = Visual sighting of non-radioed bird seen because near radioed bird;
R = Bird's position verified by **R**adio communication with another person;
X = Could not visually or telemetrically locate radio-tagged eagle.

TIME: Enter time (in 24-hour clock) that activity or observation begins.

END: Enter time activity ends or observation is terminated. Enter Secchi disk readings in centimeters with data type SEC. *Example*: 45 cm = 0045.

BREAK:

X = Observation terminated at END time and activity is still in progress.
V = Bird flies from view, disappears at end time.
Y = See next observation.

RIVER: Refers to waterways with designated kilometer segments.

SA = Salt River	TO = Tonto Creek	VE = Verde River
AF = Agua Fria River	BW = Bill Williams River	Etc.

TERRITORY: *Always* enter letter designation as follows:

B = Ash	I = Cliff	Q = Lone Pine	Y = Table Mt.
C = Bartlett	K = Coolidge	R = Mule Hoof	Z = Orme
D = Blue Point	L = East Verde	T = Pinal/Pinto	1 = Alamo
E = Canyon	M = Fort McDowell	V = Redmond	2 = Ive's Wash
F = Cedar Basin	5 (N) = Horse Mesa	W = "76"	3 = Pleasant
G = Chino	O = Horseshoe	X = Sheep	T (7) = Salome
H = Cibecue	P = Ladders	6 = Devil's Post	9 = San Carlos

SEGMENT: *Never leave SEG blank.* There are five ways segment can be entered:

1. **On a river:** Enter kilometer in which the activity takes place. For example, if a bird is perched at kilometer 36.7, the segment is 036. (Kilometer, the next column, is exact location, 036.7).

2. **On a reservoir or lake:** If activity takes place along the main channel, river kilometer is used. If activity takes place close to shore, and LAKE-LOC (Shoreline Kilometer = SKm) is appropriate, then SEGMENT is 997, and LAKE-LOC (SKm) is filled in appropriately.

3. **Off the water courses:** SEGMENT code is 998 and designate a UTM location in comments.

4. **In area with invented segment (zone):** See lists of standardized zone codes or invent new ones (codes must be in 900 range) and enter in master file. Do not worry about duplicating zone codes between territories but avoid duplication within territories. These codes are often used for birds in motion or when telemetry locations are not exact. *Use only if you can't put bird into Km section.*

5. **None of the above work:** Use 998 = See comments. Describe in comments.

Generic zone codes:

444 = Unable to locate bird.
777 = On river, but exact location is unknown.
888 = On reservoir, but exact location is unknown.
904 = Nest cliff area.
997 = See LAKE-LOC (shoreline kilometer = SKm).
998 = See notes.

KILOMETER: River kilometer (Km). Location of bird to nearest one-tenth kilometer.

TRIBUTARY: First 2 letters of tributary. *Example:* PI = Pinal Creek, PC = Pinto Creek. Fill in only if eagle is along the tributary. Then *kilometer* refers to the kilometer along the tributary.

LAKE-LOC: Reservoir shoreline location (SKm). See how maps are marked to decide whether resolution will be to the nearest 0.2 or 0.5 km of reservoir shoreline.

SIDE: River side, facing downstream:

L = Left
R = Right
I = Island
C = Channel.

ACTIVITY: *Always* fill in. If unknown, enter telemetry pulses per 15 secs, if steady.

P- = perched
PP = perched, preening
PD = perched, wings drooped
PW = perched, wet
PV = perched, vocalizing
P2 = perched, watching H_2O
PH = perched, hunting
PR = perched, roosting
PF = flushed from perch
PO = perched, other
PK = perched with prey
SW = standing in water
SS = standing on shore
SG = standing on ground
SB = standing, bathing
SO = standing, other

F- = flying
FG = flying, gliding
FB = flying < 10 m over land
FH = flying > 10 m over land
FW = flying < 10 m over water
FM = flying > 10 m over water
FR = flying to river
FA = flying away from river
FT = flying among trees
FF = flying carrying food
FS = flying carrying stick(s)
QS = perlustration (flying, scrutinizing)
FN = flying with nest lining
FP = flying perch to perch

ET = eating, in tree
ES = eating, on shore
EG = eating, on ground
EW = eating, in water
EN = eating in nest
EC = eating on cliff
EO = eating, other
NI = in nest, incubating posture
NS = standing in nest
NB = in nest, brooding posture
NR = on nest rim
NL = in nest, lying down
NF = in nest feeding young
NM = nest maintenance
NE = incubation exchange
NO = nest, other
S- = soaring
S2 = soaring over water
SL = soaring over land
SR = soaring along ridge
SU = soaring, unspecified
QC = prey capture
QF = carrion forage
QM = prey missed
QH = prey cached
QP = prey pirated
QD = prey delivered
QK = prey unknown

TP = telemetry, perched
TF = telemetry, flying

ACTIVITY, continued:

FV = flying, vocalizing
FC = flying, chasing
FE = flying, escaping
FL = flying, head down, looking
FO = flying, other
FU = flying upstream
FD = flying downstream
FQ = flying rapidly
FX = flying, interacting with other eagle in flight
FE = flying, aerial scrutiny of foraging site, perlustrating

TS = telemetry, soaring
TI = telemetry, prob. incub/brooding
TV = telemetry, variable
TX = telemetry, *could not locate*
NA = normal activities around nest
EG = egg laying
CO = copulating
CL = perched very close to mate
II = interspecific interaction
DW = drinking
WB = weird behavior (see comments)
W- = walking

Note: If activity was a forage, activity will be one of the Q codes. For any Q code, a forage form or prey delivery form must be completed.

PERCH: Perch type. *Researchers*: specify new codes as needed.

CA = conifer, old growth tree
CB = conifer, second growth
CS = snag-top conifer
SN = snag
HS = hard snag (only main branches left)
SS = soft snag
DA = deciduous, large
DB = deciduous, medium
DC = deciduous sapling
SD = snag-top deciduous
PO = other (comments)
ML = mesquite (live)
MS = mesquite snag (dead or bare)
SL = shrub, unidentified (live)
SS = shrub, unidentified (dead)
CL = cottonwood, large
SY = sycamore

BA = cut bank
CF = cliff ledge
CT = cliff top
CV = cliff face vegetation
PT = pinnacle top
PF = pinnacle face
BO = boulders
SH = shore
SB = sand bar
CC = cactus
PV = palo verde
ST = stump or stick
WP = woodpile
HV = hillside vegetation
NE = nest
JU = juniper, live
JS = juniper snag

SHADE: Is the bird perched in the shade?

N = No
Y = Yes
P = Partial Shade
U = Unknown

Only fill out on clear days. For DATA TYPE = NSC, enter data for the nest rather than the bird. Nest shade checks should be done once per sample week. Enter a data string for each transition from sun to partial shade to shade, or as appropriate. Use TIME and END.

DIST-H_2O: Estimated horizontal distance from perch to water; use codes:
1 = 0–25 m; **2** = 26–50 m; **3** = 51–100 m; **4** = 101–200 m; **5** = 201–500 m; **6** = > 500 m

ELEVATION: Estimated vertical elevation of perched eagle above water/substrate:
1 = < 1 m **2** = < 10 m **3** = 11-30 m **4** = 31-50 m **5** = > 51 m

HABITAT: Identification of river habitat near the eagle is especially important. When eagle is using habitat near water use the appropriate river or reservoir code instead of a terrestrial code unless eagle is foraging on land. For example, bird is perched on cliff over river pool: enter PO because data on perch is entered under perch. Develop more codes as appropriate.

PO = river pool (slow, smooth, nearly zero slope)
RI = riffle (fast, shallow, moderate slope, turbulent, exposed substrate)
RU = run (moderate current, non-turbulent surface, moderate slope)
PW = pocket water (boulder strewn, habitat dissociated, moderate slope)
CA = cascade (very steep slope over short distance)

RB = river bend	CL = cliffs	TA = talus
BW = backwater	UP = upland	RO = river (unspecified)
FL = farmland	RX = river (other, see comments)	
MB = mesquite bosque	RE = reservoir	WT = willow thicket
RC = reservoir cove	TT = tamarisk thicket	RS = reservoir shallows
DM = drowned mesquite area	IR = island in reservoir	
CW = cottonwoods	TE = terrestrial (unspecified)	
IF = inflow headwater of reservoir	CF = coniferous forest	
TR = tailrace of dam	XX = other (see comments)	
PN = pond		

OBSERVER: Enter initials of observer of events recorded in this string.

OBS-LOC: Observer Location. Develop 2-digit codes to identify. Some codes are:

95 = researcher in blind		96 = researcher in road vehicle
97 = nest view	98 = boat	99 = see notes

Make a list of codes specific to your territory and give a copy to supervisor. Do not worry about duplicating OBSLOC numbers between territories, but avoid duplication within a territory.

DIST-OBS: Closest horizontal distance (m) from *observer* to eagle before flushing; fill out even if it doesn't flush unless greater than 200 m.
1 = < 25 m; **2** = 26-50 m; **3** = 51-100 m; **4** = 101-200 m; **5** = 201-500 m; **6** = > 500 m.

RESP-OBS: Response to *observer* (remember to enter N if no response):

W = watching	U = flush upstream	I = activity interrupted
F = flush (see comments)	D = flush downstream	V = vocalize briefly
R = flush toward river	L = flush, leaves area	E = vocalize extensively
A = flush away from river	P = flush to perch	
N = no response		

WEATHER:

CL = clear (less than 20% clouds)	SP = sprinkle (intermittent, light)
HO = high thin overcast	RA = rain (steady, moderate)
PC = partly cloudy (21-70% dense clouds)	SH = shower (intermit., moderate)

WEATHER, continued:

OC = overcast (more than 80% clouds)	HR = heavy persistent rain
FL = light fog (visibility 100–440 m)	SL = sleet
FW = fog over water only	HA = hail
FO = dense fog (visibility less than 100 m)	SN = snow
DR = drizzle/mist (steady, light)	TS = thunderstorm (heavy, intermit.)

TEMPERATURE: Approximate temperature in degrees Fahrenheit (enter Secchi temperature here in degrees Fahrenheit):

−2 = minus 20s	+1 = plus 10s
−1 = minus 10s	+2 = plus 20s (etc.)
−0 = minus 1s	+9 = plus 90s
+0 = plus 1s	H+ = greater than 100 degrees

WIND SPEED:

C = calm	< 5 knots (<6 mph)	
L = light	6–10 knots (7–12 mph)	(you couldn't get a kite up easily)
M = moderate	11–20 knots (13–23 mph)	(you could get a kite up easily)
S = strong	21–35 knots (24–40 mph)	(hold on to your paperwork!)
G = gale	36+ knots (>40 mph)	(windier 'n heck!)

ENTRY NUMBER: To be filled in later, during computer entry.

COMMENTS: Write comments next to the letter designation for the data string. *Summarize the data string*. Concisely describe anything of interest, especially foraging, interactions (or lack of interaction) with eagles or other creatures, human–eagle interactions, crop condition, etc. Briefly describe behavior and duration. Could you read the VID band? Try to limit notes to 120 spaces. If you have additional notes in your field journal enter SN = "See Notes." Be sure that the time in the margin of your notes = TIME on the ObsForm and that you flag your notes with "C" (for Comments). String summaries in Comments are very valuable, so do not neglect them.

PUB-USER: Number of Public Users within 100 m of eagle or otherwise affecting eagle. Fill out for *all* low-flying aircraft. One boat, one vehicle, or one person walking *each* equal one public user.
9 = *nine or more* public users.

DIST-PU: Closest horizontal distance (m) from Public User to eagle before flushing (fill out even if it doesn't flush). Fill out only if PUB-USER is filled out.
1 = < 25 m; **2** = 26–50 m; **3** = 51–100 m; **4** = 101–200 m; **5** = 201–500 m; 6 = > 500 m.

RESP-PU: Response to public user. Remember to enter N if no response:

F = flush (see Comments)	P = flush to perch
V = vocalize briefly	R = flush toward river
W = watching	E = vocalize extensively
A = flush away from river	I = activity interrupted
N = no response	U = flush upstream
X = unknown	D = flush downstream
S = probable avoidance of area	L = flush, leaves area
C = certain avoidance of area	

TYPE-PU:

1 = fishing
2 = camping
3 = hiking
4 = picnicking
5 = swimming
6 = boating
7 = water skiing
8 = driving
9 = birding/photo
10 = researcher
11 = agency worker
12 = hunting
13 = logging
14 = mining
15 = construction
16 = power company
17 = shooting
18 = flying
19 = tubing
20 = cycling
21 = orv (unspecified)
22 = sonic boom
23 = rafters or farming
24 = woodcutting or jet ski
25 = dogs (domestic)
26 = cattle
98 = unknown
99 = other (comments)

MODE-PU:

1 = on foot, open view
2 = on foot, veg. buffer
3 = swimming
4 = wading
5 = boat, non-motorized
6 = motor boat, drifting/stopped
7 = motor boat, using motor
8 = auto, moving
9 = auto stopped, people inside
10 = auto stopped, people outside
11 = auto, off of road
12 = auto parked, empty
13 = auto with boat trailer
14 = motorcycle, on road
15 = motorcycle, off road
16 = 4-wheel drive (off of road)
17 = airplane
18 = helicopter
19 = auditory (explosion, gunshot)
20 = logging operation
21 = mining operation
22 = construction
23 = power company activity
24 = ATC
25 = low level flight (military)
26 = low level flight (civil)
27 = jet ski
28 =
29 =
99 = other (see Comments)

POSIT-PU: Position of public user:

R = river channel, reservoir body
S = along shore in water
L = along shore on land
I = island
G = gravel bar, dry river bed
W = within 100 m of shore, open view
V = wthn 100m shore, veg
M = more than 100 m from buffer
A = air
N = near nest
X = other (see comments)

DISTPU-H_2O: Estimated horizontal distance of public user to water; use codes:
1 = 0–25 m; **2** = 26–50 m; **3** = 51–100 m; **4** = 101–200 m; **5** = 201–500 m; **6** = > 500 m.

SIDE-PU: Side of river public user is on: (looking downstream)

L = left R = right I = island C = channel

E8.2 BANDING AND TELEMETRY

Banding and radio-telemetry have been valuable methods for studying the ecology of Arizona bald eagles. Banding nestlings with Visual Identification (VID) bands (see below) allows for future identification of an eagle throughout it's life, and upon death if the band is recovered. 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 also allows us to monitor replacement and infer mortality within the adult pair.

By radio-tagging nestlings, we learned about post-fledging habitat use, migration patterns, and mortality. In addition, we obtained information on the habitat use of the non-breeding segment of the Arizona bald eagle population by capturing and radio-tagging subadult and near-adult eagles, and by monitoring the telemetered juveniles after they returned from migration, and in their first 1–2 years of life.

In this study, we obtained vital information on the ecology of bald eagles in Arizona (1986–1989) by capturing breeding adult bald eagles for banding and radio-tagging. These telemetered adults provided information on foraging ecology, home range, movements in the non-breeding season, and mortality. By following the eagle's diel movements, we studied habitat selection within territories.

E8.2.1 Color Banding Program

BioSystems developed a color banding program in order to monitor the survival of individual nestlings and to provide a means of detecting changes in adult tenure at bald eagle breeding areas (see Section C6). We banded nestlings, subadults (1–3 years old), and near-adults (ca. 4 years old) with color-anodized aluminum VID bands on the left tarsus, and silver (aluminum) USFWS bands on the right. Breeding adult bald eagles captured from 1987–1989 were banded with VID bands on the right tarsus, and USFWS bands on the left. However, some captured near-adult and adult 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 can be read at considerable distances with Questar and other telescopes.

A single unique symbol was engraved in four locations around each VID band. We used black VID bands for breeding adults, red for subadults and near-adults, blue for 1987 nestlings, green for 1988 young, and purple for 1989 eaglets (see Figure E8-2). Beginning in 1990, blue VID bands with two symbols, one above the other, were placed on nestlings. We also banded nestling bald eagles on the Rio Yaqui, Sonora, Mexico, as part of a study being conducted by Dr. Bryan Brown in cooperation with the Mexican government and the USFWS. Mexico eaglets were banded with USFWS bands on the right tarsus and gold VID bands on the left.

During the years of our study, we chose single symbols, rather than combinations of several letters and numbers, because of the greater size of single symbols and because of the reduced implication of observer projection that the symbol is necessarily a letter or a number in normal configuration. Instead, we used letters, numbers, and other symbols (e.g., hearts, diamonds) in both normal, backward, and upside-down configurations.

E8.2.2 Radio Transmitters

We utilized three types of transmitters on Arizona eagles from 1987 to 1989. Most eagles were fitted with BioTrack 64-gram backpack transmitters having an expected three-year battery life and a mercury-

triggered activity switch. Actual life of BioTrack transmitters varied from 10 months to 2.5 years. We also used Telonics S2B5 MOD-200 65-gram backpack transmitters having an 18-month battery life and a mercury-triggered activity switch. Actual transmitter life for Telonics transmitters varied from two weeks to 18 months. In addition, we placed a Telonics RB5 MOD-050 28-gram tubular backpack transmitter with a four-month battery life on a juvenile bald eagle in 1987. All three types of transmitters emitted an adequate signal.

A telemetry company predicted having a satellite transmitter manufactured at a weight light enough for an eagle to carry prior to the completion of our study; however, the transmitter produced was bulky and weighed far more than that we consider appropriate for attachment to bald eagles. In our opinion, a transmitter of over about 90 grams is too heavy, particularly for a juvenile. For this reason, we did not place satellite transmitters on Arizona eagles.

Attachment of backpack telemetry transmitters followed procedures described by Garcelon (1985), utilizing 1.3 mm (0.5 in.) teflon ribbon and waxed cotton thread, with a 3.5-cm spacing between the transmitter and the eagle. On nestlings, however, we used a 5-cm spacing between the transmitter and

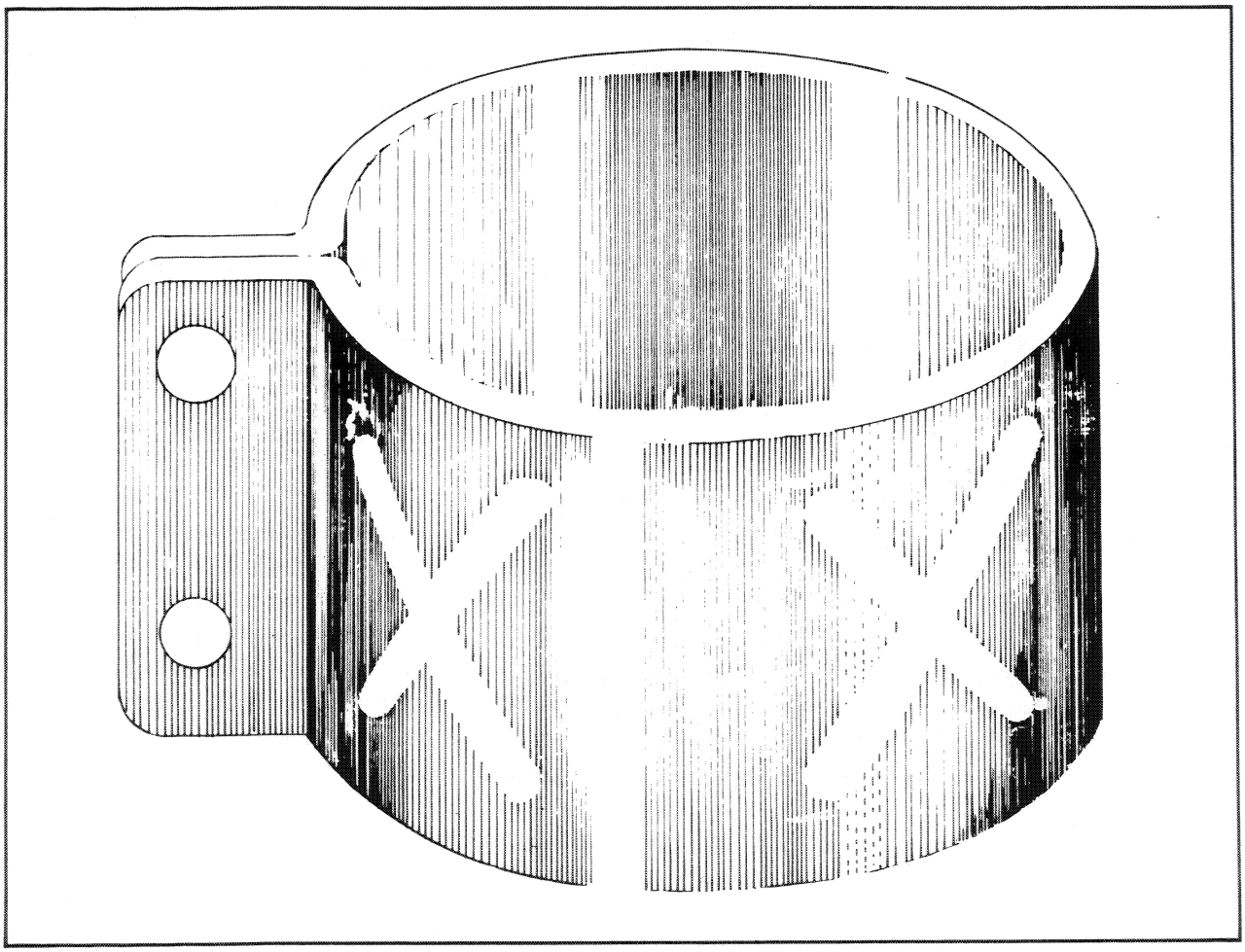


Figure E8-2. Diagram of visual Identification (VID) band used on Arizona bald eagles. Each band is engraved with a unique symbol.

the bird to accommodate future growth of the eaglet. Eaglets were radio-tagged at 9–10 weeks of age. The teflon ribbon was stitched with waxed cotton thread at the eagle's breast, and when the thread decomposes, the teflon ribbon will separate and the transmitter will fall off.

E8.2.3 Banding and Telemetry of Juveniles

Over the four years of this study, 1987–1990, 87 known young hatched in Arizona bald eagle nests. We banded 62 (81%) of the 77 eaglets surviving to six weeks of age. Arizona juveniles were banded with silver (aluminum) USFWS bands on the right tarsus and color-anodized VID bands on the left. Blue VID bands were used in 1987, green in 1988, and purple in 1989, each with a unique symbol engraved in four locations surrounding the band. Blue VID bands with two stacked symbols engraved in four places were used in 1990 and will continue to be used in Arizona in the future.

We also banded nestling bald eagles on the Rio Yaqui, Sonora, Mexico, in cooperation with Dr. Bryan Brown, the Mexican government, and USFWS. Mexico young were banded with USFWS bands on their right tarsus and gold VID bands on their left (Brown and Olivera 1988, Brown *et al.* 1989). In addition, we collected blood and feather samples from eaglets (see Section E8.2.7), and recorded mensural characteristics (see Section E8.2.8) on Juvenile Forms ("JuvForm") as shown in Figure E8-3.

In addition to banding, we radio-tagged 15 nestlings, at 8–10 weeks of age, in order to obtain data on migration, mortality, and movements of non-breeding bald eagles. Most young were fitted with BioTrack 64-gram backpack transmitters, although we telemetered one nestling with a Telonics 65 gram radio, and one with a Telonics 28 gram unit. See Section C6.1 for details on nestling bald eagles banded and radio-tagged during our study.

