The Great Trinity Forest Management Plan

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Threatened and Endangered Species

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Great Trinity Forest Management Plan

Threatened and Endangered Species

A Guide to the Laws and Treaties of the United States for Protecting Migratory Birds

A Guide to the Laws and Treaties of the United States for Protecting Migratory Birds

A fairly large number of international treaties and domestic laws have been enacted that provide protection for migratory birds. To help put the legal authorities into perspective, we have categorized them as primary and secondary authorities. Primary authorities are international conventions and major domestic laws that focus primarily on migratory birds and their habitats. Secondary authorities are broad-based domestic environmental laws that provide ancillary but significant benefits to migratory birds and their habitats.

Primary Federal Authorities for Migratory Birds

For purposes of discussion, it is helpful to group the primary authorities of the United States for migratory birds into those that protect bird populations (primarily) and those that protect bird habitats.

Protecting Bird Populations: Federal Laws

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Lacey Act

By the late 1800s, the hunting and shipment of birds for the commercial market (to embellish the platters of elegant restaurants) and the plume trade (to provide feathers to adorn lady's fancy hats) had taken their toll on many bird species. Passenger pigeons, whose immense flocks had once darkened the skies, were nearing extinction. Populations of the Eskimo curlew and other shorebirds had been decimated. The snowy egret and other colonial-nesting wading birds had been reduced to mere remnants of their historical populations. The Lacey Act (passed on May 25, 1900) prohibited game taken illegally in one state to be shipped across state boundaries contrary to the laws of the state where taken. The Lacey Act has become a very effective tool for enforcing the wildlife protective laws of the States and the Federal government (a detailed synopsis is available).

However, in the early years of the 20th century the Act was ineffective in stopping interstate shipments, largely because of the huge profits enjoyed by the market hunters and the lack of officers to enforce the law. These early failures of the Lacey Act led to passage of the Weeks-McLean Law.

Weeks-McLean Law

The Weeks-McLean Law (which became effective on March 4, 1913) was designed to stop commercial market hunting and the illegal shipment of migratory birds from one state to another. The Act boldly proclaimed that:

All wild geese, wild swans, brant, wild ducks, snipe, plover, woodcock, rail, wild pigeons, and all other migratory game and insectivorous birds which in their northern and southern migrations pass through or do not remain permanently the entire year within the borders of any State or Territory, shall hereafter be deemed to be within the custody and protection of the Government of the United States, and shall not be destroyed or taken contrary to regulations hereinafter provided therefor.

The Weeks-McLean Law rested on weak constitutional grounds, having been passed as a rider to an appropriation bill for the Department of Agriculture, and it was soon replaced by the Migratory Bird Treaty Act of 1918.

Migratory Bird Treaty Act of 1918

Following close on the heels of the Lacey Act and the Weeks-McLean Law, the framers of the Migratory Bird Treaty Act were determined to put an end to the commercial trade in birds and their feathers that, by the early years of the 20th century, had wreaked havoc on the populations of many native bird species.

The Migratory Bird Treaty Act decreed that all migratory birds and their parts (including eggs, nests, and feathers) were fully protected.

The Migratory Bird Treaty Act is the domestic law that affirms, or implements, the United States' commitment to four international conventions (with Canada, Japan, Mexico, and Russia) for the protection of a shared migratory bird resource. Each of the conventions protect selected species of birds that are common to both countries (i.e., they occur in both countries at some point during their annual life cycle). A List of Migratory Birds protected by the Migratory Bird Treaty Act is available.

For those desiring additional information on the Migratory Bird Treaty Act, a detailed synopsis is available. That section of the United States Code pertaining to the Migratory Bird Treaty Act can also be accessed.

Endangered Species Act of 1973

The relevance of this landmark legislation to migratory bird conservation needs little elaboration. For the curious, you can access the full text of the Endangered Species Act on-line. For the less curious but still interested, a detailed synopsis is available. For a full list of birds protected by the Endangered Species Act in the U.S., first click here then click on the bird icon that appears at the top of the screen. A checklist of the species protected by both the Endangered Species Act and the Migratory Bird Treaty Act is posted at List of Migratory Birds.

The Endangered Species Act is also the domestic law that confirms, or implements, the United States' commitment to two international treaties that contain important provisions for the protection of migratory birds:

- CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora)
- Pan American Convention (the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere).

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora)

A detailed synopsis of the CITES convention is available. A checklist of the species covered by both the CITES and the Migratory Bird Treaty Act is posted at List of Migratory Birds.

Other International Treaties

In additional to the conventions implemented by the Migratory Bird