Adult and Eaglet Behavior During Banding Operations. We noted distinct patterns of adult and eaglet behavior when climbing Arizona bald eagle nests to band young. When the eyrie was approached, the adult(s) in attendance began circling the area and vocalizing with the chatter call or "territorial defense call." As we entered the nest, the eaglets usually reacted in one, or a combination of three ways: (1) spread their wings and hiss, or vocalize in low, raspy, quiet versions of the adults chatter call; (2) stand facing the climber in a normal upright posture; or, (3) lay on the nest watching the climber, but taking no defensive action. The third behavior was common in two or three chick nests, when another eaglet was reacting in an aggressive manner such as in the first description.

At this point, we began talking to the eaglets in a low voice, which usually calmed them down. The climber continued talking to the young, slowly moving closer and deciding the safest way to secure the nestlings. We took our time at this juncture, to let the eaglets calm down prior to reaching for them. If two or three eaglets were the nest, we secured them all at the same time to prevent one from panicking and possibly jumping. Once the young were secured, we placed leather falconer's hoods and polypropylene booties on them. The hood immediately calmed the eaglet, which usually drooped its head as if sleeping. The booties prevented the young from grabbing the nest material, and also from pushing on the nest to escape, yet allowed the eaglet to stand in a normal manner.

By this time, the adults had usually perched somewhere and were quietly watching as we processed the eaglets. The young were banded and measured, prey remains and eggshell fragments collected, and the nest checked for parasites and monofilament or other hazards. The nestling not being handled also remained quiet (as if sleeping), and most young were docile while handled. On hot days, we hydrated

Figure E8-3. Juvenile bald eagle data form—"JuvForm".

BREEDING ADULT	USFWS	Left
	VID	Right
ALL OTHER EAGLES	USFWS	Right
	VID	Left

JUV FORM

Date _____

Bird Number _____ Bird Name _____
Breeding Area _____ Sex: Male, Female, Unknown
Nest Number _____ Estimated Age _____
Personnel _____
Climbing Technique _____
Time: Near Nest _____ Left Area _____ Total _____
Secured _____ Released _____ Total _____
Handling _____ Processed _____ Total _____
Blood Sample (cc) _____ Wing: Right, Left
Feather Sample Location _____ Wing: Right, Left
USFWS Band Number _____ Color _____ Leg: Right, Left
Visual ID Band Symbol _____ Color _____ Leg: Right, Left
Transmitter: Type _____ Position _____
Number _____ Frequency _____
Pulse (Beats/Min): Active _____ Perched _____

Measurements:	Right	Left
Hallux Length (mm)	_____	_____
Foot Pad Length (mm)	_____	_____
Tarsus Length (mm)	_____	_____
Tarsus Width - Dorsal/Ventral (mm)	_____	_____
Tarsus Width - Lateral (mm)	_____	_____
Wing Chord Length (cm)	_____	_____
Eighth Primary Length (cm)	_____	_____

Tail Length (cm): Tip To Sheath _____ Tip To Base _____
Culmen Length (mm) _____
Beak Depth (mm) _____
Weight (kg) _____
Crop: Full, Partial, Empty
Sternum: 1.0) Keel bladed - minimal breast muscle
1.5)
2.0) Keel bladed - more prominent breast muscle
2.5)
(Normal) 3.0) Keel protrudes slightly above breast muscle
3.5)
4.0) Keel flush with breast muscle
4.5)
5.0) Keel inundated in breast muscle

Color: Iris: Brown, Sepia, Other _____

Feet: Yellow, Pale Yellow, Other _____

Cere and Beak: Blackish-Grey, Other _____

Feathers:

WT White	BL Black	BR Brown
WD White Down	GD Grey Down	SP Sepia
GY Grey	GB Grayish Black	TN Tan
WF White Flecking	TE Tawny Edges	TW Tawny
WB White With Brown Mottling		
BW Brown With White Mottling		
Other - Write In Colors		

Head _____ Tail _____

Back _____ Breast _____

Abdomen _____

Upper Wings: Coverts ____ Primaries ____ Secondaries ____

Under Wings: Coverts ____ Primaries ____ Secondaries ____

Eggs: Whole - Collected # _____, None Found

Fragments - Collected # Sets _____, None Found

Prey Remains: In Nest - Collected, Not Collected, None Found

Below Nest - Collected, Not Collected, None Found

Nest Lining - Collected, Not Collected, None Found

Mexican Chicken Bugs - High, Moderate, Low, None Found

Foreign Matter: In Nest _____

Below Nest _____

Temperatures (C): Ambient _____

Nest Surface _____

10-12 cm Within Nest _____

Surface (Outside Nest) Exposed To Sun _____

Comments _____

_____

_____

the eaglets with 20-25cc of water prior to leaving the nest. Hydrating the young may be especially important in Arizona where heat stress can have adverse effects on the eaglets throughout the nesting season (see Section C3.5).

When the young were released and the climbers began leaving the area, the adults left their perches and resumed vocalizing and flying around the area. Some adults continued this behavior until we were out of sight. The time period for adult(s) to return to the nest varied between pairs, likely influenced by age of the eaglets, time since the last prey delivery, and individual tolerance levels of the adult eagles. If the young were older or had been recently fed, the adults tended to stay away from the nest longer. Adults returned to the nest from four minutes to eight hours after banding climbs. Although in isolated cases a nest climb disrupted the adult's usual behavior pattern for the remainder of the day, the eagles always returned to their normal procedures the following day.

Climbing nests to band young may be the most lengthy disturbance at a breeding area in any one season. However, 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 cases of severe disturbance 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, has 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 (Driscoll 1985, Driscoll and Buckley 1986). Climbing the nest to band young at six weeks of age presents no threat to the eaglets or the success of the nest (see Section C2.2). In most instances, we climbed nests in the morning and the eagles were 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) indicated that climbing nests to band Arizona eaglets had an adverse effect on productivity the following year, our data show no such correlation, and even suggest a stronger nest site tenacity the following year (see Section C2.2). Our findings are concurrent 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."

E8.2.4 Banding and Telemetry of Subadults and Near-Adults

Prior to our study, no Arizona bald eagles had been banded or telemetered as subadults (1–3 years old) or near-adults (ca. 4 years old). From 1987–1989 we captured five subadult and three near-adult bald eagles in Arizona. We banded the non-breeding eagles with red VID bands on the left tarsus and silver (aluminum) USFWS bands on the right. Each eagle was also radio-tagged with a BioTrack 64 gram backpack transmitter. See Section C6.2 for details on subadult and near-adult bald eagles banded and radio-tagged during our study.

E8.2.5 Banding and Telemetry of Breeding Adults
Prior to our study, no Arizona bald eagles had been banded or telemetered as adults. During 1987-89 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. Two pairs of eagles were captured (at the Ladders and Horseshoe territories) to study the comparative habitat and prey utilization between the sexes. Adults were banded with black VID bands on the right tarsus and silver (aluminum) USFWS bands on left. However, some captured eagles had been banded as nestlings in previous studies (see Section C6.1), in which case we placed the VID band on the tarsus opposite the USFWS band. Each adult was also radio-tagged with a BioTrack 64 gram or Telonics 65 gram backpack transmitter. Three adults were later recaptured, two of which we fitted with new transmitters. See Section C6.3 for details on adult bald eagles banded and radio-tagged during our study.

E8.2.6 Eagle Captures
Prior to BioSystems' research on Arizona bald eagles (1986–1990), no Arizona bald eagles had been captured, banded, or telemetered, with the exception of banding eaglets (six of which were radio-tagged) in the nest (see Section C6). In order to study the ecology of bald eagles in Arizona, BioSystems captured breeding adult bald eagles for banding and radio-tagging. Upon capture, eagles were banded with VID bands on one tarsus and silver (aluminum) USFWS bands on the other (see above). We also fitted each eagle with a 64-gram BioTrack or 65-gram Telonics backpack transmitter, collected blood and feather samples (see Section E8.2.7), and recorded mensural characteristics (see Section E8.2.8). These telemetered adults provided information on foraging ecology, home range, movements in the non-breeding season, and mortality. By following the eagle's diel movements, we studied habitat selection within territories. In addition, we captured near-adults, subadults, and juveniles to study the migration patterns, movements, survivorship and ecology of the native population of non-breeding bald eagles in Arizona.

BioSystems' biologists utilized a variety of techniques to capture bald eagles, including a radio-controlled bow net, a radio-controlled power snare, and noosed fish. In addition, USFWS biologist (and eagle capture expert) Mike Lockhart introduced us to the technique of decoy eagles. Each of these techniques was used in conjunction with a blind, so trappers could get to the eagles within seconds of capture. The only exception was noosed fish used on reservoirs where we used a boat positioned at a suitable distance from the set.

E8.2.6.1 Radio-controlled Bownet. The radio-controlled bald eagle bownet was designed and built by Ron Jackman and Grainger Hunt (BioSystems Analysis, Inc.). The bownet is basically two semicircles of light metal, with netting between. One semicircle is anchored to the ground, and the other (when triggered) comes over the target animal, enclosing it in a dome of net when the circle is completed. Bownets have been used to capture raptors since medieval times, and have been modified through the years to trap various species (Bloom 1987). However, most bownets in the past have been manually operated by pulling a string from a blind. Jackman and Hunt made a major improvement in the bownets design by using garage door springs to power the net (Jackman *et al.* in prep.). The springs can be adjusted to control the speed of the bow, and create a fast enough trap to successfully capture the wary bald eagle. The radio-controlled bownet is an extremely effective bald eagle trapping technique, which allows for the selective capture of target individuals.

E8.2.6.2 Radio-controlled Power Snare. Due to the rugged terrain and the potential hiking distances necessary to capture adult bald eagles at some of the remote breeding areas in Arizona, we needed a very light trap with the effectiveness of the bownet. The radio-controlled power snare was designed and built

by Ron Jackman and Grainger Hunt (BioSystems) specifically to capture bald eagles in the rugged terrain of the remote Arizona territories. Our radio-controlled power snare was based on a manually operated snare system developed by Hertog (1987) for capturing white-bellied sea-eagles in Australia. The snare is nylon coated fishing leader placed around a bait fish or mammal, which closes around the eagles legs when triggered. The power snare is a very intricate trap, however, and if not set up properly will fail to catch the target bird. The power snare can be used on land or in shallow water, and has proved to be an extremely effective bald eagle trap (Jackman *et al.* in prep.).

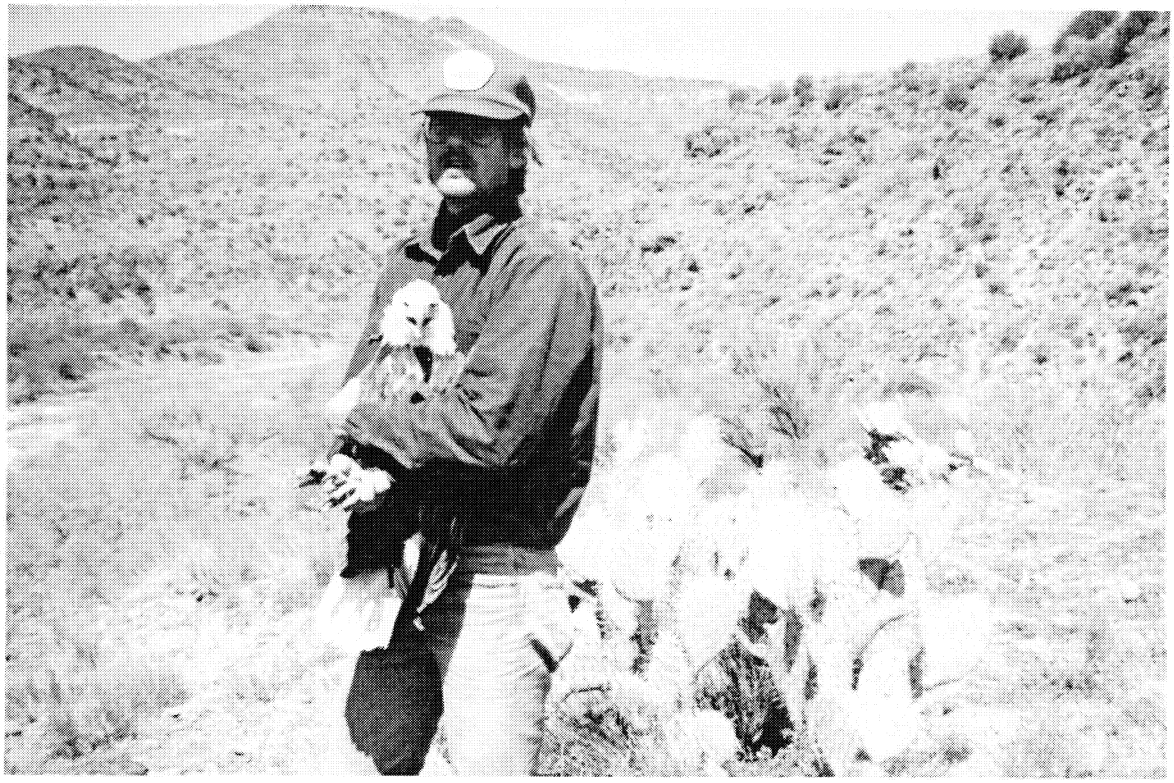


Plate E18. Ron Jackman with the East Verde male bald eagle just before release, March 1987 (photo by D. Driscoll).

E8.2.6.3 Noosed Fish. The technique of noosed fish was first used successfully by Robards (1967) and improved by Cain (1989) to capture bald eagles in Alaska. BioSystems learned the technique from Leonard Young and Richard Frenzel in 1983, and used it successfully on the Pit River in California to capture adult and subadult bald eagles. The set is a dead fish, stuffed with styrofoam so it will float belly up. Monofilament nooses are then attached so they will close on the eagle's toes when it grabs the fish. The monofilament line is fastened to shock chord, then attached to a piece of drift wood (floating set, especially used in oceans or deep water) or anchored to the bottom (stationary set). When the anchored set is used, this technique requires examination of water depths in the vicinity, with special attention to shelves, slopes, and drop-offs. The floating set must be constantly monitored, since it could drift away and become a hazard to other eagles or ospreys.

The number of nooses varies with trappers, and it appears some arrangements are more effective in certain regions than others. For instance, Cain (1989) describes a four-noose clover-leaf arrangement

using herring for bait. This combination is very effective for capturing bald eagles in Alaska (R. Hunter pers. comm., Driscoll unpublished field notes, P. Schempf pers. comm., T. Bowman pers. comm.). However, the bait fish used varies with the prey species normally taken by eagles in a particular area, and arrangements work differently with different species and sizes of fish (Jackman *et al.* in prep.). The nooses are designed so if the eagle is not captured, the fish slides off the noose line, and the bird is rewarded with its catch.

In areas such as Alaska where eagles are numerous, nesting sites are close together and competition for the food resource is high; the eagles take the bait faster, and appear to grab it harder, using a larger portion of their foot to secure the prey (Driscoll unpublished field notes). This stands to reason, since the eagle would have a greater chance of protecting its food from a pirating neighbor if it had a good grip on the fish. In areas where eagles are less plentiful, pirating is less frequent, and there is less competition for the food resource (Arizona and parts of California), eagles tend to delicately pluck carrion fish from the water, using only the tips of their talons (Driscoll unpublished field notes, Jackman unpublished field notes). When an eagle takes a fish this gingerly (not actually grabbing it deeply or hard with their toes), the chances of capture are greatly decreased; often the noose closes around the talon and slides off. We devised many systems of noose configuration before finding several that led to a higher percentage of successful captures on certain species of bait fish (Jackman *et al.* in prep.).

E8.2.6.4 Decoy Eagles. During our research in Arizona, we had the pleasure of working with Mike Lockhart, USFWS. Mike is an eagle capture expert who invented the well known "Lockhart Method" of catching eagles using weakened and padded leg-hold traps. The weakened Number 3 leg-hold traps are wrapped with leather and taped to protect the eagle's toes. In contrast to the name, these traps capture the eagle by the toe, not the leg. The traps are placed around a dead mammal (on land) or fish (in shallow water) and concealed with dirt. Sponge is used under the pressure plate to prevent the capture of lighter, non-target animals such as gulls, ravens, and vultures. After catching and banding hundreds of golden eagles by this method during the 1970's, Lockhart discovered that eagles could easily remove the old USFWS crimp-on bands with their beaks (much to the demise of his banding study). Thus he is credited with identifying the need for the current rivet bands now used on bald and golden eagles.

Lockhart also used decoy eagles to attract wild eagles to his sets. These "lure eagles" are injured birds which have been rehabilitated, but are not releasable. Although only a few eagle experts are allowed to care for injured bald and golden eagles, this method is extremely effective when dealing with a target eagle that is "smarter" than the biologists trying to catch it. There is no detectible adverse effect on the decoy birds.

E8.2.6.5 Discussion. Each of the above techniques requires special habitat characteristics for its use. In addition, expertise and foresight are necessary to insure the trapping situation is safe for the eagles and the operators. Capturing and handling bald eagles requires extreme patience, attention to detail, and concern for the eagle's safety under all possible circumstances. In all cases, we found traps to be the most effective when fresh bait was used. If a large carcass (road-killed deer) was used as bait, we could place sets on a small portion, simply by exposing the meat. The eagles always went to the site of exposed meat first, ignoring the larger skin-covered carcass. This was valuable knowledge, since a large carcass can be used to attract numerous non-breeding eagles. Details on the design, construction, and effectiveness of the bald eagle capture techniques used by BioSystems are presented in Jackman *et al.* (in prep.).

The safest method is noosed fish, since the captured eagle just floats on the water and is easily picked up, with virtually no chance for injuring itself. Since fish are normal eagle prey and can be taken on the wing, eagles are easily lured to these sets; however, the method is not selective. The radio-controlled power snare is likely the second safest technique, followed by the radio-controlled bownet, and both of these have the advantage of being selective. Thus, if the adult female came to the set, and we wanted to catch the male, we could let her feed without triggering the trap. Both of these methods are extremely successful, but it is more difficult to lure an eagle to a set where it must land on the ground to feed. The decoy eagle technique is also very successful, and the presence of the eagle usually keeps non-target animals such as ravens, vultures, or gulls away from the set; however, this method is not selective.

E8.2.7 Bald Eagle Samples

For each eagle handled, we collected feather samples, clipped from the distal 3 cm of a tail, back, or upper wing covert feather, for trace element analysis. All feather samples are on deposit at the Western Foundation of Vertebrate Zoology in Camarillo, California. In addition, blood samples of up to 5 cc were drawn from the brachial vein for DNA restriction fragment length polymorphism studies (see Section E7), electrophoresis of enzymes, and contaminant analysis.

E8.2.7.1 Blood Samples. From 1987 to 1989, we collected blood samples from 73 bald eagles; 13 Arizona breeding adults, three near-adults (ca. 4 years old) (two of unknown origin and one Arizona bird—banded), five subadults (ca. 1–3 years old) of unknown origin, 46 Arizona juveniles, and six juveniles from Mexico. Blood samples were separated into three vials and sent to: (1) Dr. Jonathan Longmire (Los Alamos National Laboratory) for DNA restriction fragment length polymorphism studies; (2) Dr. Donald Morizot (University of Texas) for electrophoresis of enzymes; and, (3) the U.S. Fish and Wildlife Service for contaminant studies. The results of the electrophoretic and DNA fingerprinting analyses are given in sections A5.2 and C8.

In 1987, we collected blood samples from 22 bald eagles in Arizona (Table E8-1). Six blood samples were taken from five individual adult eagles (two recaptures), one from a subadult (ca. 3 years old) which was rehabilitated for a broken wing, and 15 from the 20 nestlings banded in 1987. Blood was not drawn from the two Orme eaglets because they appeared too stressed, or three Horseshoe young, which were banded and measured on the nest ledge by only one climber (it takes two people to draw blood).

We collected blood samples from 30 bald eagles in 1988 (Table E8-2). Blood samples were taken from five breeding Arizona adults, two near-adults (one banded as a nestling in 1984 at the East Verde breeding area and one of unknown origin), and 19 Arizona nestlings. Blood was also collected from four nestlings on the Rio Yaqui, Sonora, Mexico.

Bald eagle blood samples were collected from 21 individuals in 1989 (Table E8-3). Blood samples were taken from two of three breeding Arizona adults. An adult male (AM07), from the Cibecue territory, was rehabilitated after a broken wing, and we later recaptured him on Roosevelt Reservoir (only one sample was drawn). We took blood samples from a near-adult and four subadults captured in the winter, while attempting to radio-tag the Ladders male, although some of the eagles were very large and appeared to be from northern populations. Blood samples were collected from 12 Arizona nestlings, and two nestlings on the Rio Yaqui, Sonora, Mexico 1989).

E8.2.7.2 Feather Samples. From 1987 to 1989, we collected feather samples (3 cm clipped from the tip of a single tail, back, or upperwing covert feather) from 77 bald eagles; 15 Arizona breeding adults, three near-adults (ca. 4 years old, two of unknown origin and one Arizona bird banded), five subadults (ca. 1–3 years old) of unknown origin, 47 Arizona juveniles, six Mexico juveniles, and one Mexico adult found dead below the Hecho nest.

Table E8-1. Blood samples collected from Arizona bald eagles in 1987.

Breeding Area	Sex *	Number	Blood (cc)
Adults			
Pinal	F	AF01	2.5
Pinal	F	AF01	2.0
Blue Point	M	AM01	—
Blue Point	M	AM01	2.0
East Verde	M	AM02	3.0
Horseshoe	F	AF02	3.0
Pinto	F	AF03	5.0
Subadults			
San Carlos (non-breeding)	F	SF01	3.3
Juveniles			
Orme	M	JZ01	—
Orme	F	JZ02	—
Fort McDowell	M	JM03	3.5
Horse Mesa	M	J504	3.2
Horse Mesa	M	J505	3.0
Coolidge	M	JK06	3.2
Coolidge	M	JK07	3.4
Ladders	M	JP08	2.4
Ladders	M	JP09	3.3
Blue Point	M	JD10	3.2
Blue Point	M	JD11	3.0
Blue Point	F	JD12	2.2
Horseshoe	F	J013	—
Horseshoe	M	J014	—
Horseshoe	F	J015	—
Redmond	F	JV16	3.2
Redmond	M	JV17	3.2
Pinal	?	JT18	3.4
Pinal	?	JT19	3.2
East Verde	F	JL20	3.2

* Sexual differentiation based on body measurements. Sex known for adults.

Table E8-2. Blood samples collected from Southwest bald eagles in 1988.

Breeding Area	Sex *	Number	Blood (cc)
Adults			
Horseshoe	M	AM03	4.0
Bartlett	M	AM04	4.1
Ladders	F	AF04	3.5
Redmond	M	AM05	4.0
Cliff	M	AM06	3.5
Near-adults			
Salome Bay (Winter)	M	NM01	4.9
Salome Bay (Winter)	F	NF01	5.0
Arizona Juveniles			
Alamo	F	J121	5.0
Ladders	M	JP22	5.0
Ladders	M	JP23	5.0
Orme	M	JZ24	5.0
Ive's Wash	M	J225	5.0
Cliff	F	JI26	5.0
Cliff	M	JI27	5.0
Coolidge	M	JK28	5.0
Coolidge	M	JK29	5.0
76	F	JW30	5.0
76	F	JW31	5.0
Blue Point	M	JD32	5.0
Blue Point	M	JD33	5.0
Blue Point	F	JD34	5.0
Horseshoe	M	JO35	5.0
Lone Pine	M	JQ36	4.5
Lone Pine	M	JQ37	2.2
Redmond	F	JV38	5.0
Redmond	F	JV39	5.0
Mexico Juveniles			
Fig Tree	F	J-01	5.0
Fig Tree	F	J-02	5.0
Rio Sahuaripa	M	J-03	2.5
Rio Sahuaripa	M	J-04	5.0

* Sexual Differentiation based on body measurements. Sex known for adults.

Table E8-3. Blood samples collected from Southwest bald eagles in 1989.

Breeding Area	Sex *	Number	Blood (cc)
Adults			
Cibecue	M	AM07	5.0
Cibecue	M	AM07	—
Pinto	F	AF03	2.0
Ladders	M	AM08	—
Near-adults			
Ladders (Winter)	F	NF02	5.0
Subadults			
Ladders (Winter)	M	SM01	5.0
Ladders (Winter)	M	SM02	5.0
Ladders (Winter)	M	SM03	3.0
Ladders (Winter)	M	SM04	3.0
Arizona Juveniles			
Alamo	M	J140	5.0
Ive's Wash	F	J241	5.0
Ive's Wash	M	J242	3.0
Fort McDowell	F	JM43	5.0
Fort McDowell	F	JM44	5.0
East Verde	M	JL45	4.5
East Verde	F	JL46	5.5
Ladders	M	JP47	3.2
Ladders	M	JP48	3.5
Pinal	M	JT49	5.0
Bartlett	M	JC50	4.0
Bartlett	F	JC51	2.5
Mexico Juveniles			
Rio Sahuaripa	F?	J-05	5.0
Rio Sahuaripa	F?	J-06	5.0

* Sexual differentiation based on body measurements. Sex known for adults.

In 1987, we clipped the feathers of 25 bald eagles in Arizona (Table E8-4). Seven feather samples were taken from six individual adult eagles (two recaptures), one from a subadult (ca. 3-year-old) which was rehabilitated for a broken wing, and 17 from the 20 nestlings banded in 1987. Feather samples were not collected from the three Horseshoe young which were processed on the nest ledge by one climber.

We collected feather clips from 30 bald eagles in 1988 (Table E8-5). Feather samples were taken from five breeding Arizona adults, two near-adults (one banded as a nestling in 1984 at the East Verde breeding area and one of unknown origin), and 18 Arizona nestlings (one Lone Pine nestling only had pin-feathers when banded). Feather clips were also collected from four nestlings and one dead adult on the Rio Yaqui, Sonora, Mexico.

Bald eagle feather samples were clipped from 22 individuals in 1989 (Table E8-6). Feather samples were taken from three breeding Arizona adults (one recapture), a near-adult and four subadults of unknown origin (possibly northern birds), 12 Arizona nestlings, and two nestlings on the Rio Yaqui, Sonora, Mexico.

E8.2.8 Bald Eagle Measurements and Plumage Characteristics

From 1986–1990, we measured and recorded plumage characteristics of 100 bald eagles; 18 Arizona breeding adults, three near-adults (ca. 4 years old, two of unknown origin and one Arizona bird banded), five subadults (ca. 1–3 years old) of unknown origin, 64 Arizona juveniles, one Mexico adult, and nine Mexico juveniles. Body measurements recorded from Arizona bald eagles included hallux length, foot pad length, tarsus length, tarsus width (dorsal/ventral and lateral), wing chord length, eighth primary length, tail length, culmen length, and beak depth. Difficulty in measuring foot pad length accurately due to the eagles closing their feet, and concern over possible injury to toes, resulted in discontinuation of this measurement. Hallux length, culmen length, beak depth, wing chord length, eighth primary length, and tail length measurements followed Bortolotti (1984a), as did those for foot pad and tarsus length (Bortolotti 1984b). Tarsus width (dorsal/ventral and lateral) measurements followed Garcelon *et al.* (1985). Methods of tail length measurement varied from Bortolotti's to include length of the central retrices from the distal end to the sheath on juveniles. We recorded mensural characteristics and other data from nestlings on Juvenile Forms (JuvForms) (see Figure E8-3), and captured eagles on Capture Forms ("CapForm") as shown in Figure E8-4.

Sex was known for adult eagles, from observed copulations, and we found that we could use sexually dimorphic measurements in adults, to determine the sex of nestlings four weeks of age or older (Driscoll notes). Ages were known in some cases, from band recoveries in captured eagles or known hatch dates in nestlings; however, when not known, we estimated age based on plumage characteristics. Captured eagles not banded were aged according to known-age eagles from other populations (McCollough and Krohn 1986) and the plumage of known-age (banded) Arizona eagles (Driscoll notes). Similarly, in cases of unknown hatch dates, nestlings were aged by development and plumage of eaglets from other populations (Bortolotti 1984a, Bortolotti 1984b, Driscoll unpublished field notes) and that of known-age Arizona young (Driscoll notes).

We determined the physical condition of each bird on the basis of crop condition, body condition, and weight. Measurements of crop condition included three categories: full, partial, and empty. We measured body condition using a five-point scale based on breast muscle and sternum keel protrusion:

Table E8-4. Feather samples collected from Arizona bald eagles in 1987.

Breeding Area	Sex*	Number	Feather Clip**
Adults			
Pinal	F	AF01	Tail
Pinal	F	AF01	UWC
Blue Point	M	AM01	—
Blue Point	M	AM01	Tail
East Verde	M	AM02	Tail
Horseshoe	F	AF02	Tail
Pinto	F	AF03	UWC
Horse Mesa	M	5A02	Tail
Subadults			
San Carlos (non-breeding)	F	SF01	UWC
Juveniles			
Orme	M	JZ01	UWC
Orme	F	JZ02	UWC
Fort McDowell	M	JM03	UWC
Horse Mesa	M	J504	UWC
Horse Mesa	M	J505	UWC
Coolidge	M	JK06	UWC
Coolidge	M	JK07	UWC
Ladders	M	JP08	UWC
Ladders	M	JP09	UWC
Blue Point	M	JD10	UWC
Blue Point	M	JD11	UWC
Blue Point	F	JD12	UWC
Horseshoe	F	JO13	—
Horseshoe	M	JO14	—
Horseshoe	F	JO15	—
Redmond	F	JV16	Back
Redmond	M	JV17	UWC
Pinal	?	JT18	UWC
Pinal	?	JT19	UWC
East Verde	F	JL20	UWC

* Sexual differentiation based on body measurements. Sex known for adults.
** 3 cm clipped from tip of indicated feather. UWC = Upperwing covert.

Table E8-5. Feather samples collected from Southwest bald eagles in 1988.

Breeding Area	Sex*	Number	Feather Clip**
Arizona Adults			
Horseshoe	M	AM03	UWC
Bartlett	M	AM04	UWC
Ladders	F	AF04	UWC
Redmond	M	AM05	UWC
Cliff	M	AM06	UWC
Arizona Near-adults			
Salome (Winter)	M	NM01	UWC
Salome (Winter)	F	NF01	UWC
Arizona Juveniles			
Alamo	F	J121	UWC
Ladders	M	JP22	UWC
Ladders	M	JP23	UWC
Orme	M	JZ24	UWC
Ive's Wash	M	J225	UWC
Cliff	F	JI26	UWC
Cliff	M	JI27	UWC
Coolidge	M	JK28	UWC
Coolidge	M	JK29	UWC
76	F	JW30	UWC
76	F	JW31	UWC
Blue Point	M	JD32	UWC
Blue Point	M	JD33	UWC
Blue Point	F	JD34	UWC
Horseshoe	M	JO35	UWC
Lone Pine	M	JQ36	UWC
Lone Pine	M	JQ37	—
Redmond	F	JV38	UWC
Redmond	F	JV39	UWC
Mexico Juveniles			
Fig Tree	F	J-01	UWC
Fig Tree	F	J-02	UWC
Rio Sahuaripa	M	J-03	UWC
Rio Sahuaripa	M	J-04	UWC
Mexico Adults			
Hecho	M	A-01	UWC

* Sexual differentiation based on body measurements. Sex known for adults.

** 3cm clipped from tip of indicated feather. UWC = upperwing covert.

Table E8-6. Feather samples collected from Southwest bald eagles in 1989.

Breeding Area	Sex*	Number	Feather Clip**
Adults			
Cibecue	M	AM07	UWC
Cibecue	M	AM07	—
Pinto	F	AF03	UWC
Ladders	M	AM08	UWC
Near-adults			
Ladders (Winter)	F	NF02	UWC
Subadults			
Ladders (Winter)	M	SM01	UWC
Ladders (Winter)	M	SM02	UWC
Ladders (Winter)	M	SM03	UWC
Ladders (Winter)	M	SM04	UWC
Arizona Juveniles			
Alamo	M	J140	UWC
Ive's Wash	F	J241	UWC
Ive's Wash	M	J242	UWC
Fort McDowell	F	JM43	UWC
Fort McDowell	F	JM44	UWC
East Verde	M	JL45	UWC
East Verde	F	JL46	UWC
Ladders	M	JP47	UWC
Ladders	M	JP48	UWC
Pinal	M	JT49	UWC
Bartlett	M	JC50	UWC
Bartlett	F	JC51	UWC
Mexico Juveniles			
Rio Sahuaripa	F?	J-05	UWC
Rio Sahuaripa	F?	J-06	UWC

* Sexual differentiation based on body measurements. Sex known for adults.
** 3 cm clipped from tip of indicated feather. UWC = upperwing covert.

Figure E8-4. Bald eagle capture form—"CapForm".

BREEDING ADULT	USFWS	Left
	VID	Right
ALL OTHER EAGLES	USFWS	Right
	VID	Left

CAP FORM

Date _____

Bird Number _____ Bird Name _____
Breeding Area _____ Sex: Male, Female, Unknown
Capture Location _____
Estimated Age (Years): Adult, 5.5, 5.0, 4.5, 4.0, 3.5, 3.0
2.5, 2.0, 1.5, 1.0, Other _____
Personnel _____
Capture Technique _____
Portion Of Body Captured _____
Time: Captured _____ Secured _____ Released _____
Handling _____ Total _____
Blood Sample (cc) _____ Wing: Right, Left
Feather Sample Location _____ Wing: Right, Left
USFWS Band Number _____ Color _____ Leg: Right, Left
Visual ID Band Symbol _____ Color _____ Leg: Right, Left
Transmitter: Type _____ Position _____
Number _____ Frequency _____
Pulse (Beats/Min): Active _____ Perched _____

Measurements:	Right	Left
Hallux Length (mm)	_____	_____
Foot Pad Length (mm)	_____	_____
Tarsus Length (mm)	_____	_____
Tarsus Width - Dorsal/Ventral (mm)	_____	_____
Tarsus Width - Lateral (mm)	_____	_____
Wing Chord Length (cm)	_____	_____
Eighth Primary Length (cm)	_____	_____

Tail Length (cm) _____
Culmen Length (mm) _____
Beak Depth (mm) _____
Weight (kg) _____
Crop: Full, Partial, Empty

Sternum:
1.0) Keel bladed - minimal breast muscle
1.5)
2.0) Keel bladed - more prominent breast muscle
2.5)
(Normal) 3.0) Keel protrudes slightly above breast muscle
3.5)
4.0) Keel flush with breast muscle
4.5)
5.0) Keel inundated in breast muscle

Color: Iris: Yellow, Pale Yellow, Brown, Sepia, Buffy Brown
Ochre (Cream), Pale Ochre, Other _____

Feet: Yellow, Pale Yellow, Other _____

Cere and Beak: Yellow, > 70% Yellow,
Blackish-Grey or < 30% Yellow:
Entirely Blackish-Grey
Yellow restricted to nares and base of beak near the gape
Yellow throughout beak

Feathers:

WT White	BL Black	BR Brown
WD White Down	GD Grey Down	SP Sepia
GY Grey	GB Grayish Black	TN Tan
WF White Flecking	TE Tawny Edges	TW Tawny

WB White With Brown Mottling
BW Brown With White Mottling
Other - Write In Colors

Head: Feathers _____, Brown eye-stripes,
White with brown flecking or rachi

Tail: Feathers _____
White with brown, black, or grey flecking,
White with brown or black band at distal margin,
White with brown or black vertical stripes

Back: Feathers _____
Inverted White Triangle On Mantle

Breast: Feathers _____

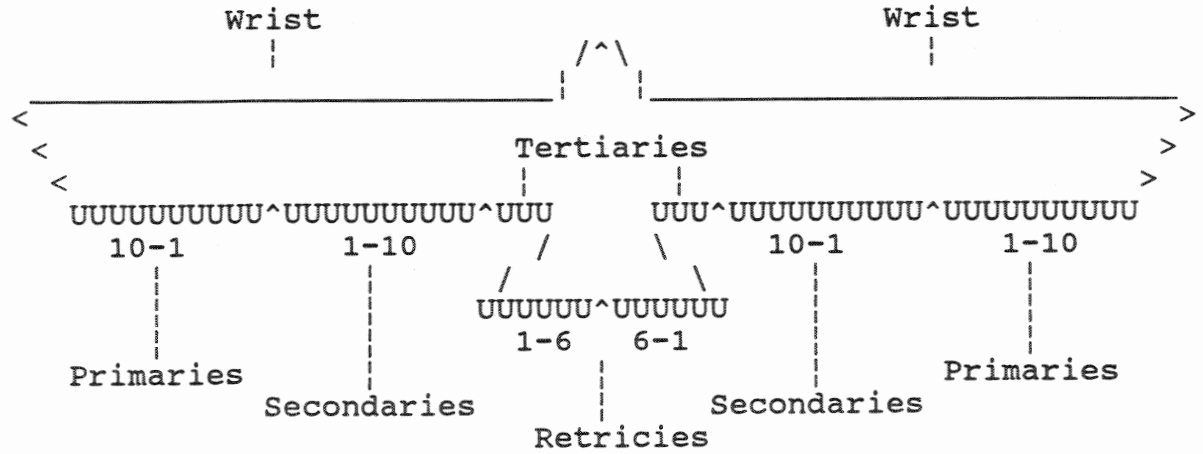
Abdomen: Feathers _____

Upper Wings: Coverts ____ Primaries ____ Secondaries ____

Under Wings: Coverts ____ Primaries ____ Secondaries ____

New Primaries:	Right:	1	2	3	4	5	6	7	8	9	10
	Left:	1	2	3	4	5	6	7	8	9	10
New Secondaries:	Right:	1	2	3	4	5	6	7	8	9	10
	Left:	1	2	3	4	5	6	7	8	9	10
New Retrices:	Right:	1	2	3	4	5	6				
	Left:	1	2	3	4	5	6				

Comments _____
_____
_____



1. Sternum keel bladed with minimal breast muscle;
2. Sternum keel bladed with more prominent breast muscle;
3. Sternum keel protrudes slightly above breast muscle (Normal);
4. Sternum keel flush with breast muscle; and,
5. Sternum keel inundated in breast muscle.

We recorded weight to the 0.1 kg utilizing a triangular bandage to secure the eagle and a Pesola scale.

Plumage characteristics recorded from Arizona bald eagles included the iris, feet, cere, and beak color, as well as the color of the head, tail, back, breast, and abdomen feathers. We also noted coloration of the upper- and under-wing coverts, primaries, and secondaries. In addition, we examined the molt sequence of the primaries, secondaries, and retrices.

E8.2.9 Ground Tracking

Telemetry data are the best measure of the overall geography of foraging because, with telemetry, the bird's whereabouts are known at all times. Visual data on movements are far less complete because observations depend entirely on observer location. For the same reason, visual observations of eagles foraging give unreliable estimates of foraging range and the relative importance of habitat. In studies without telemetry, the number of foraging observations near the nest are often over-represented because an observer is normally present there. Taken together, however, the telemetry visitation data, augmented by foraging data, and, where possible, prey delivery observations, provides a fairly accurate account of movements and habitat-use by the eagle.

To study habitat selection by the telemetered adult eagles, BioSystems researchers utilized the principle of "time-lines," uninterrupted, minute-by-minute records of the movements and activities of the birds. To obtain this amount of detail it was necessary for teams of radio trackers to spread out individually throughout each studied territory and to maintain radio communication. As the eagle flew by one person, the next was advised of its approach. Data were recorded onto field notebooks or tape recorders, but were transferred as soon as possible onto obsforms (see E8.1). Shared data points were worked out within tracking teams with the goal of accounting for all the eagle's time–space utilization in as much detail as possible, especially with regard to foraging. Mercury switches in the transmitters changed the pulse rate when the transmitters tilted from near-vertical (eagle perched) to horizontal (eagle flying or lying down) attitude, which enabled us to interpret the activities of the eagles when they were out of our sight. A steady slow pulse indicated a perched eagle; a fast pulse demonstrated that the eagle was flying or lying down (incubating). A regular alternation of pulse rate usually meant the eagle was eating. Soaring was indicated by a coming and going of fast-mode signal strength, an effect which results from the changing relative orientations of transmitting and receiving antennas as the soaring bird circles. We were able to refine our interpretation of the signals and the idiosyncracies of particular transmitters on the basis of frequent visual verification of behaviors.

Tracking teams normally worked ten continuous days at a territory, with four days off. The first day of a ten-day period was spent: (1) in a briefing attended by all personnel, (2) in logistics, and, (3) then traveling to the study site. Tracking teams spent days 2–9 obtaining time-line data, usually from dawn until at least mid-day, and often until dusk. Ordinarily, tracking continued through the morning of the tenth day; then the researchers returned home. These periods were as follows:

Period	*Inclusive*	*10-day period*
1	12/8/86–12/19/86	12/8–12/17
2	12/20/86–1/3/87	12/22–12/31
3	1/4/87–1/17/87	1/6–1/15
4	1/18/87–1/31/87	1/20–1/29
5	2/1/87–2/14/87	2/3–2/12
6	2/15/87–2/28/87	2/17–2/26
7	3/1/87–3/14/87	3/3–3/12
8	3/15/87–3/28/87	3/17–3/26
9	3/29/87–4/11/87	3/31–4/9
10	4/12/87–4/25/87	4/14–4/23
11	4/26/87–5/9/87	4/28–5/7
12	5/10/87–5/23/87	5/12–5/21
13	5/24/87–6/6/87	5/26–6/4
14	6/7/87–6/20/87	6/9–6/18
15	6/21/87–7/4/87	6/23–7/2
16	7/5/87–1/2/88	1st Off-season
17	1/3/88–1/16/88	1/5–1/14
18	1/17/88–1/30/88	1/19–1/28
19	1/31/88–2/13/88	2/2–2/11
20	2/14/88–2/27/88	2/16–2/25
21	2/30/88–3/12/88	3/1–3/10
22	3/13/88–3/26/88	3/15–3/24
23	3/27/88–4/9/88	3/29–4/7
24	4/10/88–4/23/88	4/12–4/21
25	4/24/88–5/7/88	4/26–5/5
26	5/8/88–5/21/88	5/10–5/19
27	5/22/88–6/4/88	5/24–6/2
28	6/5/88–6/18/88	6/7–6/16
29	6/19/88–7/2/88	6/21–6/30
30	7/3/88–12/31/88	2nd Off-season
31	1/1/89–1/14/89	1/3–1/12
32	1/15/89–1/28/89	1/17–1/26
33	1/29/89–2/11/89	1/31–2/9
34	2/12/89–2/25/89	2/14–2/23
35	2/26/89–3/11/89	2/28–3/9
36	3/12/89–3/25/89	3/14–3/23
37	3/26/89–4/8/89	3/28–4/6
38	4/9/89–4/22/89	4/11–4/20
39	4/23/89–5/6/89	4/25–5/4
40	5/7/89–5/20/89	5/9–5/18
41	5/21/89–6/3/89	5/23–6/1
42	6/4/89–6/17/89	6/6–6/15
43	6/18/89–6/22/89	6/20–6/29
44	6/30/89–12/31/89	3rd Off-season

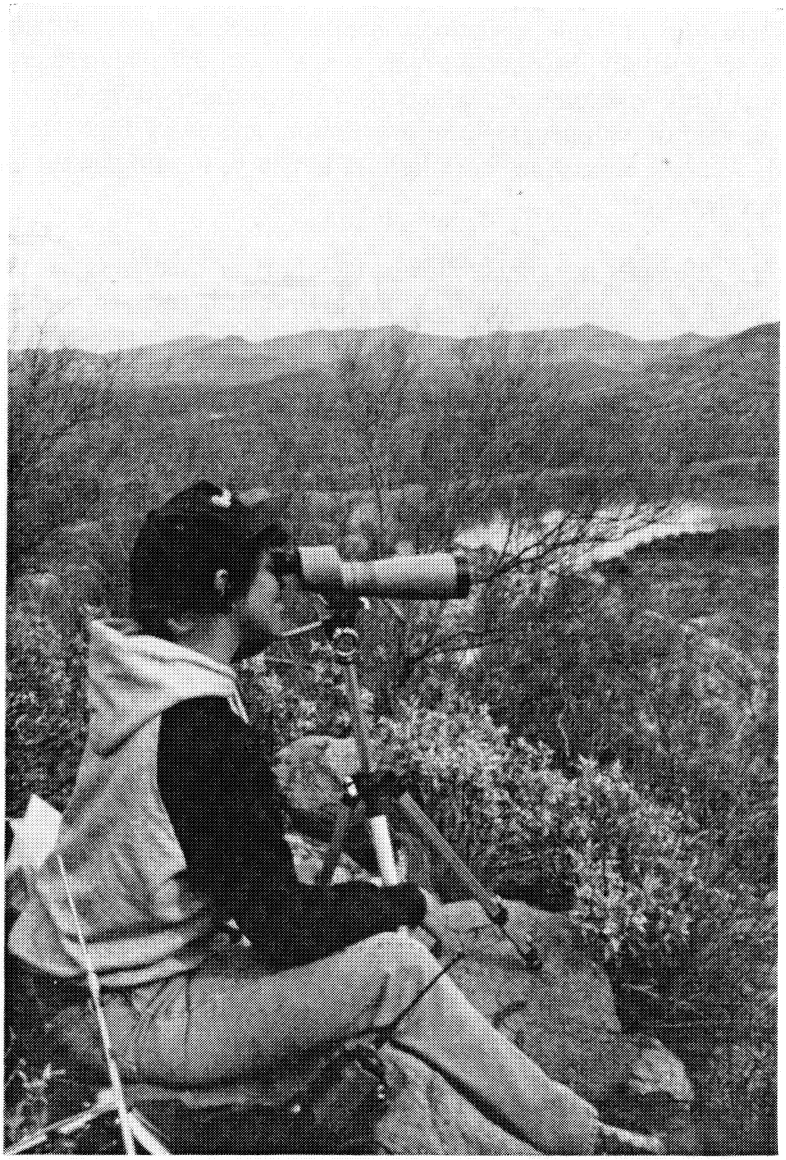


Plate E19. Trish Carroll observing the Horseshoe nest from across the river (photo by T. Gatz).

To increase sample sizes during analyses, we grouped pairs of ten-day periods into 28-day periods. For example, Period 1 plus Period 2 equals the first 28-day period, and so on. The reason why these periods are 28 days in length is that they encompass the 4 days off between 10-day periods and two days on either end.

Telemetry tracking of river-nesting bald eagles in this and other studies by BioSystems has shown that foraging habitat is essentially "linear;" that is, the foraging range focuses on the river habitat itself and its associated reservoirs and lakes. In these studies, we found that almost all visual or telemetric

observations of perched eagles could be accurately related to specific river locations, easily identifiable by the researcher on the basis of terrain features and vegetation.

To reference the distribution of eagle visitations, habitat variables, prey distributions, public use occurrences, and all other spatially distributed events, we marked the river centerline on topographic maps with kilometer and tenth-of-kilometer graduations. The resulting River Map Atlas ("map book") formed the basis for all studies with geographical implication, and every BioSystems worker carried a map-book in the field. After a short time working in a territory, locations were easily referred to in terms of tenth-kilometer segments.

In the case of reservoirs, kilometer markings followed the old river channel rather than estimates of the reservoir centerline. Because the eagles frequented the reservoir shores, and because these were often difficult to relate to the distribution of river kilometers, we indexed the shoreline with kilometer and two-tenths-kilometer (0.2 km) graduations. For this, we followed the shoreline distribution depicted on current USGS topographic maps using dividers (compass) indexed at 0.5 km in width; the 0.2-km graduations were free-hand interpolations.

The kilometer graduations in the map books were sometimes inaccurate in referring to exact field locations because of physiographic changes occurring since the production of topographical base maps. These changes included (1) shifts in the distribution of river channels as a result of flooding and (2) reservoir substrate evolution affecting shoreline distribution. In addition, shoreline profiles continually changed in response to reservoir elevation. These discrepancies were usually minor, however, and rarely presented difficulties in identifying specific locations.

In the field, we first recorded the location of an eagle in terms of the full kilometer segment (SEG) it occupied, then to 0.1 km (along the river) or the appropriate reservoir shoreline kilometer (see LAKE-LOC (SKm) on the ObsForm). We then indicated the side as left or right (with the observer looking downstream), island, or river channel. We also noted its distance to water and its elevation above the substrate. If we could not identify the eagle's location to the level of a full kilometer segment, we used zone codes to reference larger segments that encompassed several river kilometers and were identifiable as positioned between familiar landmarks. The codes were as follows:

Blue Point Zone Codes:

907 km 21.8 downriver (dam downstream unspecified)
913 km 9.4 downriver (unspecified)
912 km 9.5–12.2 (parking lot to WFP curve)
911 km 12.3–14.2 (WFP curve to Sheep Bridge)
910 km 14.3–15.7 (Sheep Bridge to BP Bridge)
909 km 15.8–19.5 (BP Bridge to Bulldog Cliffs)
908 km 19.6–21.8 (Bulldog Cliffs to Dam)
903 km 21.9 upriver (unspecified)
901 Nest overland to Bulldog Cliffs
906 km 21.9–25.4 (Lower Reservoir)
914 km 25.4 East (upriver WSC unspecified)
917 Land Between Lakes (between Upper and Lower Reservoir overland)
916 Willow Springs Canyon (mouth km 25.4)
900 Nest Area (terrestrial up WSC)

915 East of Willow Springs Canyon
905 km 25.5-31.0 (Upper Reservoir)
904 km 31.1-36.5 (River Channel to Morman Flat Dam)

Ladders Zone Codes:

909 km 157.0-162.7 (downriver of nest)
901 km 161.9-157 (downstream of Big View)
902 km 162-164.3 (greater nest area)
908 km 162.8-182 (upriver of nest)
903 km 164.4-165.3 (Verde Falls area)
905 km 165.4-168.4 (Beasley cliffs area)
906 km 168.5-171.6 (Beasley Flat area)
907 km 171.7-174.0 (White Cliffs Area)
912 km 174.1-178.0 (WC Creek mouth area
913 km 178.1-182.0 (Camp Verde)
910 Wingfield Mesa (off-river northeast)
911 (Beasley area) zones 905 and 906
914 West Clear Creek unspecified

Bartlett Zone Codes:

910 km 32.5 downriver (unspecified)
907 km 35.2 downriver (unspecified)
909 km 32.0-33.1
908 km 33.2-34.1 (Island Area)
906 km 34.2-35.2 (Riffle Area)
912 km 35.1-35.3 (Nest Area)
900 km 35.1 upriver (unspecified)
915 km 39.3-56.0 (reservoir unspecified)
911 km 39.3-42.0 (dam to boat ramp)
913 km 42.1-51.0 (Ramp to Bartlett Flats)
914 km 51.1 upriver (N. of Bartlett Flats)

Horseshoe Zone Codes:

900 km 73.3 downriver (below dam)
907 km 73.3-73.5 (dam area)
922 km 73.4 upriver (above dam)
910 dam overland to nest
998 reservoir unspecified
901 lak-loc 0.0-6.2 (dam to Deadman's Cove) or km 73.4-76.6
902 lak-loc 6.3-10.0 (Deadman's Cove to bend) or 76.7-79.8
903 lak-loc 10.1-13 (bend to cottonwoods) or km 79.9-83.4
906 km 82.6-82.8 (immediate 1988 nest area)(1987 nest was at km 83.0)
904 km 83.5-88.0 (Ister Flat)
905 km 88.1 upriver (upriver Ister Flat)
912 Sunset Mts. to dam (west overland)
914 nest o.p. upstream (west overland)
916 nest upstream (east overland)
918 below dam (west overland)
920 below dam (east overland)

Pinal/Pinto Zone Codes:

916	West of Salome Bay (km 87.0 downstream)
900	West of Schoolhouse Point
925	Salome Bay (lak-loc 36.5–42.0)
910	km 112.3 downriver (from 288 bridge)
915	km 88.0–93.0 (Salome to Grapevine)
923	upriver of km 93.0 (unspecified)
909	km 93.0–97.9 (Grapevine to Schoolhouse)
913	Sierra Anchas (north of reservoir)
914	Pinto Creek (unspecified)
901	km 98.0–101.7 (Schoolhouse to mouth)
902	101.8–112.3 (mouth to 288 bridge)
917	km 101.7–104.9 (Cottonwood Acre)
918	km 105.0–108.4 (Meddler Point)
919	km 108.5–110.9 (Diversion Dam Area)
920	km 111.0–112.2 (288 Bridge Area)
903	km 112.3 upriver (from 288 bridge)
921	Klondike Mt.(unspecified)
914	Pinal Creek Area (unspecified)
904	Nest Cliff Area (km 0.4 Pinal Creek)
922	km 113.0 upriver (unspecified)
911	km 113.0–115.0 (White Stripe Cliffs)

East Verde Zone Codes:

701	downstream from "Bend Cliff" (km 127.0) (km 123.0–126.8)
702	Houston Creek to "Bend Cliff" (km 126.9–128.7)
703	East Verde River to Houston Creek (km 128.8–130.7)
704	nest to East Verde River (km 130.8–133.2)
705	nest area (133.3–133.9)
706	upstream from nest area to Fossil Creek mouth (134.0–136.2)
707	upstream from Fossil Creek mouth (136.3–141.3)
710	East Verde River (general)
711	East Verde River (km 0.0–8.0)
712	East Verde River (km 8–20)
720	Fossil Creek

Generic Zone Codes:

444	unable to locate bird
777	river (unspecified)
888	reservoir (unspecified)
997	see lake loc (reservoir shoreline kilometer)
998	see notes
999	see notes

We also used codes to identify often-used locations of the observer (OBSLOC). Examples of these codes are as follows:

Observer locations at Horseshoe Territory (ObsLoc):

00	below dam
01	0–6 (LAK-LOC) Dam to Deadman's Cove
02	6–10 Deadman's to Point
03	10–13 Point—Bend above nest
04	13–Sheep Bridge
05	km 84–85
10	Nest OP (Observation Point) above camp
26	Camp at km 81.8
29	OP Hill (see 10)

Observer locations at Blue Point Territory (ObsLoc):

801	Peak on "ridge between the lakes," east of Butcher Jones picnic area. True north of km 25.7, true west of km 28.3, elev. 1942 feet.
02	All of the lake parking areas, east of the Marina. Lak-Loc 19.0–20.2.
03	Area across from Bulldog Cliffs, west end. Km 19.5–19.8.
04	Blue Point overlook, west of the bridge, both north and south of the highway. Km 15.2–16.0 area.
05	Overlook 80 m north of the Marina turnoff from Bush Highway, overlooking the lake. True west of LAK-LOC: 20.1.
06	Sheep flats overlook. Km. 14.5–14.8.
07	Overlook north of "Dip" sign. Km. 13.4.
08	Overlook north of curve at km 13.1.
09	Camp OP (Observation Point): 2 mi. true north of OP 5. Elevation 2,000 feet.
10	SRP Housing area, from Bush Highway turnoff to river access area. Km 20.2–21.0.
11	Road area from km 18.0–18.5. Does not overlook the river, used for telemetry checking only.
12	Fish Camp. Lak-Loc. 16.7.
13	Dam to km 24.8 to Pinnacle Point Area. Lower Reservoir.
14	Km 24.8–27.2. Channel Between the Lakes.
15	Boat tie up point on E. side of Willow Springs Cove. See lake map for exact location.
16	Km 27.2–31.0. Lower portion of Upper Reservoir.

Observer locations at Pinal/Pinto Territory (ObsLoc):

01	the tip of Grapevine Point (SKm 15.5).
02	Schoolhouse Point, including the OPs on the bluff just behind.
03	"Red Cliffs Overlook" back from Schoolhouse Point, above Skm 21.5, east of the main road and south of the corral.
04	the Hwy 288 bridge and nearby turnouts on the road.
05	the tip of Cougar Point (SKm 101.1).
06	"Red Cliffs II" at the east end of the Red Cliffs, km 103.4, side right.
07	nest view—includes nest observation ridge south of km 112.6 and nearby locations used from time to time.
08	Klondike Mt Saddle.
09	"GumTree OP" (turnout on road west of the Rock House store)
10	Meddler Point OP.
98	boat.
99	see notes.

Observer locations at Bartlett Territory (OBSLOCS):

02	nest
04	km 33.7 (river left)
06	camp (km 35.5, river right)
08	km 30.3 (river right)
10	km 32 overlook (unspecified downstream)
11	downstream of dam to damkeeper's house
12	sw tip of reservoir by Forest Service cabin
13	boat ramp
14	Rattlesnake Cove
15	peak 2303
16	S.B. Cove
17	Bartlett Flats

We also recorded the occurrence by eagles at frequently-used perches which we identified and periodically updated in the ObsForm instruction manual. At Pinal/Pinto Territory, for example, our list of frequently-used perches was as follows:

Name	*Code*
"Stubby Saguaro Attack Perch"	SKm 18.0, SL, 3,3, RE
"Drowned Cottonwood"	SKm 22.5, SN, 1,2, RE
"Black Mesquite"	SKm 27.0, MS, 1,2, RE
"The Table"	SKm 28.0, BA, 1,2, RE
"The Knife"	SKm 17.5, ridge top
"Red Cliffs"	Km 101.6, BA, 1,3, RO

E8.2.10 Airplane Tracking

For aerial tracking we used Cessna 172 and 182 airplanes fitted with two side-facing antennas. A switch box in the cabin enabled separate monitoring of antennas. Position fixes were recorded on aeronautical charts and notebooks using Mountain Standard Time and statute miles. Our technique in monitoring the path of a migrating juvenile was to locate the bird, then land at an airport along its predicted course and wait for an hour or two before relocating the bird. Information on migrating eagles was recorded on Airplane Tracking Forms (Figure E8-5).

We also conducted airplane roll call surveys throughout Central Arizona during October through May for purpose of: (1) recording the return to Arizona of telemetered migrant juveniles and subadults; (2) studying their movements and habitat selection; (3) verifying the occurrence of telemetered adults at territories; and, (4) detecting and locating mortalities. In a typical roll call flight, we flew from Mesa airport to the confluence of the Salt and Verde rivers, scanning all transmitter frequencies at 3-second intervals. We then climbed north up the Verde River to the mouth of the East Verde River, thence up the East Verde about 10 km, and thence back to the mouth of the East Verde. By this time, we were at an altitude of 8,500 ft MSL from which we sometimes were able to detect telemetry signals of flying birds over 100 km away. We then flew to Camp Verde or Cottonwood where we circled and listened for signals, especially to the north and west. We then flew to Mormon Reservoir and south to Tremaine Reservoir, climbing to a higher altitude for terrain clearance and to maximize reception. We would then fly to Payson and down Tonto Creek to Roosevelt Reservoir and thence up the Salt River to near White River, Arizona. During this leg of the flight we would make occasional detours to search for signals up the larger tributaries to the north of the river (e.g., Canyon Creek) and up the Black River as well. We

would then fly southeast to the area of Eagle Creek and down the Gila River to San Carlos Reservoir, thence to Roosevelt Dam and down the Salt River to Mesa.

This survey route developed on the basis of having detected telemetered eagles in previously unsurveyed areas, and, as we obtained new knowledge of areas frequented by eagles, the route expanded from surveys strictly on the Salt and Verde rivers to that described above. We also occasionally flew to Yuma, thence up the Colorado River, to Alamo Reservoir, and back to Mesa.

E8.3 STUDIES AT NESTING TERRITORIES

E8.3.1 Recording Prey Deliveries

In a previous study of prey selection by bald eagles on the Pit River in California, we obtained results using time-lapse photographs that were unavailable in analyses of prey remains. One factor favoring photographic data (or direct visual observation) was that the skeletal remains of certain prey types

OBSFORM FOR TRACKING MIGRATING EAGLES BY AIRPLANE

DATE __/__/__ TIME ____ BEST FREQUENCY 165. ____ BIRD ____

ACTIVITY ___ (or no. of pulses in 15 seconds) SOARING? _____

OBSERVER ___ WEATHER ___ (Entry No. _____)

LOCATION OF BIRD _____

COMMENTS _____

LATITUDE _____ LONGITUDE _____

HABITAT _____ LCL WINDS ALOFT FCST: 3000 feet = _____ deg @ _____ kts

6000 feet = _____ deg @ _____ kts 9000 feet = _____ deg @ _____kts

12000 feet = _____ deg @ kts TERRAIN ALTITUDE UNDER BIRD _____ feet

SURFACE WINDS AT (nearest) _____ AIRPORT = _____ degrees at ____ kts

MORE COMMENTS (Use back of form if needed):

Figure E8-5. Observation form for tracking migrating eagles by airplane.

Plate E20. Robin Hunter recording prey deliveries at Willow Springs Canyon (Blue Point) nest (photo by P. Carroll).

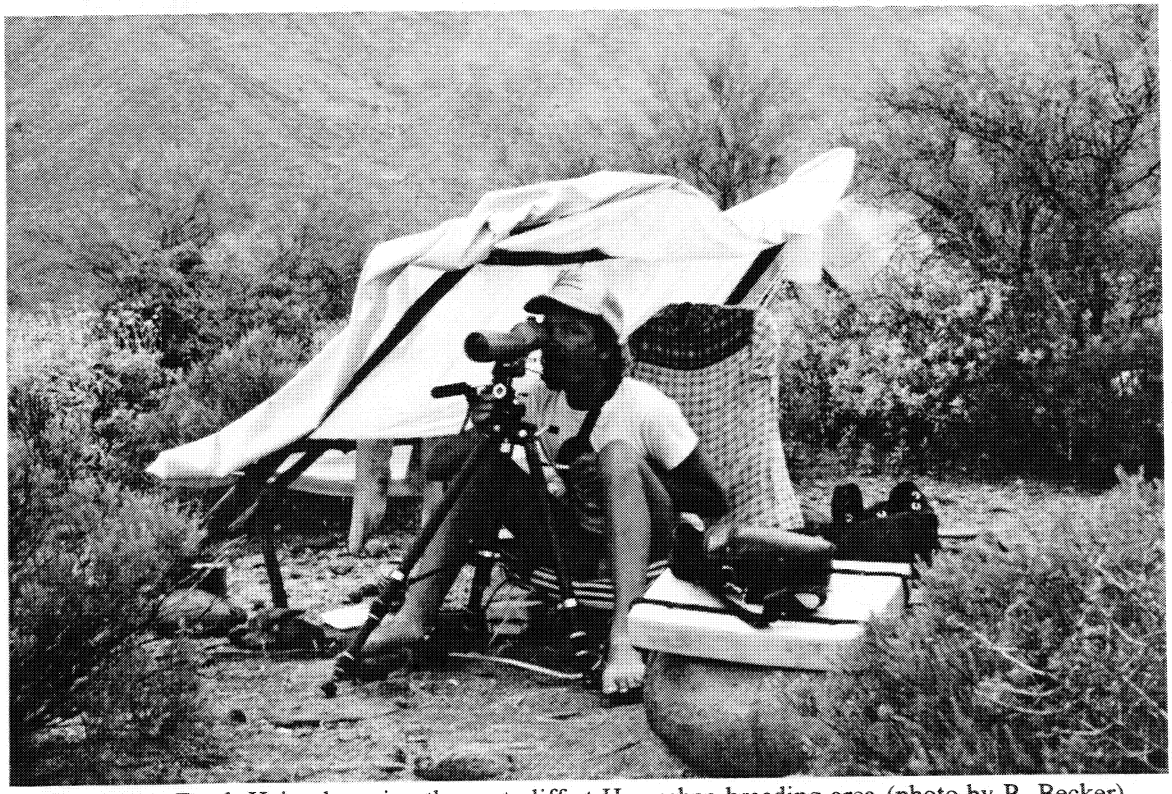


Plate E21. Frank Hein observing the nest cliff at Horseshoe breeding area (photo by P. Becker).

persisted in the nest longer than others so that some species were over-represented in dietary estimates based solely on prey remains (BioSystems 1985).

For our study in Arizona, however, an even more compelling reason supported the use of visual data. Our study teams actively tracked the movements of foraging telemetered adults within the territories, witnessed numerous foraging events, but were often unable to determine the prey species because the eagle took it directly to the nest without leaving prey remains at the foraging site. Identifying prey as it was delivered to the nest allowed us to connect the time of delivery with a foraging event observed just before the delivery. Moreover, if we were unable to directly observe an attack on prey, we were still cognizant through telemetry of the location of the eagle in the minutes preceding the delivery. We were therefore able to link specific microhabitat or, at worst, distinct portions of the eagle's home range with the species of prey, its approximate size, the proportion delivered, and, in many cases, whether it had been taken alive or as carrion.

In Arizona, we opted to observe prey deliveries visually rather than by time-lapse camera or video system. Both of the latter techniques seemed inadvisable to us because of disturbance in changing film and batteries (every 5 days) and the because of the many advantages of having someone stationed near the nest in radio communication with the tracking team.

We selected the observation points with the aim of getting as clear a picture of the nest bowl as possible without disturbing the birds either by our presence or while entering or leaving the location. Distances to the nests varied from about 125 m to about 400 m. In some cases, we constructed blinds to minimize disturbance, but where pairs did not appear concerned by our presence, we observed the eagles without blinds, careful to be as unobtrusive as possible.

In most cases we used standard spotting scopes (15–60×) to identify prey items in the nests. In difficult situations arising from distance, poor observation angles, or light factors, we used a more powerful Questar telescope. All data associated with prey identification were recorded on Prey Delivery Forms (Figure E8-6).

We identified delivered prey by observing physical characteristics, using them first to assign general taxonomic categories (i.e., class) and then proceeding into more specific categories (e.g., family) and, finally, where possible, to species. For example, a channel catfish would first be classified as (1) a fish (prey type) on the basis of observed fins, etc.; then as (2) a catfish, possibly by reason of having seen barbels and mouth; and finally, as (3) a channel catfish because of head shape, skin color, and other characteristics. We were careful not to attempt to identify an item based on initial impressions, but rather we attempted to describe and draw exactly what we saw; that is, instead of assuming any prior knowledge of prey identity, we concentrated on observed characteristics. The implication of this was that another person, who might examine the field description and drawings, would come to the same conclusion as to the identification of the prey item, or the inability to identify it. Characteristics used to identify fish species taken by bald eagles in Arizona are presented in Figure E8-7.

In the case of a sucker, for example, the space on the form for species was left blank while information was recorded, such as fish, long, cylindrical, large anal fin, ventral fleshy mouth, scales present, lightly forked tail, white ventral coloration, brown dorsum. Drawings were made for further documentation of exactly what was visible of the prey item. Only after all these data were recorded was an attempt made to identify the species. Observers then estimated their confidence in the identification on a scale of one

Figure E8-6. Bald eagle prey delivery and identification form.

PREY DELIVERIES TO NEST

ENTRY _____ TERRITORY _____ PREY TYPE _____

DATE _____ BIRD _____ TRUE LENGTH _____in.

TIME _____ ID MODE _____ LENGTH DEL _____in.

OBSERVER _____ PREY STATUS _____ PERCENT WT DEL ____%

HOW STATUS DETERMINE _____

SPECIES _____

CONFIDENCE (scale 1-5, 5 = positive ID) ___ G.M.N. _____

PREY DESCRIPTION _____

_____

_____

PREY ORIGIN _____

_____

COMMENTS _____

_____

_____

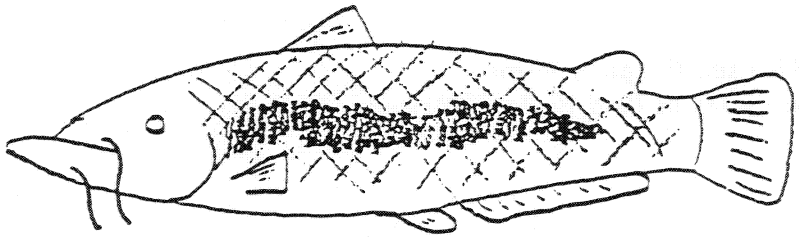
_____

PREY DRAWINGS:

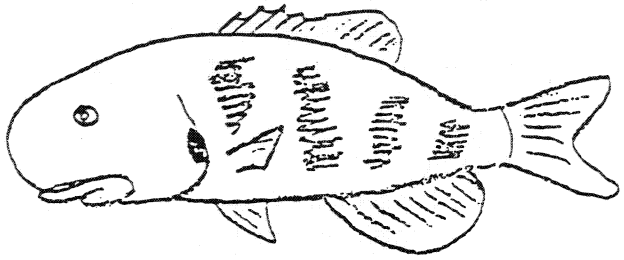
Fish Identification Form—
BioSystems Study of Bald Eagles in Arizona

1. Caudal Fin:
   a. Square or rounded
   b. Forked
2. Dorsal Fin:
   a. One lobe
   b. Two lobes—if two lobes:
      aa. obviously connected
      bb. barely connected
3. Dorsal Fin:
   a. No spines
   b. Spines
4. Dorsal Fin:
   a. Short
   b. Long
5. Adipose Fin:
   a. Present
   b. Absent
6. Barbels:
   a. Present
   b. Absent
7. Scales:
   a. Distinct
   b. Inconspicuous or absent
8. Anal Fin:
   a. Much longer than dorsal fin
   b. About equal to dorsal fin
   c. Much shorter than dorsal fin
9. Mouth:
   a. Terminal
   b. Subterminal
10. Jaw:
    a. Lower jaw projects beyond upper jaw
    b. Upper and lower jaw about equal
    c. Upper jaw projects beyond lower jaw
11. Pelvic Fins:
    a. Well behind pectoral find
    b. Slightly posterior to pectoral fins
12. Pectoral Fins Perpendicular to Body:
    a. Yes
    b. No
13. Anal Fin:
    a. Longer than wide
    b. Length and width equal
    c. Wider than long
14. Body Shape:
    a. Dorsoventrally compressed
    b. Laterally compressed
    c. Cylindrical
15. Markings:
    a. Single dark horizontal band
    b. Multiple dark vertical bands
    c. Multiple dark horizontal bands
16. Caudal Peduncle:
    a. Thick
    b. Thin
17. Dark Spot or Spots:
    a. Absent
    b. On operculum
    c. On body

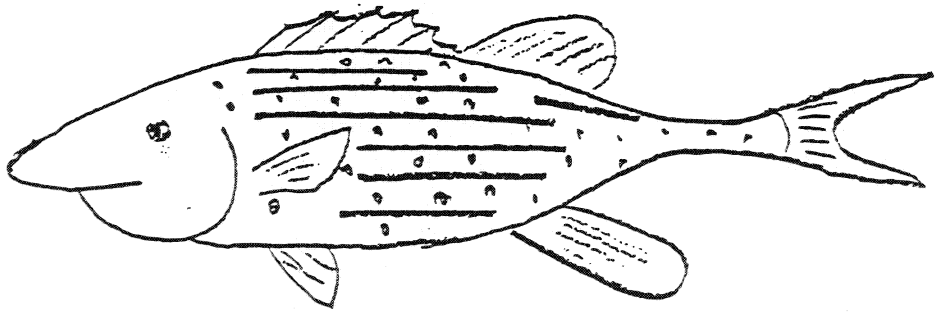
Figure E8-7. Characteristics used to identify fish species taken by bald eagles in Arizona.



1a 10a
2a 11a
3a 13a
4a 15a
5a 16a
6a 17a
7a
8a
9a



1b 10b
2a 11b
2*aa* 13b
3b 15b
4b 16a
5b 17b
6b
7b
8b
9b



1b 10c
2b 11b
2*bb* 13c
3b 15c
4b 16b
5b 17c
6b
7b
8c
9b

Cross Section

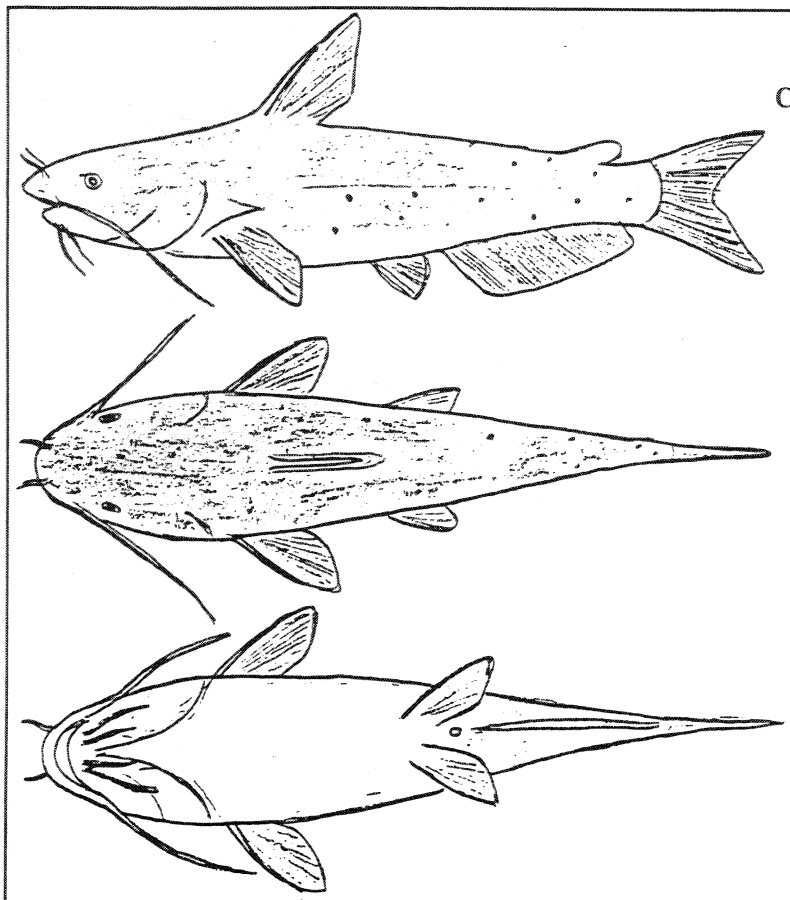
12a, 14a

12b, 14b

12b, 14c

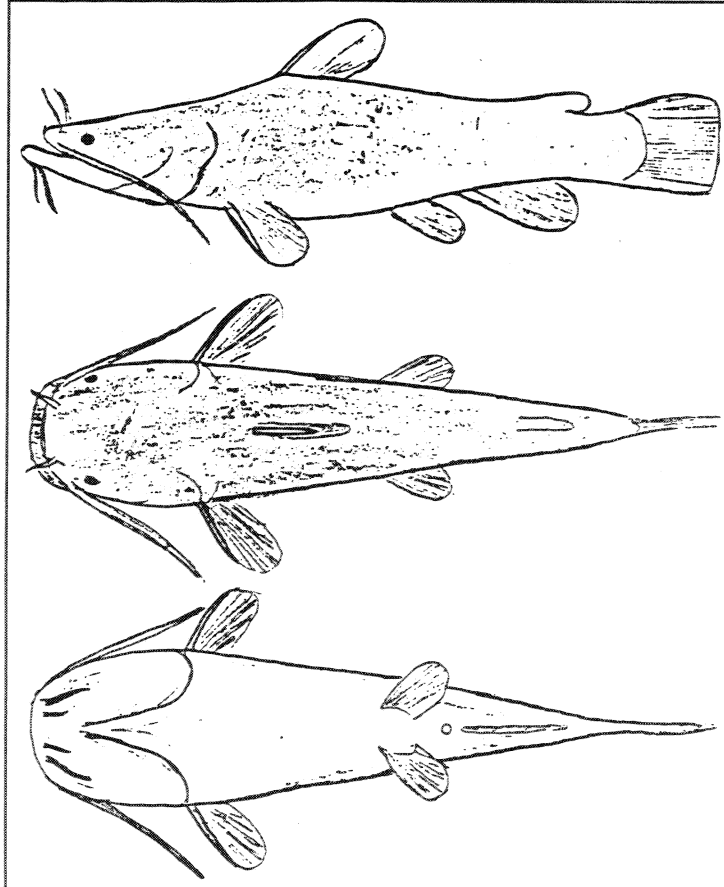
Illustrations by Michael J. Cross

Figure E8-7. (Page 2 of 8) Hypothetical fish showing prey identification characteristics.



Channel Catfish

Caudal Fin:	Deeply forked with pointed lobes.
Anal Fin:	Much longer than wide.
Dorsal Fin:	Short, triangular with spine.
Pectoral Fins:	Spined, triangular; extends perpendicular to body.
Pelvic Fins:	Triangular; well behind pectoral fin.
Mouth:	Terminal, barbels longer than head; upper jaw extends past lower jaw.
Body:	Elongated; dorsally grey to grey-green; ventrally white (may have black speckles); scaleless.
Adipose Fin:	Present.



Flathead Catfish

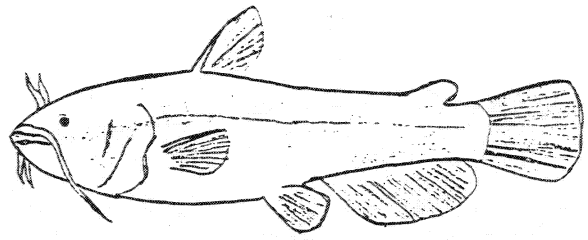
Caudal Fin:	Rounded or square.
Anal Fin:	Rounded, as long as wide.
Dorsal Fin:	Small, rounded, spined.
Pectoral Fins:	Spined, rounded; extends perpendicular to body.
Pelvic Fins:	Rounded; well behind pectoral fins.
Mouth:	Terminal, long barbels; lower jaw extends past upper jaw.
Body:	Head dorsoventrally compressed; color brown to olive, drab (may be mottled); scaleless.
Adipose fin:	Present.

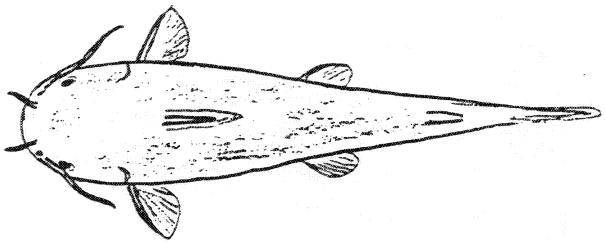
Illustrations by Michael J. Cross

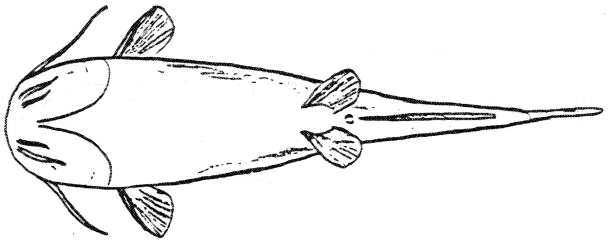
Figure E8-7. (Page 3 of 8)

Bullhead

Caudal Fin:	Rounded or square.
Anal Fin:	Rounded, longer than wide.
Dorsal Fin:	Small, rounded, spined.
Pectoral Fins:	Spined, rounded; extends perpendicular to body.
Pelvic Fins:	Rounded; well behind pectoral fins.
Mouth:	Terminal, long barbels; lower and upper jaw equal in length.
Body:	Color variable; dorsally dark; ventrally white to yellow; scaleless.
Adipose Fin:	Present.

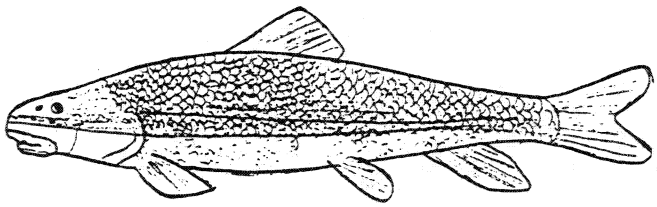


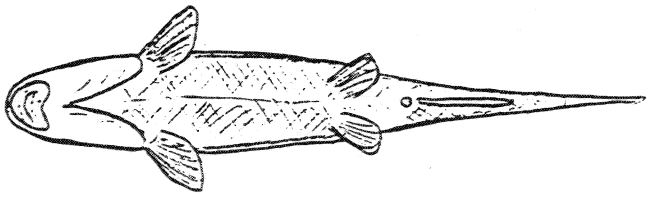




Sucker

Caudal Fin:	Deeply forked with rounded lobes.
Anal Fin:	Large, lobate.
Dorsal Fin:	Single, small, triangular.
Pelvic Fins:	Well behind pectoral fin.
Mouth:	Subterminal, fleshy lips.
Body:	Cylindrical, long.
Coloration:	Bicolored; brown dorsally; white to yellow ventrally (may have black lateral band).





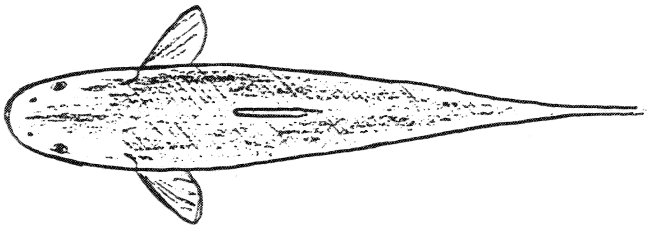


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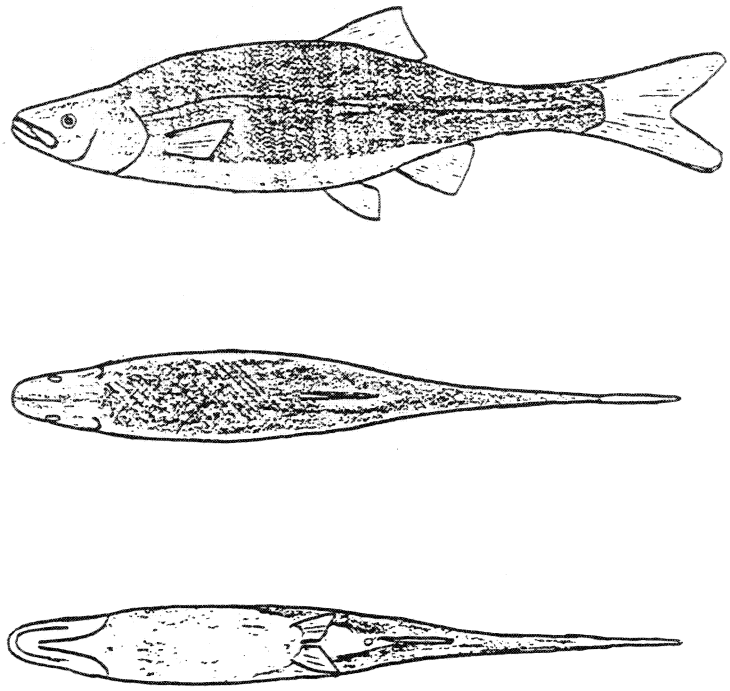
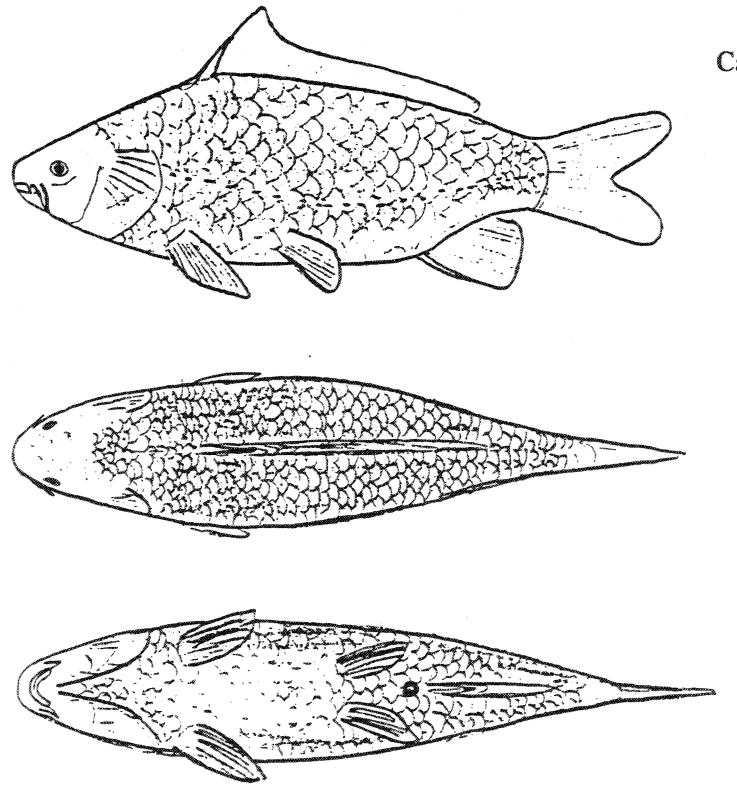
Figure E8-7. (Page 4 of 8)



Gila Robusta (Roundtail Chub)

Caudal Fin:	Deeply forked with rounded lobes.
Anal Fin:	Square distal margin.
Dorsal Fin:	Small, square distal margin.
Pectoral Fins:	Pointed.
Pelvic Fins:	Pointed; well behind pectoral fins.
Mouth:	Terminal, large.
Body:	Color variable; grey to bronze; small, pointed head; may have hump behind head; tiny scales.
Caudal peduncle:	Very narrow.
Breeding color:	Ventral surface red.



Carp

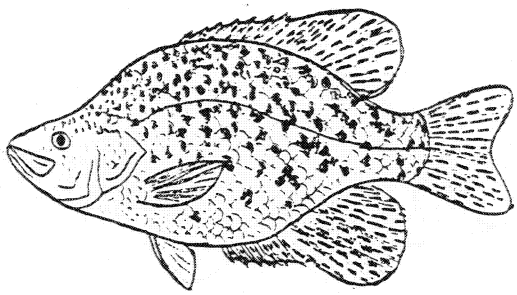
Caudal Fin:	Deeply forked with rounded lobes, distinct rays (may have reddish tinge).
Anal Fin:	Square distal margin; anterior spine.
Dorsal Fin:	Single, long, anterior spine.
Pelvic Fins:	Well behind pectoral fin.
Mouth:	Terminal, small barbels.
Body:	Robust, long; large scales; variable color (often yellow-green).
Operculum:	Straited.

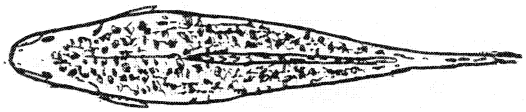
Illustrations by Michael J. Cross

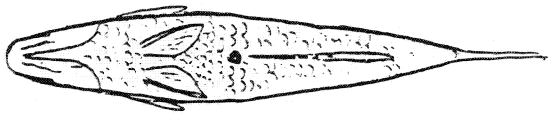
Figure E8-7. (Page 5 of 8)

Black Crappie

Caudal Fin:	Moderately forked with rounded lobes.
Anal Fin:	Large-lobed fin; similar in length to dorsal fin; anterior portion spined.
Dorsal Fin:	One lobe with anterior portion spined.
Pectoral Fins:	Pointed tip.
Pelvic Fins:	Barely posterior to pectoral fin.
Mouth:	Terminal and large; lower jaw slightly longer than upper jaw.
Body:	Laterally compressed (pan-shaped); small head with sharp depression above eye; color olive-green on back; silver-white on sides; black checkering on sides; dorsal, anal, caudal fins—dark checkering.

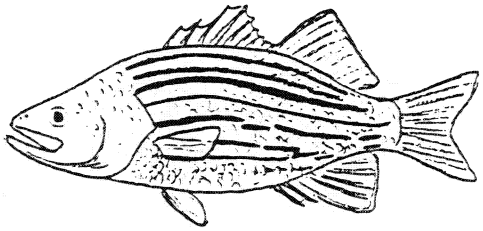






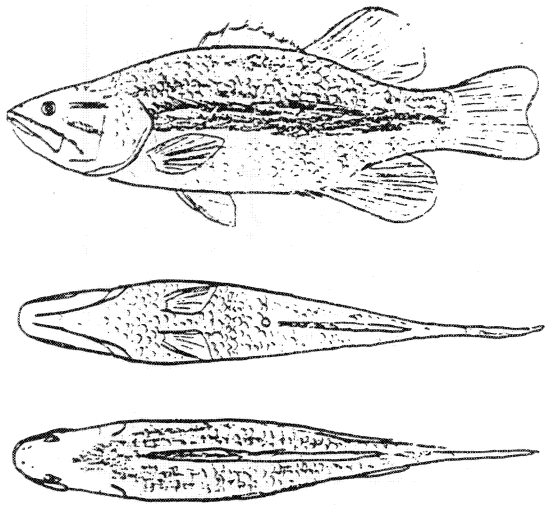
Yellow Bass

Caudal Fin:	Moderately forked with pointed lobes.
Anal Fin:	Large, posterior margin squared; two spines on anterior margin.
Dorsal Fin:	Two lobes barely connected; anterior lobe spined; distal margin squared.
Pectoral Fins:	Pointed tip.
Pelvic Fins:	Barely posterior to pectoral fin.
Mouth:	Terminal and relatively small.
Body:	Laterally compressed; color golden tint; many dark lateral stripes (stripes are broken).



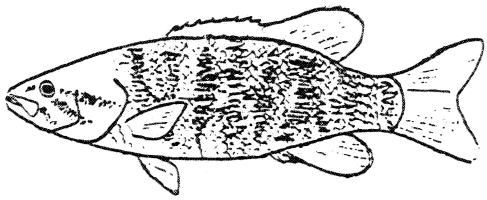
Illustrations by Michael J. Cross

Figure E8-7. (Page 6 of 8)



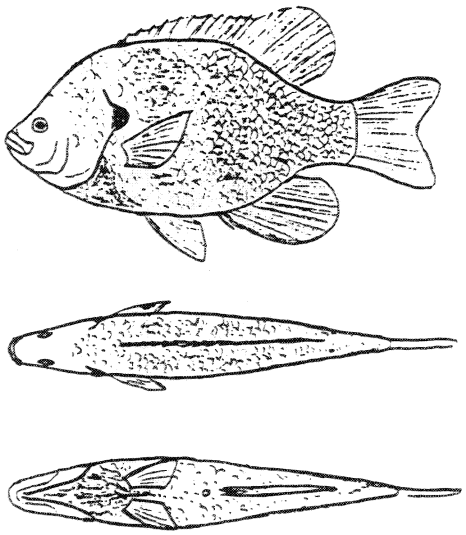
Largemouth Bass

Caudal Fin:	Moderately forked with rounded lobes.
Anal Fin:	Similar in size to second lobe of dorsal fin.
Dorsal Fin:	Two lobes barely connected; anterior lobe spined.
Pectoral Fins:	Pointed tip.
Pelvic Fins:	Barely posterior to pectoral fin.
Mouth:	Terminal; upper jaw extends past posterior margin of eye.
Body:	Dorsum green to olive-green; dark lateral band; white ventrally; may have dark bands on operculum.



Smallmouth Bass (see largemouth bass for dorsal and ventral views)

Caudal Fin:	Moderately forked with rounded lobes.
Anal Fin:	Similar in size to second lobe of dorsal fin.
Dorsal Fin:	Two lobes obviously connected; anterior lobe spined.
Pectoral Fins:	Pointed tip.
Pelvic Fins:	Barely posterior to pectoral fin.
Mouth:	Terminal; upper jaw does not extend past posterior margin of eye.
Body:	Color green to bronze; no dark lateral band; may have dark vertical bands; white ventrally; often red eye; three dark bands on operculum.



Bluegill

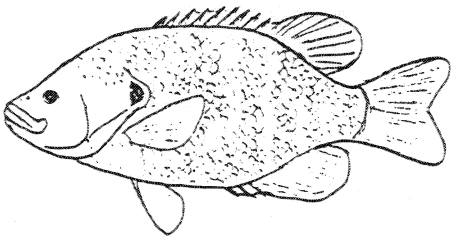
Caudal Fin:	Moderately forked with rounded lobes.
Anal Fin:	Large-lobed; anterior portion spined.
Dorsal Fin:	Two lobes obviously connected; usually a posterior spot on fin; anterior lobe spined.
Pectoral Fins:	Pointed tip.
Pelvic Fins:	Barely posterior to pectoral fin.
Mouth:	Terminal and small.
Body:	Laterally compressed (pan-shaped); color variable; may have dark vertical bands on side and iridescent blue sheen on body; single dark spot on posterior margin of operculum.

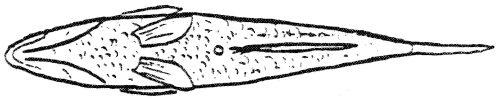
Illustrations by Michael J. Cross

Figure E8-7. (Page 7 of 8)

Green Sunfish

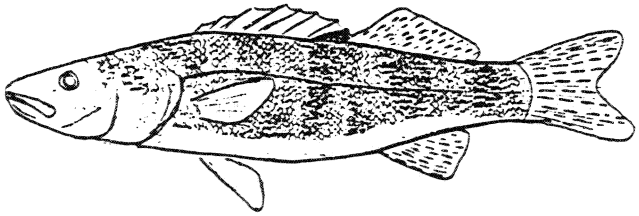
Caudal Fin:	Moderately forked with rounded lobes.
Anal Fin:	Large lobed; usually with posterior dark spot; anterior portion spined.
Dorsal Fin:	Two lobes obviously connected; usually with posterior dark spot; anterior lobe spined.
Pectoral Fins:	Pointed tip.
Pelvic Fins:	Barely posterior to pectoral fin.
Mouth:	Terminal and large; extends to middle of eye.
Body:	Laterally compressed, but not as deep as Bluegill's; color variable; single, dark operculum spot; may have iridescent turquoise grid on operculum and sides.

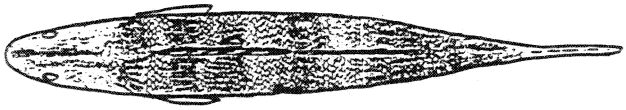




Walleye Pike

Caudal Fin:	Moderately forked with rounded lobes; ventral surface light.
Anal Fin:	Square distal margin.
Dorsal Fin:	Large, two lobes; lobes barely connected; anterior lobe spined with dark spot on posterior margin; square distal margin.
Pectoral Fins:	Pointed.
Pelvic Fins:	Pointed; barely behind pectoral fins.
Mouth:	Terminal, large.
Body:	Fusiform; golden-brown.
Eye:	Iridescent pupil.





Illustrations by Michael J. Cross

Figure E8-7. (Page 8 of 8)

to five, with five being a positive identification. We dealt with low confidence scores by assigning the item to a higher taxonomic level.

On the prey delivery form we recorded information from the time the item was delivered until it was fully consumed. Observing the entire feeding process was sometimes necessary in identifying the item because visual input was often only a series of momentary glimpses. The most common difficulty was when the eagles obstructed our view of prey items with their bodies.

We determined the status of the prey taken by the eagle on the basis of whether the prey item was obviously alive or dead when delivered, fresh or decomposed, limp or stiff. These status estimates were derived from observing the prey as it was delivered, as it lay in the nest, and from information communicated via hand-held radio to the nest observer from those who may have witnessed the foraging event.

We estimated prey size by comparing the item with the length of the eagle's bill and other body parts or with objects of known size in the nest. Where only part of a prey item was delivered, we estimated the original size of the prey before dismemberment and the percent of biomass delivered. We were occasionally able to check estimates recorded by nest observers with actual measurements of fish prior to acquisition by the adult eagles; for example, during the taking of bait fish during unsuccessful trapping attempts. We were sometimes also able to verify species identification with prey body parts collected by trackers at eagle foraging sites.

Because of the similarity of desert and Sonora suckers, we were usually unable to differentiate between them with observational methods alone; we therefore grouped them as "sucker sp." on the prey delivery form, using the key characteristics described above. We identified carp by their usually large size, a single, long dorsal fin, deeply forked tail with rounded lobes, barbels present, striated opercula, and large, distinct scales. Black crappies were round, laterally compressed, lightly forked tail, salt and pepper appearance; anal and dorsal fins were large, similar in size, and anteriorly spiny. Catfish were identified by absence of scales and the presence of barbels. Flathead and channel catfish could be easily distinguished from one another. Flatheads were dorso-ventrally compressed, with an unforked tail and a conspicuous underbite. Channel catfish were more cylindrical, had a deeply forked tail with pointed lobes, long anal fin, speckles dorsally, with an overbite. Yellow bass were laterally compressed with a lightly forked tail, two dorsal fins, conspicuous broken lateral striping. The largemouth bass typically had a dark lateral band, and maxilla that extended behind the eye, while smallmouth bass had no lateral band and the maxilla extended to the eye. The eye of the smallmouth was typically red, and the fish sometimes had vertical barring.

Each observer participated in several training seminars at field headquarters in which reference collections of frozen fish and other taxa known to be taken by bald eagles were provided for examination and identification of key morphological characters. Researchers were asked to identify the specimens viewed briefly at a distance of 200 meters through spotting scopes, and several people were initially selected as nest observers on the basis their performance. Whenever possible, potential nest observers accompanied fisheries crews during surveys and sampling efforts to provide further exposure to fish species occurring in the study area.

Plate E22. Paula Becker collecting prey remains at Horseshoe (photo by F. Hein).

E8.3.2 Prey Remains Identification

We collected bald eagle prey remains throughout the course of the study. Collections were made from the nests during nest climbs. Typically, we climbed active nests twice each year to collect remains, once during the middle to late part of the chick cycle (coinciding with banding/telemetering activities), and again following the fledging of young. If possible, we also collected prey below nests; however, logistics involved in climbing many cliff nest sites often prevented this collection. We observed large differences in the number of prey remains present at Arizona nests and speculate that some nests were cleaned by the adults (Driscoll 1985, Driscoll and Buckley 1986), by woodrats, and other scavengers. All bones, fur, and feathers were bagged and labeled for later identification following the field portion of the study. We also collected approximately two quarts of fine nest lining from each nest for a fish scale analysis

aimed at determining use of fish not represented by bones, and the use of soft-boned fish (e.g., trout, chub). Telemetry trackers collected additional prey remains following foraging events, from on or below perches subsequent to eagle feeding activity, and from below commonly used perches in the territory.

Prior to identification of bald eagle prey remains, we constructed a reference collection of common fish species known to occur in the Salt, Verde, Gila, and Bill Williams river drainages (Minckley 1973), and expected to occur in the bald eagle's diet. We used the reference bones to accurately identify species and size of fish represented by each prey item found in the prey collections. For each fish species we collected from five to ten individuals of various sizes, weighed and measured them, and parboiled them to remove all flesh. We then weighed, dried, and labeled all bones for reference. Examples of bones used to identify fish included: crania, clavicles (cleithra), opercula, preopercula, 1st vertebrae, dorsal spines, dentaries, maxillaries, and premaxillaries. Specific identifying characteristics were used to separate fish species from homologous bones (i.e., suckers vs. carp from their opercula). Bones selected for such identification varied for species and between collections. We sent bones of unusual fish species to the University of Michigan, Museum of Zoology, for verification by Dr. R.R. Miller and Dr. G.R. Smith.

In addition to reference bones, we constructed a fish scale reference collection. Along with scale keys (Lagler 1940, Casteel 1972), we used the reference scales to identify fish from collections represented only by scales and from scales found in the nest linings. We determined the ages of fish scales by standard methods (Bagenal and Tesch 1971); we used length/annulus tables (Carlander 1969, 1977) to determine size of fish represented by scales. Mean lengths of fish species for a particular territory were used if scales could not be aged.

We identified bird, mammal, and herptile remains by comparison with reference samples from the University of Arizona Mammalogy Collection and from the University of California at Davis, Department of Wildlife and Fisheries, study collection. We estimated numbers of birds and mammals by grouping like parts (e.g., coot wings); only one individual was counted for small collections of feathers or tufts of fur. We identified mammal hair remains using mammal hair keys (Adorjan and Kolenosky 1969, Moore *et al.* 1974), comparison with mammal study skins, and microscopic examination. We obtained the weights (biomass) for non-fish prey from standard mean weights (Burt and Grossenheider 1964, USBLM 1979, Steenhof 1983, Dunning 1984). We chose an arbitrary upper limit of 2,500 grams to represent biomass of large mammalian prey represented by bones and/or fur. We used average weights of commonly utilized species for individuals identified only to family or genus.

From the fish bone reference collection, we determined relationships of "bone length" to "total body length" for each fish species (McConnell 1952, Hansel *et al.* 1988). We calculated regression equations for all identifying bones (using "Lotus 1-2-3" software on an IBM-PC), and used the equations to estimate total length of fish represented by bones in the prey remains collection. Because unattached bones in prey collections for a particular date and collection site were often components of the same fish, we utilized the following procedure to avoid duplication: First, we calculated the confidence intervals (95%) of each equation to determine the probable range of total length represented by the bones. For a given collection we calculated total length for each bone and then sorted (dBase III+ software) all like bones for a particular fish species. The bones with the most entries and relatively low confidence intervals were examined first. We grouped pairs of these bones, for example right and left opercula, on the basis of their measuring within 1mm of one another (or 5 mm for broken items whose lengths were estimated). We marked as prey items each pair and the remaining odd entries.

Plate E23. Robin Hunter-Long recording prey deliveries at Ladders breeding area (photo by P. Carroll).

Our rationale for this procedure derived from our reference collection which showed that pairs did not vary by more than 1.0 mm. The next step was to match the opercula with other bones whose confidence intervals for total lengths overlapped with the total body lengths computed for the opercula. Also from the reference collection we learned that different parts of the same fish had specific proportional relationships; for example, opercula and clavicles of suckers never varied by more than 2.0 mm. We eliminated from the data set those entries that were eclipsed by the confidence intervals or by special relationships. The final result was to leave the fewest number of unmatched parts and, thus, the fewest numbers of individual fish represented by the prey remains. Total fish numbers were probably

underestimated because of the likelihood that matched ones could have been from different fish of the same approximate size.

We calculated total weights for the selected (non-duplicate) fish prey items using length-to-weight equations from this study, from Carlander (1969, 1977) and Becker (1983). From these total weights we subtracted the weights of bones and scales (from regression equations in the reference collection) plus five percent of the total weight to arrive at the edible biomass for each prey item. The five percent total weight reduction estimated unavailable biomass such as flesh attached to discarded bones, discarded viscera, and other uneaten parts. No biomass adjustments were made for bird or mammal weights.

E8.3.3 Foraging Microhabitat Measurements

To determine what specific habitat features were responsible for attracting eagles, we recorded data concerning each foraging attempt. As soon as possible after witnessing a foraging event, but without disturbing the eagle, we went to the exact strike point and measured habitat variables. Information recorded included identification of the specific eagle (if known from telemetry), method of attack, type of perch, distance from perch to strike point, wind velocity, cloud cover, water surface conditions, and shoreline characteristics. Data were taken on the size and type of the prey, whether it was taken alive or as carrion, and what the eagle did with it. Microhabitat features included water depth, water temperature, turbidity (Secchi disk), stream velocity, surface condition, stream substrate, submerged vegetation, and distance from strike point to shore. In some cases certain data were obtained even when the exact strike point was not observed e.g., if conditions such as depth and surface turbulence were homogeneous over wide areas. We looked for evidence to identify the prey species caught. In some cases were obliged to wait for varying periods to avoid disturbance to the eagles, especially near the nest.

Forage field kits contained Forage Forms (Figure E8-8), the code sheet, river maps, a metric measuring device (2 m), thermometer, Secchi disk, a floating object, and ziplock bags for prey remains collections. We placed date/time/location/observer labels inside prey remains bags to correspond to specific forage forms. Each "Forage Form" contained 38 fields; data codes and instructions accompanied the forms as follows:

ENTRY. Filled in later, during computer entry.

OBSERVERS of event (initials); example JLL/ATG.

TERR = territory code.

BIRD = bird identification number.

SUCCESS:

S = successful K = unknown U = unsuccessful X = see comments
R = retrieval of prey obtained previously but left near foraging location
P = perlustration (scrutiny of prospective forage site)

ID mode:

C = collected remains after eagle vacated
W = observed eagle with prey
B = observed prey before capture
P = determined by time-lapse photography
X = see comments

Figure E8-8. Bald eagle forage form.

FORAGE FORM

1. ENTRY ____
2. DATE ___/___/___
3. TIME _____
4. OBSERVERS ___/___
5. RIVER ____
6. TRIB ____
7. SEG ____
8. KM ____.__
9. LAKLOC ___.__
10. SIDE ____
11. TERRITORY ____
12. EASTING ____
13. BIRD ____
14. AGE ____
15. SUCCESS ____
16. ID ____
17. PREYTYPE ____
18. LENGTH ____ cm
19. STATUS ____
20. DISPO ____
21. ITEM ____
22. ATTACK ____
23. PERDIST ____ m
24. PERTYPE ____
25. DEPTH __cm (Item no.) __
26. TEMP ____°C
27. TURB ____ cm
28. VELOC ____
29. SURFACE ____
30. SUBSTRATE ____
31. VEG ____
32. SHORDIST ____
33. INTERVAL ____
34. WIND ____
35. RIVHAB ____

36. PREY DESCRIP _____

37. HAB DISCRIP _____

38. FORAGE DESCRIPTION/COMMENTS _____

_____

_____

_____

_____ (continue on back)

MAP/DIAGRAM

PREYTYPE:

F = fish A = amphibian B = bird
C = unidentified carrion M = mammal
U = unknown R = reptile X = see comments

Estimated **LENGTH** of the prey in centimeters

STATUS:

A = caught alive R = retrieval C = taken as carrion
P = prey pirated S = prey sick or injured prior to discovery by eagle
U = unknown

Prey **DISPO**sition (what the eagle did with the prey):

P = eagle flew to perch with prey
S = flew to shore with prey
D = dragged or swam prey to shore
F = flew out of sight with prey
N = flew to nest with prey (no speculation)
A = ate prey on site
X = see comments and/or notes

PREY COLLected? Y = yes, remains collected; N = no remains collected.

ATTACK mode:

1 saw prey from perch, then attacked
2 probably saw prey from perch, then attacked
3 flew from perch, but probably saw prey while flying
4 flew in from elsewhere, saw prey from air
5 flew from perch, landed on shore, waded in, got prey
6 pirated prey from another species (write in species)
7 pirated prey from adult eagle
8 pirated prey from subadult eagle
9 displaced adult eagle from carrion
10 displaced subadult eagle from carrion
11 displaced another species from carrion (write in species)
99 see comments and/or notes

PERDIST: Estimate distance from attack perch to prey in meters. Enter 999 if greater than 1000 m.

PERTYPE: Perch type (see obsform instructions).

DEPTH: In centimeters at point of attack.

999 = more than 200 cm 998 = on shore

TEMP: Water temperature in °C or °F, preferably °C (submerge thermometer).

TURBidity: Use Secchi disk; express in cm.
999 = clear to bottom or greater than 200 cm.

VELOCity: Number of seconds for object to travel one meter.
999 = no current.

SURFACE condition:

1. glassy
2. swirls
3. one cm peaks
4. two cm peaks
5. three cm peaks
6. four cm peaks
7. five cm peaks
8. whitecaps
9. see comments and/or notes

SUBSTRATE (beneath attack point):

1. mud
2. sand
3. fine gravel
4. gravel and sand
5. coarse gravel
6. pebbles (less than 2 cm)
7. pebbles (2-5 cm)
8. rocks
9. bedrock
10. other (see comments and/or notes)

00. no data, water too deep

Submerged **VEG**etation:

1. none
2. grassy bottom
3. algae (mossy coating) on bottom substrate
4. algae (mossy floor) on bottom - a solid mat
5. rooted aquatic plants (more than 20 cm from surface)
6. rooted aquatic plants within 20 cm of surface
7. floating live aquatic plants
8. floating dead plant material (dense)

99. see comments or notes

00. no data—water too deep

SHORDIST: Estimated distance from nearest shore to attack point in meters. 999 = on shore.

INTERVAL: In hours (and tenths of hours) between eagle attack and measurement of Items 25–31.

WIND: See ObsForm instructions.

RIVHAB: See ObsForm instructions.

(Item no.) This number assigned later by prey data person.

PREY DESCRIPtion: Identify the prey species. If prey is not identifiable, describe it.

HAB DESCRIPtion: Describe habitat (micro- and macro-).

Some ideas for **COMMENTS**: explain ID criteria if prey identified visually from distance; describe prior events, ideas, insights, associated observations, etc. Summarize and be concise. The core facts of the observation must be written in the first 500 spaces (characters plus spaces between words).

MAP/DIAGRAM: Think about someone who hasn't been there. Will the map/diagram make sense and be useful in understanding the foraging event and locating the strike point?

E8.3.4 Carrion Surveys

We conducted surveys for carrion on both rivers and reservoirs. In the latter case, we often did them along with a waterfowl survey. We selected stretches of shoreline where carrion might accumulate (coves, bends in the former river channel, and especially the areas where rivers entered reservoirs). We followed reservoir shorelines slowly in the boat and recorded all carrion found. We identified and measured all fish and noted their availability to eagles. Fish lengths were measured from the tip of the head to the base of the caudal peduncle (bending the tail sharply toward the body and noting where a crease appears in the area where the tail fin joins the main body). We noted factors contributing to fish's death (e.g., prop strikes, hook in stomach, emaciated, evidence of spawning). Dead birds, mammals, etc., were also be noted. In addition to reservoir surveys, at least two 100-m areas on the river in each territory were designated for carrion surveys, particularly where channel bends occurred. We chose areas where dead fish might accumulate.

E8.3.5 Waterfowl Surveys

Because waterfowl are important prey of bald eagles we conducted waterfowl surveys periodically within the home ranges of pairs. Surveys were made from fixed points or by making counts while traveling along a water body. Surveys were done the same way, at roughly the same time, and from the same places or survey routes. The goal was to establish when (seasonally), where, and in what habitats waterfowl were present. Data recorded included date, data type (wfs), the times each survey began and ended, river, territory, survey segment codes, habitat, observer, observer location, and weather information. Under comments (ObsForm) we entered the numbers and species of waterfowl seen, as follows:

GB = great blue heron	MD = mallard	CB = canvasback
QB = green-backed heron	PT = pintail	RN = r-n duck
BN = b-c night-heron	GD = gadwall	GN = goldeneye (sp)
GE = great egret	AW = wigeon	MO = common moorhen
SE = snowy egret	SH = shoveler	CO = coot
WG = western grebe	BH = buffle head	GL = gull (sp)
EG = eared grebe	RD = ruddy duck	PE = shorebirds ("peeps")
PB = pied-billed grebe	CM = c. merganser	UD = unident. duck
DC = cormorant	CT = cin. teal	UG = unident. goose
CG = C. goose	GW = g-w teal	U- = unidentified
SG = snow goose	RH = red-head	XX = No waterfowl seen

For example, under comments on the ObsForm, we might enter the following: 22 MD, 4 PT, 120 C0, 4 U. We attempted accurate counts of small numbers of waterfowl and made broad estimates of larger numbers.

E8.3.6 Nest Climbs

From 1987–1989, we climbed nests twice each season, once for banding, and again after the juveniles had fledged, to collect prey remains and nest measurements. However, in 1990 nests were only entered to band young, and in 1986 only for prey remains collection. We scheduled nest climbs to band eaglets at six weeks of age, and to attach radio transmitters at nine weeks. Some young were processed in the nest, while terrain features at other sites required transporting eaglets to level areas (see Section E8.2.3). We also collected blood and feather samples from juveniles (see Section E8.2.7), and recorded mensural characteristics (see Section E8.2.8).

In addition to processing young, we collected eggshell fragments, unhatched eggs, nest lining, and prey remains, and checked the nest for parasites, monofilament, fishing hooks, and other hazards. After the nestlings had fledged, we again climbed nests and collected these samples, but also measured nest site characteristics (see Section E8.3.7).

Nest lining was collected for parasite inventories and the recovery of small prey parts (i.e., trout and sucker scales). We sent a portion of the nest lining samples to Dr. James Phillips (Babson College) for parasite inventories (see Section C3.4), and sifted through the remainder for small prey parts. Details on prey remains analysis are provided in Sections B6 and E8.3.2. Monofilament, fishing hooks, and other foreign matter collected in Arizona bald eagle nests is discussed in Section C3.3.

We collected eggshell fragments and whole eggs for analysis of eggshell thinning and pesticide levels. From 1986 to 1990, we collected 71 sets of eggshell fragments, from 23 Arizona bald eagle breeding areas (Table E8-7). No known eggs were laid at the Ash, Devil's Post, Mule Hoof, Pinto, or Pleasant territories during our study. Eggshell fragments were sent to Dr. Lloyd Kiff at the Western Foundation for Vertebrate Zoology for measurement and archiving. In 1986, we only climbed nests after young had fledged and not all active nests were entered, resulting in a low number of samples (n = 8) from seven breeding areas. We collected 22 sets of eggshell fragments from 14 breeding areas in 1987, including a crushed egg from Sheep and two crushed eggs from "76". Similar samples (n = 19) were recovered from 12 territories in 1988, and (n = 18) from 14 breeding areas in 1989, including a crushed egg from Cliff. In 1990, nests were climbed only to band young. Due to the low number of nests producing young to banding age (9), only four sets of fragments were collected. We found more than one set of fragments in some nests. By 1990, we had sampled 23 of the 28 breeding areas.

In addition, from 1986 to 1990, we salvaged 11 whole eggs from nests after the adults had abandoned, and before ravens, raccoons, ringtails, and other scavengers entered the nest (Table E8-8). These eggs were sent to Dr. Robert Risebrough (Bodega Bay Institute) for contaminant analysis. See Section C2.3 for further details on egg characteristics of Arizona bald eagles.

E8.3.7 Nest Measurements

From 1987–1989, we climbed Arizona bald eagle nests after the young had fledged (or the breeding attempt had failed) to collect prey remains and mensural data. Nest characteristics recorded on Nest Forms ("NestForm", see Figure E8-9) included diameter of the egg bowl, soft material, and whole nest on the four major axis (N–S, E–W, NE–SW, NW–SE), and depth of the egg bowl, inner nest (from rim to inner nest surface at center), and whole nest (from rim to base). We also measured the diameter of the largest and smallest nest sticks, and an additional ten randomly selected sticks. We recorded the condition of

Table E8-7. Eggshell fragments collected from Arizona bald eagle nests, 1986-1990.

Sample	Breeding Area	Nest No.	Sample	Breeding Area	Nest No.
AZ-86-01	Lone Pine	1	AZ-88-07	76	3
AZ-86-02	Cibecue	2	AZ-88-08	Pinal	3
AZ-86-03	Cliff	4	AZ-88-09	Ive's Wash	1
AZ-86-04	Redmond	4	AZ-88-10	Sheep	1
AZ-86-05	East Verde	7	AZ-88-11	Ladders	4
AZ-86-06	Redmond	5	AZ-88-12	Alamo	2
AZ-86-07	Canyon	5	AZ-88-13	Coolidge	3
AZ-86-08	Cedar Basin	4	AZ-88-14	Cliff	4
AZ-87-01	Redmond	4	AZ-88-15	Horseshoe	8
AZ-87-02	Coolidge	1	AZ-88-16	Ladders	4
AZ-87-03	Blue Point	6	AZ-88-17	Ladders	5
AZ-87-04	Pinal	2	AZ-88-18	Redmond	6
AZ-87-05	Pinal	2	AZ-88-19	Lone Pine	4
AZ-87-06	Cedar Basin	4	AZ-89-01	Perkinsville	*
AZ-87-07	Redmond	5	AZ-89-02	Ladders	3
AZ-87-08	Orme	1	AZ-89-03	Fort McDowell	1
AZ-87-09	Chino	2	AZ-89-04	Cliff	4
AZ-87-10	Horse Mesa	2	AZ-89-05	Cliff	4
AZ-87-11	Coolidge	1	AZ-89-06	Cliff	4
AZ-87-12	Horseshoe	1	AZ-89-07	Orme	1**
AZ-87-13	Lone Pine	2	AZ-89-08	Pinal	1
AZ-87-14	Ladders	3	AZ-89-09	Table Mountain	3
AZ-87-15	East Verde	6	AZ-89-10	Pinal	1
AZ-87-16	Blue Point	6	AZ-89-11	Pinal	1
AZ-87-17	Redmond	5	AZ-89-12	Horse Mesa	2
AZ-87-18	Sheep	1	AZ-89-13	Redmond	5
AZ-87-19	Sheep	1	AZ-89-14	Horseshoe	8
AZ-87-20	76	3	AZ-89-15	Blue Point	1
AZ-87-21	76	3	AZ-89-16	Sheep	1
AZ-87-22	76	3	AZ-89-17	Ive's Wash	1
AZ-88-01	Alamo	2	AZ-89-18	Alamo	2
AZ-88-02	Blue Point	6	AZ-90-01	Alamo	2
AZ-88-03	Horseshoe	8	AZ-90-02	Bartlett	1
AZ-88-04	Redmond	6	AZ-90-03	Orme	3
AZ-88-05	76	3	AZ-90-04	Redmond	5
AZ-88-06	Blue Point	6			

* 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.

Table E8-8. Whole eggs collected at Arizona bald eagle breeding areas, 1986–1990.

Year	Breeding Area	Nest
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
1990	Ive's Wash	2
1990	Ladders	4
1990	Ladders	4

the nest (good, poor, remnant, fallen), as well as the elevation, directional aspect, and type (cylinder, bowl, inverted cone, or disk), and identified the vegetative species used for nest lining and sticks (see Sections A2.2 and C2.2 for discussion).

Characteristics of the nest substrate were also quantified, and varied for trees, cliffs, and pinnacles. For trees, we noted the nest's location (e.g., on the main bole or on a limb); the tree conformation; shading effect (on nest) of the canopy; species; status (e.g., live, dead-top, percent canopy, hard snag [only primary limbs], soft snag [secondary branches]); and the nest tree's affiliation with other trees. We also measured the distance and diameter of major branches supporting the nest, the height of the nest, and tree height and diameter.

For cliff and pinnacle nests, we noted the nests location (on top or face of cliff or pinnacle), and measured the nest ledge diameter on the four major axis (N–S, E–W, NE–SW, NW–SE). We also recorded the directional aspect of the cliff, distance from cliff or pinnacle top to nest, height of nest, height and length of the cliff or pinnacle, and the distance from the pinnacle to the nearest cliff.

We became aware of heat stress as a contributing factor to juvenile bald eagle mortality at the end of the 1988 breeding season (see Section C3.5). From 1989–1990, we recorded four temperatures (Celsius) 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 nest) exposed to direct sunlight.

In addition, the major habitat within 0.5 km of the nest, distance to water, and water type (perennial, intermittent, free flowing, or regulated stream or reservoir) was recorded. We also documented the presence of eggshell fragments, whole eggs, prey remains, nest parasites, and foreign material (monofilament, fish hooks, plastic, etc.) in the nest.

Figure E8-9. Bald eagle nest form—"NestForm".

NEST FORM Date _____

Breeding Area _____ Nest Number _____
Personnel _____
Climbing Technique _____
Time: Near Nest _____ Left Area _____ Total _____
Climbing: Start _____ End _____ Total _____

Measurements:	North/South	East/West	NE/SW	NW/SE
Bowl Width (mm)	_____	_____	_____	_____
Bowl Depth (mm)	_____			
Depth From Nest Rim To Center (cm)	_____			
Soft Material (cm)	_____	_____	_____	_____
Nest (cm)	_____	_____	_____	_____
Nest Depth (cm)	_____			

Width Of Sticks (mm): Maximum _____ Minimum _____
Random 1 _____ 2 _____ 3 _____ 4 _____ 5 _____
6 _____ 7 _____ 8 _____ 9 _____ 10 _____
Nest Condition: Good, Poor, Remnant, Fallen
Nest Accessibility: Walk In, Rope, Spikes, Technical Climb
Elevation (feet) _____
Nest Aspect: North, South, East, West, NW, NE, SW, SE
Nest Type: Cylinder, Bowl, Inverted Cone, Disk
Nest Material:

_____	Palo Verde	_____	Mesquite	_____	Ocotillo
_____	Cottonwood	_____	Sycamore	_____	Ogave
_____	Sotol	_____	Ponderosa	_____	Pinyon
_____	Cane Cholla	_____	Juniper	_____	Willow
_____	Teddy Bear Cholla	_____	Brittle Bush	_____	Cherry

Other _____
_____

Support Structure:
Tree Nest: Nest Location: On Trunk, On Limb
Nest Tree Conformation: 1 2 3 4 5 6 7
Other _____
Nest Shade: Full, Partial, None
Distance Between Major Branches At Nest Level(cm):
1_____ 2_____ 3_____ 4_____ 5_____
Diameter Of Major Branches At Nest Level (cm):
1_____ 2_____ 3_____ 4_____ 5_____
Diameter Of Tree At Base Of Nest _____
Distance From Tree Top To Nest Level _____
Height Of Nest (Ground To Base) _____
Height Of Tree _____
Tree Type: Species _____
Tree: Live, Dead-Top, % Canopy ___
Snag: Hard, Soft
Other _____
Tree: Isolated, In Grove
Area of Grove _____
Diameter Of Tree At Breast Height (DBH) _____
Distance To Nearest Large Tree _____
Other _____

Cliff Nest: Location Of Nest: Top, Face, Other _____
Ledge Area (cm): North/South _____
East/West _____
NE/SW _____
NW/SE _____
Cliff Aspect: N, S, E, W, NE, NW, SE, SW
Distance From Cliff Top To Nest Level _____
Height Of Nest (Ground To Base) _____
Height Of Cliff _____
Length Of Cliff _____
Other _____

Pinnacle Nest: Nest Location: Between Pinnacle And Cliff, Top, Face, Other _____
Ledge Area (cm): North/South _____
East/West _____
NE/SW _____
NW/SE _____
Distance From Pinnacle Top To Nest Level ___
Height Of Nest (Ground To Base) _____
Height Of Pinnacle _____
Length Of Pinnacle _____
Distance To Nearest Cliff _____
Pinnacle: Free Standing, Part Of Cliff
Pinnacle On Cliff (Distances):
Cliff Top To Nest Level _____
Ground To Pinnacle Base _____
Cliff Top To Pinnacle Top _____
Pinnacle To Cliff _____
Length Of Cliff _____
Other _____

Habitat: Major Habitat Within 0.5 km Of Nest _____
_____
Distance To Water _____
Type of Water _____

Eggs: Whole - Collected # _____, None Found
Fragments - Collected # Sets _____, None Found

Prey Remains: In Nest - Collected, Not Collected, None Found
Below Nest - Collected, Not Collected, None Found

Nest Lining - Collected, Not Collected, None Found

Mexican Chicken Bugs - High, Moderate, Low, None Found

Foreign Matter: In Nest _____
Below Nest _____

Temperatures (C): Ambient _____
Nest Surface _____
10-12 cm Within Nest _____
Surface (Outside Nest) Exposed To Sun _____

Comments _____
_____
_____

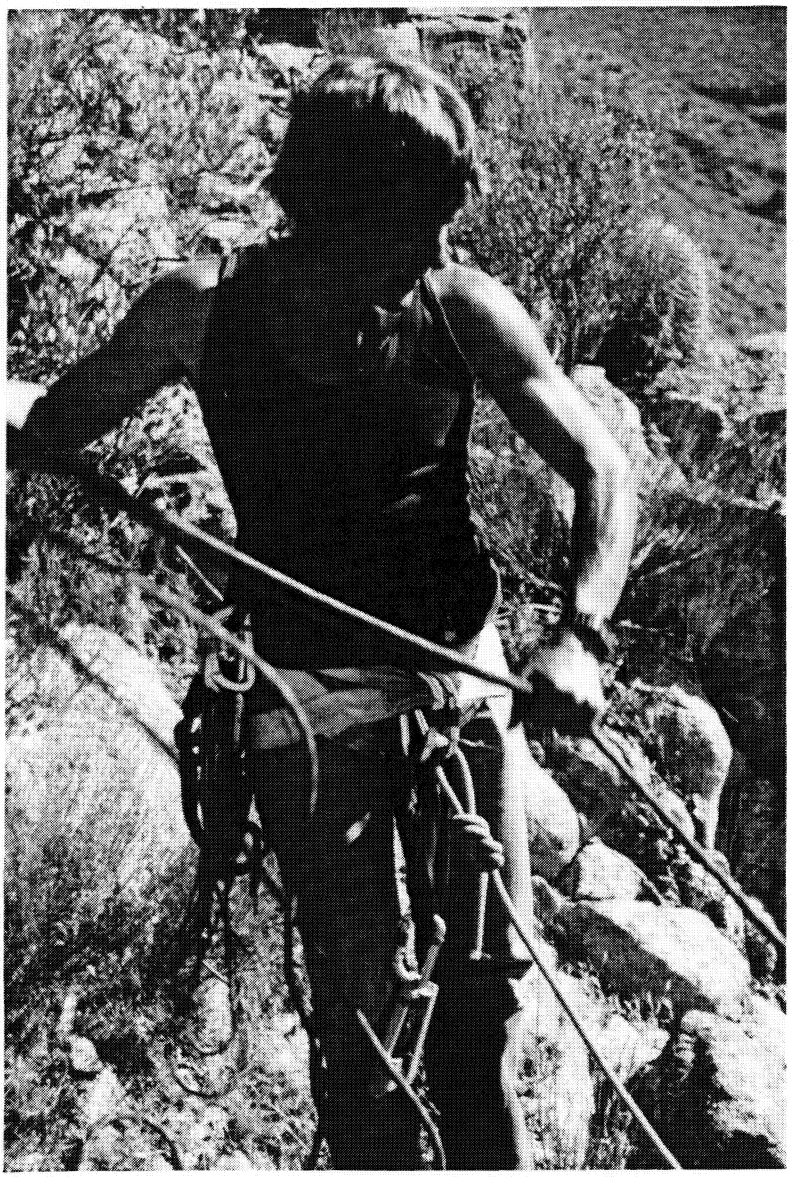


Plate E24. Daniel Driscoll preparing to descend to the Redmond nest, May 1988 (photo by T. Gatz).

E8.3.8 Bald Eagle Habitat Mapping

We mapped habitat in six of the seven priority bald eagle breeding areas quantitatively by kilometer on rivers (per River Km, see Glossary) and reservoirs (per shoreline SKm) using the BioSystems Arizona River Map Atlas and Habitat Mapping Forms (Figure E8-10). We mapped habitat in the seventh breeding area (East Verde) in far greater detail. In some cases, reservoirs were mapped at current levels and at maximum pool levels (high water mark). Habitat data are on file at the Bureau of Reclamation,

	DATE		DATA	WATER LEVEL			LOCATION								HABITAT			OBS	RIVER KM			PASS. DIST.				ENTRY NO.	
LETTER	DATE		DATA TYPE	RIVER FLOW (CFS)	RESERVOIR ELEVATION 1-LOW	RESERVOIR ELEVATION 2-HIGH	RIVER	TERRITORY	SEGMENT	PERCH KILOMETER	TERRITORY	LAKE-LOC	LAKE-SEG	PERCH LAKE-LOC	PERCH SIDE	PERCH 1-LOW	PERCH 2-HIGH	OBSERVER	% RUN	% POOL	% RIFFLE	# RIFFLES	PASS DIST.	TYPE PASS DIST.	P.O. SIDE	SEG. SIDE	ENTRY NO.	LETTER
A			M A P																								A
B																											B
C																											C
D																											D
E																											E
F																											F
G																											G
H																											H
I																											I
J																											J
K																											K
L																											L

HABFORM

Computer Records Verified _____

COMMENTS AND NOTES: 60 SPACES

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	

Figure E8-10. Bald eagle habitat mapping form—"HabForm".

Phoenix. For each river kilometer Km or reservoir shoreline kilometer (SKm), we scored the following habitat attributes:

FLOW - river flow in cubic feet per second

RSEL1 - reservoir elevation on day of mapping

RSEL2 - reservoir elevation at spillway level

SEG - river Km segment (see BioSystems River Map Atlas)

KMPCH - the 100 m segment containing the main perch per Seg

SKM - reservoir shoreline kilometer

LKPCH - the 100 m SKm containing the main perch per Skm

SD - side of the river with main perch (Left/Right, facing downstream)

PCH1 - Hunting Perches, as follows:

0 = No data
1 = No cliffs within 200 meters of water, and no snags or trees within 50 meters of water (at high water mark)
2 = Cut-bank < 10 meters high, small snag, or large live tree 25-50 meters of water (or small phone pole)
3 = Large live tree with perch branch within 25 meters of water
4 = Small cliff, cut-bank ≥ 10 meters high, or large snag within 25 meters of water, or small snag in water
5 = Large promontory cliff or snag

PCH2 - as above, from reservoir high water mark

REH1 - reservoir depth within 20 ft of shore at current pool level):

0 = No data
1 = > 200 cm (6 ft)
2 = 101-200 cm (3-6 ft)
3 = 61-100 cm (2-3 ft)
4 = 31-60 cm (1-2 ft)
5 = < 30 cm (1 foot)

REH2 - reservoir depth within 20 ft of shore at high water mark

RN - percent of Km that is run habitat

PO - percent of Km that is pool habitat

RI - percent of Km that is riffle habitat

NR - the number of riffles in the seg

PD - passive disturbance, as follows:

0 = No data
1 = Major disturbance within 25 meters of water
2 = Major disturbance 26–50 meters from water
3 = Major disturbance 51–100 meters from water
4 = Major disturbance 101–200 meters from water
5 = Minor disturbance within 25 meters of water
6 = Minor disturbance 26–50 meters from water
7 = Minor disturbance 51–100 meters from water
8 = Minor disturbance 101–200 meters from water
9 = No passive disturbance within 200 meters of water

TPD - main type of passive disturbance in seg. Major Use Area: boat launch (BL), tuber launch (TL), paved road (PR) or parking lot (PL), designated camp site (DC), dirt road river access in high use (RA), dwellings (DW), major operations (MO). Minor Use Area: dirt road (DR), undesignated camp site (UC).

SPD - the side of the river with the most passive disturbance

EA - eagle activity index: 1=low...5=high; used in reaches with "nest effect" (see Section A.8 Glossary)

SS - segment eagle visitation score

SP - % segment eagle visitation score

LS - shoreline kilometer visitation score

LP - % shoreline kilometer visitation score

E8.4 ANALYSIS OF TRACKING DATA

As described in Section B2, data on the movements of telemetered adult eagles in the nesting areas studied by telemetry represent more or less uninterrupted "time-lines" of eagle activity from dawn usually until mid-afternoon for 8½ consecutive days in each period. Each time an eagle changed locations or behaved differently relative to foraging, trackers entered a new data string on the ObsForm.

In all, there were some 36,600 ObsForm data records, each containing 53 data fields describing the movements and activities of bald eagles in the seven territories and the ancillary data pertaining to these

activities. We entered these data to an IBM-PC, using "dBASE III+" software, and hand-checked every field of every record on print-outs.

To begin our analysis of home range and habitat selection, we first separated the data into files according to individual birds and eliminated all records involving incidental observations rather than time-line tracking data from those files. These refined data files on the movements and activities of individual telemetered adults varied from 758 records for the Cliff male to 5,132 records for the Blue Point male, with an average of 2,611 records per telemetered adult (n = 9 individuals).

We then separated within each file the activities that might be indicative of foraging from all other activities. This "activity filter" selected all variations of: (1) perching (see 2-letter activity codes listed on the ObsForm Instructions in Section E8.1); (2) eating (except eating in nest); (3) standing; (4) foraging (all Q-codes except QD); (5) flying with head-down looking; (6) walking; (7) telemetry perched; and, (8) telemetry variable (probably eating). We sorted the resulting file chronologically and subdivided it into 28-day periods, each of which contained 15 days of time-line tracking data. Each 28-day period comprised a pair of inclusive 10-day periods with off-days included (see ground tracking, above). For example, periods 1 and 2 made up a 28-day period, and so on. The purpose of the 28-day periods was to provide data samples of sufficient size for seasonal comparisons in habitat and prey selection. The resulting files contained information of two types, including (1) the number of minutes an eagle remained at a location (actually the duration of observation) and (2) the frequency of visitations to each location.

We found that the first measure (time spent at each location) offered a relatively poor appraisal of habitat selection compared to the visitation frequency data. Consider this scenario: An eagle loafed for 146 minutes at a location 300m downstream from the nest (in sight of the nest), then flew two kms upstream where he perched for five minutes at each of three locations, some 200 m apart. At the last of these, the eagle successfully foraged, after which, he returned to the nest area where he spent the remainder of the day (62 minutes). Clearly, the time data alone award small significance to the foraging area where he spent only about two percent of the time.

By contrast, the visitation technique recognized each of the locations where the eagle perched, the assumption being that the eagle selected each area on the basis of its quality as habitat. Each location visited received a score of one point. If the eagle left a location and entered another 100-m segment along the river, but then returned to the original location, the latter received another point. Thus, locations that were repeatedly revisited received the most points.

The accuracy with which we were able to locate eagles affected the analysis of visitation scores. In most cases, we were able to assign a perched or foraging bird to a specific 100-m (0.1-km) segment along the river. If we could not do so, we attempted to locate it within a full kilometer, and, failing that, to a "zone," as explained in Section E8.2.10. In constructing bar graphs which describe the foraging ranges of the various telemetered eagles, we account for these imprecise locations, as explained in the Figure legends.

Another difficulty associated with the visitation frequency technique was the very large number of visitations to the nest which tended to grossly overshadow the other visitation scores. Eliminating the nest area from a habitat selection analysis was inappropriate because the nest vicinity was often an important foraging area. We, therefore, consulted the prey delivery data to estimate what percentage of all forages by the eagle were made in the nest vicinity. This percentage became the visitation percentage

Plate E25. Jack Barclay monitoring post-fledging juvenile bald eagles at the Orme breeding area, May 1987 (photo by T. Gatz).

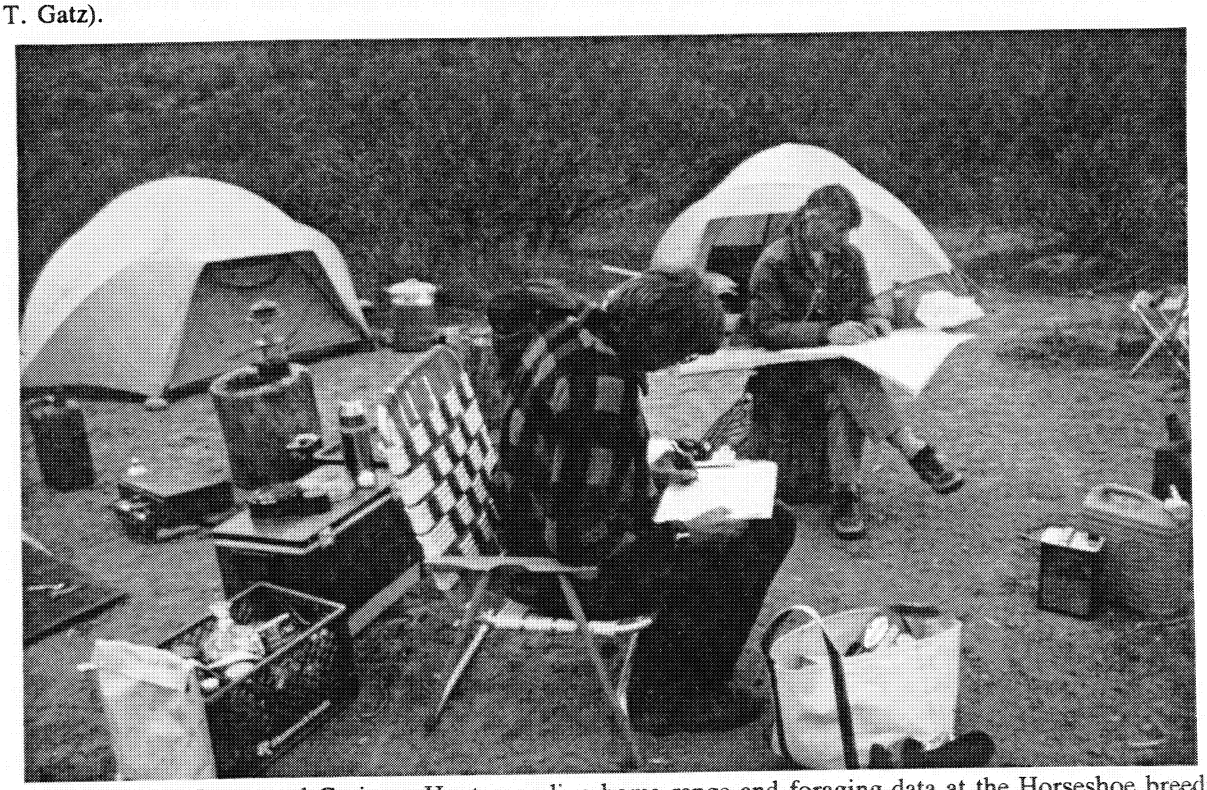


Plate E26. Robin Hunter and Grainger Hunt recording home range and foraging data at the Horseshoe breeding area, spring 1988 (photo by T. Gatz).

for the nest area, and percentages of all other areas in the territory were correspondingly adjusted to reflect the weighted percentage for the nest area.

Plate E27. Ed Bianchi and Jeff Simms seining fish on the lower Verde River (photo by P. Becker).

E8.5 GENERAL METHODS FOR STUDYING FISHERIES

Objectives of the fisheries studies were to identify: (1) relative abundance of prey fish within eagle territories; (2) seasonal and diel changes in the distribution and abundance of prey vulnerable to eagles (i.e., in shallow water); (3) timing and duration of spawning within eagle territories and its effect of fish availability; (4) relative and absolute abundance of riverine habitat within eagle territories; and, (5) effect of water management on prey availability.

To meet the study objectives, the fisheries team had to work closely with the eagle biologists to stay informed on the foraging activity of the birds in each territory. As new information was obtained, the fisheries team often had to respond quickly to changes in the eagles' foraging locations and species taken by the eagles at several territories concurrently. We also had to make some assumptions about foraging patterns of the eagles so we could collect baseline data necessary to determine if changes in fish abundance, water management, or fish activity might explain the foraging patterns of the eagles.

Several factors influenced the fisheries techniques employed during this study namely :

1. The study area was huge, encompassing over 325 km of the Salt and Verde rivers, 100 km of reservoirs (Bartlett, Horseshoe, Roosevelt, Saguaro), 20 km of the East Verde River and the lower portions of nine tributary streams (Fossil Creek, Carrizo Creek, West Clear Creek, Cherry Creek, Pinal Creek, Tonto Creek, Sycamore Creek, Lime Creek, Houston Creek).

2. The fisheries studies had to be conducted concurrently with eagle foraging studies, which required that we did not disrupt eagle activity or influence prey availability during sampling.

3. Flows were quite variable in study reaches, ranging from 0 cfs to several thousand cfs during the nesting season; requiring sampling techniques to accommodate these changes in flows.

4. Since bald eagles forage only in the top 0.6 m of water, fish availability in shallow water (< 0.6 m) and the surface of pools or reservoirs was more important to document than overall fish abundance in a river or reservoir.

5. We wanted to identify the behavioral attributes of fish which make them vulnerable to eagles.

6. Study emphasis on eagle pairs sometimes changed during a season due to nest failures or difficulties in capturing specific birds. The fisheries team was then required to move into an "new" territories and assess habitat conditions and prey availability. Therefore, we had to rely on sampling techniques which would allow us to quickly assess foraging conditions in a territory, rather than focus on long-term, labor intensive methods.

Based on the objectives of the study, budget restrictions, and sampling requirements, we chose to use direct observation (visual surveys) as our primary method. However, whenever possible, we used other sampling techniques, such as gill netting, electrofishing and seining to verify our observational data. For our purposes, direct observation was more advantageous than more traditional fisheries methods (i.e., electrofishing, seining, gill netting) for several reasons, namely: (1) fish behaviors could be observed; (2) repeated sampling within nesting territory did not compromise eagle foraging studies by reducing fish abundance or increasing carrion; (3) large field crews, which would have increased labor costs and disturbed the eagles, were not needed; (4) data could be collected relatively quickly, allowing for a wider sampling of areas; (5) the top 0.6 m of habitat could be surveyed regardless of flow or overall depth; and, (6) surveys could be conducted in remote areas, difficult to access with most sampling equipment.

We are not the first to use direct observation in fisheries studies. Direct observation with snorkel gear is commonly used for determination of species composition and abundance. Under some circumstances, observational data are even considered superior to conventional methods (Goldstein 1978; Northcote and Wilkie 1963; Slaney and Martin 1987; Hankin 1986; and Hankin and Reeves 1988). Direct observation

(visual estimation) is particularly useful in streams and rivers where the use of electrofishing is prohibited by such factors as deep water, abundant macrophytes, and particularly high or low conductivity (Griffith 1981). The observation method is commonly used for determining microhabitat use (Helfman 1981; Grossman *et al.* 1987a; Grossman *et al.* 1987b; Rimmer *et al.* 1984; Shirvell and Dungey 1983; Gosse and Helm 1981; Fausch and White 1981; Griffith 1972), macrohabitat use (Hartman and Brown 1987; Hicks and Watson 1985), and comparative behavior and habitat partitioning (Griffith 1972; Werner *et al.* 1977; Reeves *et al.* 1987).

Below is a description of the different methods we use to characterize habitat conditions and fish availability in large rivers (Salt and Verde), tributary streams, and reservoirs.

E8.5.1 Aquatic Habitat

E8.5.1.1 Aquatic Habitat Surveys. We conducted habitat surveys in some of the priority study areas to: (1) determine relative and absolute habitat abundance; (2) ascertain whether bald eagle foraging areas differed significantly from non-foraging areas; (3) determine if bald eagles foraged in habitat in proportion to its abundance or actively selected specific habitat types; and, (4) select representative fish sampling locations.

In these habitat surveys, two biologists divided the river into discrete habitat units based on their physical characteristics (see Table E8-9). For each habitat type identified, we noted the location of its upstream boundary to the nearest 0.1 km, habitat length, percent fish cover, percent braided, presence of a tributary, whether the eagle was known to forage in the habitat, carrion abundance by species, whether fish spawning activity was observed, and average slopes for the right and left river banks (Figure E8-11).

In addition, a representative transect was placed in each habitat type to determine habitat width, substrate composition, and depth profiles. Habitat length and width were measured to the nearest foot using a fiberglass tape. All other parameters were estimated independently by the two biologists and recorded once agreement was reached. Habitat types were documented through photographs.

E8.5.1.2 Super-riffles. We mapped the distribution and characteristics of super-riffles by airplane in the Salt River from Granite Reef Dam to the confluence of the White and Black rivers (Km 0.0–247.0) and in the Verde River from the confluence with the Salt River to Camp Verde (Km 0.0–185.0) on 3 July 1990. At this time, flow in the Salt River was quite variable, ranging from around 100 cfs in the upper Salt River, above Roosevelt Reservoir, to 1600 cfs in the lower Salt River, downstream of Saguaro Reservoir. Flows in the Verde River fluctuated between 30 cfs near Camp Verde to 125 cfs below Bartlett Reservoir. Three biologists mapped the habitat from an airplane flying at an altitude of approximately 1000 ft above the river. During the flight, we used the BioSystems River Map Atlas to determine the location of each super-riffle to the closest 0.1 km.

Once located, each super-riffle was given an overall ranking (1, 2, 3) depending on visual estimates of size and persistence at higher flows. A ranking of "3" was given to a habitat which showed all the characteristics of a super-riffle at low flows but we questioned whether moderate flow increases would eliminate the habitat. A ranking of "2" was given to habitats that would persist during moderate flow increases but would most likely lose its riffle characteristics during high flows. The top ranking, "1," was given to habitat which we predicted would persist even at high spring flows.

Figure E8-11. Aquatic habitat survey form for Arizona streams.

River ____ ___ Date ____ Crew ___/___

River km	Habitat Number	Habitat Type	Habitat Length	Habitat Width	% Substrate (transect) Mud	Sand (<⅛)	Gravel (⅛-2.9")	Rubble (3-12")	Boulder (>12")	Bedrock	Cover Type Dominent = 1 and % of Habitat) Vegetation	Logs	Rocks	Undercut

Habitat Number	% Habitat with Depths (0-2 ft)	(2-4 ft)	(4-6 ft)	(6-8 ft)	(>8 ft	% Habitat Braided	Trib (Y/N)	For. Site (Y/N)	Carrion (sp.&#)	Spawning Activity (sp. & description)	Slope Rt Bank	Lf Bank

Habitat Types:

A1 Pool (0-4 ft)
A2 Pool (4-8 ft)
A3 Pool (>8 ft)

LB = Low Gradient Run
HB = High Bradient Run
C = Riffle

D = Eddy (>2ft)
G = Backwater
F = Cascade

BS1 = Boulder Strewn (Rock < 2 ft)
BS2 = Boulder Strewn (Rock > 2 ft, # = 1-5)
BS3 = Boulder Strewn (Rock > 2 ft, # = >5)

Table E8-9. Aquatic habitat type definitions used in stream surveys.

Pool:	River habitat that has slow water velocity, water surface elevation gradient near zero, and holds significant amounts of water at zero flow. A "shallow pool" is < 4 ft deep, a "medium-depth pool" is 4–8 ft deep, and a "deep pool" = > 8 ft deep.
Run:	River habitat characterized by moderate current, non-turbulent surface, moderate slope. Runs are typically too deep to be riffles, too fast to be pools, and few large boulders. A "slow run" has a relatively smooth surface; a "fast run" has noticeable surface turbulence.
Riffle:	River habitat of fast, shallow water, moderate slope, turbulence, and exposed substrate. Streambed elements consist primarily of gravel (0.16–2.5 in. in diameter) and rubble (2.5–10.0 in. in diameter).
	Normal Riffle: A riffle which becomes a run with moderate flow increases.
	Super-Riffle: Riffles which maintain habitat integrity under a wide variety of flows. As flow increases, water depth and velocity increase in only a small area of the habitat, while overall the amount of shallow water increases in the riffle due to the spreading of water across a gravel bed.
Pocket Water:	River habitat characterized as boulder strewn; habitat dissociated, moderate slope (see Boulder Strewn).
Cascade:	River habitat with very steep slope over short distance.

Since few of the gravel bars making up the super-riffles extended entirely across the river channel, we also noted whether the tip of the riffle was oriented upstream, downstream, or parallel to its base. We also documented whether the super-riffle occurred in close proximity to a cliff, braid, tributary or river bend. If the habitat was associated with river bend, we noted if it was located on the inside or outside portion of the river channel.

E8.5.1.3 River Flow and Reservoir Elevation. River flow in the study area were characterized using data obtained from the Salt River Project and the U.S. Geological Survey. Gaging stations are located at various points along the Salt and Verde rivers. Flows were examined from data taken at the following gaging stations: Verde River below the Bartlett Dam, Verde River at Camp Verde, Verde River below the Horseshoe Reservoir, Salt River at the Roosevelt Reservoir, and the Salt River below the Stewart Mountain Dam. Flows were taken on a daily basis at these gaging stations. From these daily flow rates, mean monthly flows were obtained by averaging daily flows over each month. Minimum and maximum discharge rates were also determined for each month. Mean monthly flows and the range of monthly flows in each eagle territory were presented for the three-year study period (December 1986 to June

1989). River flows were also presented on a daily basis from December to June during the months eagle studies were conducted.

Reservoir elevations were examined using data provided by the Salt River Project. Water elevations were taken daily at Roosevelt, Bartlett, Horseshoe and Saguaro reservoirs. These data were averaged over each month to obtain mean monthly elevations for the study period (1986–1989). The range of minimum and maximum reservoir elevations were also determined for each month.

E8.5.2 Fish Abundance, Activity, and Distribution

E8.5.2.1 Relative Abundance. We were unable to determine the relative abundance of eagle forage fish in each of the nesting territories by direct sampling due to the size of the study area (see Section D2). Instead, we compiled the most recent information on fish communities in the various river reaches, tributaries and reservoirs by obtaining: (1) published reports by the AGF and USFWS; (2) personal communication with state and federal agency personnel; and, (3) field data from D. Hendrickson of the AGF Nongame Branch, M. Jakle of Bureau of Reclamation, and C. Zeibell of Arizona Cooperative Fisheries Research Unit. We augmented this information on fish communities on an incidental basis with data we collected during our fisheries surveys.

E8.5.2.2 Visual Surveys. Our biologists conducted two types of visual surveys in the Salt and Verde rivers, a roving survey and a fixed point survey. In both surveys, biologists used polarized sunglasses, 10× binoculars, and 20–60× spotting scopes to assist in fish identification. Fish activity was placed into four general categories: Feeding, Courtship, Courtship and Spawning, and Lethargic. If courtship or spawning was observed, the estimated proportion of fish exhibiting such behavior was noted to serve as an index of spawning intensity.

In the roving surveys, depending on flow, either one or two biologists walked along the river bank noting habitat, depth, location (to nearest 0.1 km), time, abundance, and activity of fish observed. Whenever possible, we climbed trees and cliffs to get a better view of the fish in the river. In general, we spent less than 1 hour at each site where fish were observed to allow us to survey large sections of the river in a single day. These roving surveys were conducted several times a month in the various eagle territories to identify changes in the activity and vulnerability of fish over time and during different flows. Although we were generally unable to identify fish in water deeper than 1.2 m we feel that the surveys accurately represented foraging opportunities for the eagles since they rarely forage deeper than 0.6 m. During these surveys, we also recorded air and water temperatures at least 3 times daily.

Our fixed point surveys were directed toward documenting diel changes in fish activity and availability during the nesting season at locations frequented by the eagles. We concentrated our efforts at locations where a cliff or rock pinnacle provided an overview of the foraging site. Height of these observation points ranged from 10–80 m above the river. At each location, we quantified the number of fish in shallow water (< 1 m) and their activity at one-hour intervals from dawn to dusk. At some locations, poor lighting or glare limited observation during the early morning or late afternoon.

In Saguaro Reservoir, we also conducted several fixed point surveys at Willow Spring Cove and Peregrine Cove during the 1988 and 1989 nesting season to document changes in fish activity and availability over time. We made our observations from elevated vantage points (either rock pinnacles or hillsides) using polarized glasses and 10× binoculars. Fish numbers and activity were noted in one-hour intervals from dawn to dusk when adequate light was available.

We also surveyed tributary streams of the Salt and Verde rivers to quantify the distribution and abundance of eagle forage fish. The shallow depth, narrow width, and clear water of these streams made them ideal for visual surveys. These roving surveys were usually conducted by a single biologist walking along the streambank noting the habitat type encountered, number and size of fish species observed, and the number and size of any carrion fish. The biologist also noted the number, size range and location (km and depth) of any spawning fish observed. Polarized glasses and binoculars aided in species identification. The first time a survey was carried out in a particular tributary stream, habitat lengths and widths were measured so that the relative and absolute abundance of specific habitat types could be calculated.

In some tributary streams, it was necessary for two biologists to participate in the surveys during high flows. At such times, the biologists walked on opposite banks of the streams so that the entire streams could be surveyed. We also noted when water depth or cover (i.e., undercut banks) precluded complete coverage of a habitat. A subsample of these habitats was subsequently surveyed using snorkeling gear. In each tributary stream, several gill nets were also placed in pool habitat to verify our observational data.

E8.5.2.3 Gill Nets. To verify our observational data, we routinely collected suckers and carp using floating gill nets and throw nets in riffles, runs and shallow pools (< 3 ft deep). In deeper pools, we set gill nets overnight to collect fish. Fish collected were identified to species, measured (SL and TL), weighed, and sexed. We also noted whether breeding tubercles were present and their location. The reproductive status of each fish was assessed in two steps. First, we recorded whether the fish released gametes during initial handling. Ripe fish were considered to be those that released either eggs (RSE) or milt (RSS) during initial handling. Non-ripe fish were those that did not release gametes during initial handling (NRS). Regardless of their reproductive status, all fish were then dissected to further document gonadal development. Fish were placed into one of five categories depending the abundance of gametes and gonad development. Fish with numerous gametes in their gonads (> 50% full) were designated either EG (eggs abundant) or SM (sperm abundant). Fish with well developed gonads but were less than 50 percent full where designated SPO (spawned out). Adult fish with small, shrunken gonads containing no gametes were designated A (atrophy). Fish which contained no discernable gonads were designated UN (undeveloped). Although it may appear that the 50 percent fullness criteria for designating fish either EG, SM or SPO is somewhat arbitrary, we rarely found a fish that was between 70 percent and 20 percent full. We also recorded the percent fullness of every dissected fish for future reference if we deemed the criteria to be inappropriate.

Additional data collected on female fish included the color and size of eggs released and retained in the gonads. In general, two different types of eggs were present in the ovaries depending on the developmental stage. Primary eggs were those that were either released from the gonads or that comprised the greatest percentage of eggs in the ovary. Secondary eggs were those that were retained in the ovary and ranked second in terms of their abundance.

E8.5.2.4 Floating Gill Nets/Throw Nets. Since the majority of sucker spawning and eagle foraging occurred in riffle and run habitat, we wanted to collect fish from these habitats to determine their relative abundance, mean size, and reproductive status. However, we wanted to avoid producing carrion that would effect foraging studies being conducted concurrently. Electrofishing was not feasible due to its potential to produce carrion, particularly delayed carrion production. Seining was not effective because the fish were able to avoid the net, and the current in many of these habitats was too high to drag the net through. Instead, we used a floating gill net and throw net to catch fish in shallow habitat. The gill net employed was 6 ft deep × 80 ft long with a weighted lead line and floats on the top of the net. The net

Plate E28. Frank Hein and "Woodie" at Horseshoe (photo by P. Becker).

was divided into four 20-foot-long panels of mesh size ½″, 1″, 2″ and 4″. Two people positioned the net across the river just upstream from the sample location. The net was allowed to float downstream into the sample area. As the net floated downstream, one person held the net at each end and walked downstream keeping the net spread open. Entire habitats were sampled except when large numbers of fish were caught in the upper portions of the habitat.

Similarly, throw nets were used to catch fish in shallow water habitat, and also provided the opportunity to catch actively spawning fish. One person equipped with 6′-diameter throw net (mesh size 2′) carefully approached spawning and foraging fish and threw the net over the fish. This method provided us with

the opportunity to verify our assessment of the reproductive status of fish based on their behavior with an actual physical examination of gonadal development.

To catch fish in deep pools, we used variable gill nets (same design as the floating gill nets), set overnight. A minimum of two nets were used in each habitat to collect fish. Nets were set so that the entire water column was sampled.

Fish caught during netting were identified, measured, weighed, inspected for disease or parasites, and assessed for gonadal development. All fish collected were killed and either buried, used (in special cases) to supplement food for eagles in other territories, or kept for the reference collection.

Each area sampled by floating gill nets was characterized in terms of its location (within 0.1 km), habitat type, length, width, depth (minimum, maximum, average), velocity, percent cover, and substrate (dominant and subdominant). Habitat conditions in areas sampled by gill nets set overnight or throw nets were obtained from previous comprehensive habitat surveys.

E8.5.2.5 Snorkeling Surveys. In several reaches of the Salt River (Blue Point and Pinal territories), we conducted visual surveys using wet suits and snorkeling gear to aid in the determination of relative abundance and distribution of forage fish. During these surveys, two biologists floated down the river noting the habitat type encountered and the number and size of adult fish (either alive or dead) observed in each habitat. The biologists swam parallel to one another on different sides of the river trying to keep equal distance between themselves and the closest river bank. Although this approach did not allow complete coverage of the river, representative transects were sampled. In some territories (Blue Point), the surveys were repeated several times over the nesting season. By comparing numbers and sizes of fish observed in each survey, we could detect if significant changes in the distribution of fish occurred over time.

E8.5.2.6 Electrofishing. Comprehensive electrofishing surveys were conducted in only one eagle territory (East Verde) during the study. Methods are described in Section B4.4. We avoided electrofishing during the nesting season so as not to bias our eagle foraging studies, since shocked fish may not die for several days.

E9 SPECIES LIST

MAMMALS

Common Name	Species Name
Beaver	*Castor canadensis*
Blacktail jack rabbit	*Lepus californicus*
Coyote	*Canis latrans*
Desert cottontail	*Sylvilagus auduboni*
Domestic cow	*Bos* sp.
Domestic sheep	*Ovis aries*
Eastern cottontail	*Sylvilagus floridanus*
Gray wolf (timber)	*Canis lupus*
Grizzly bear	*Ursus horribilis*
Ground squirrel	*Citellus* sp.
Hognose skunk	*Conepatus leuconotus*
Javelina	*Tayassu tajacu*
Mule deer	*Odocoileus hemionus*
Muskrat	*Ondatra zibethica*
Nutria	*Myocastor coypus*
Raccoon	*Procyon lotor*
Ringtail	*Bassariscus astutus*
River otter	*Lutra canadensis*
Rock squirrel	*Citellus variegatus*
Woodrat	*Neotoma* sp.

BIRDS

American black duck	*Anas rubripes*
American coot	*Fulica americana*
American wigeon	*Anas americana*
Bald eagle	*Haliaeetus leucocephalus*
Black eagle	*Aquila verreauxii*
Black-crowned night-heron	*Nycticorax nycticorax*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Cinnamon teal	*Anas cyanoptera*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Common moorhen	*Gallinula chloropus*
Common murre	*Uria aalge*
Common raven	*Corvus corax*

BIRDS (cont.)

Common Name	Species Name
Domestic chicken	*Gallus gallus*
Double-crested cormorant	*Phalacrocorax auritus*
Dusky seaside sparrow	*Ammodramus maritimus nigrescens*
Eared grebe	*Podiceps nigricollis*
Gadwall	*Anas strepera*
Gambel's quail	*Callipepla gambelii*
Golden eagle	*Aquila chrysaetos*
Great blue heron	*Ardea herodias*
Great egret	*Casmerodius albus*
Great horned owl	*Bubo virginianus*
Green-backed heron	*Butorides striatus*
Green-winged teal	*Anas crecca*
Gulls	Fam. Laridae
Harris' hawk	*Parabuteo unicinctus*
Heath hen	*Tympanuchus cupido cupido*
Herring gull	*Larus argentatus*
Mallard	*Anas platyrhynchos*
Mourning dove	*Zenaida macroura*
Northern shoveler	*Anas clypeata*
Northern pintail	*Anas acuta*
Peregrine falcon	*Falco peregrinus*
Pied-billed grebe	*Pocilymbus podiceps*
Red-tailed hawk	*Buteo jamaicensis*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Rough-legged hawk	*Buteo lagopus*
Ruddy duck	*Oxyura jamaicensis*
Sharp-shinned hawk	*Accipiter striatus*
Shorebirds	Fam. *Charadriidae* Fam. *Scolopacidae*
Short-tailed shearwater	*Puffinus tenuirostris*
Snow goose	*Chen caerulescens*
Snowy egret	*Egretta thula*
Snowy owl	*Nyctiea scandiaca*
Western grebe	*Aechmophorus occidentalis*
White-faced ibis	*Plegadis chihi*
Wild turkey	*Meleagris gallopavo*

REPTILES

Common chuckwalla	*Sauromalus obesus*
Sonoran mud turtle	*Kinosternon sonoriense*
Spiny softshell turtle	*Trionyx spiniferus*

FISH

Common Name	Species Name
American eel	*Anguilla rostrata*
Atlantic menhaden	*Brevoortia tyrannus*
Black bass	*Micropterus* sp.
Black crappie	*Pomoxis nigromaculatus*
Blue catfish	*Ictalurus catus*
Bluegill	*Lepomis machrochirus*
Bluehead sucker	*Pantosteus discobolus*
Bonytail chub	*Gila elegans*
Brown bullhead	*Ictalurus nebulosus*
Brown trout	*Salmo trutta*
Buffalo	*Ictiobus* sp.
Carp	*Cyprinus carpio*
Chain pickerel	*Esox niger*
Channel catfish	*Ictalurus punctatus*
Cisco	*Coregonus artedii*
Colorado squawfish	*Ptychocheilus lucius*
Desert sucker	*Catostomus clarki*
Flannelmouth sucker	*Catostomus latipinnis*
Flathead catfish	*Pylodictis olivaris*
Gizzard shad	*Dorosoma cepedianum*
Golden shiner	*Notemigonus crysoleucas*
Green sunfish	*Lepomis cyanellus*
Humpback chub	*Gila cypha*
Largemouth bass	*Micropterus salmoides*
Mosquito fish	*Gambusia affinias*
Northern pike	*Esox lucius*
Rainbow trout	*Salmo gairdneri*
Razorback sucker	*Xyraunshen texanus*
Red shiner	*Notropis lutrensis*
Roundtail chub (Colorado river)	*Gila robusta*
Sacramento sucker	*Catostomus occidentalis*
Smallmouth bass	*Micropterus dolomieui*
Sonora sucker	*Catostomus insignis*
Speckled dace	*Rhinichthys osculus*
Striped bass	*Morone saxatilis*

FISH (cont.)

Tilapia	*Tilapia* sp.
Utah chub	*Gila atraria*
Utah sucker	*Catostomus ardens*
Walleye	*Stizostedion vitreum*
White catfish	*Ictalurus furcatus*
White perch	*Morone americana*
White sucker	*Catostomus commersoni*
Yellow bass	*Morone mississippiensis*
Yellow bullhead	*Ictarus natalis*
Yellow perch	*Perca flavescens*

ARTHROPODS

Common Name	Species Name
Lousefly	*Icosta nigra*
Mexican chicken bug	*Haematosiphon inodorus*
Tick	*Argas cooleyi*

PLANTS

Cotton	*Gossypium hirsutum*
Cottonwood	*Populus fremontii*
Desert willow	*Salix exigua*
Goodding willow	*Salix gooddingii*
Mesquite	*Prosopis* sp.
Salt cedar	*Tamarix chinensis*

OTHER

Abalone	*Haliotis* sp.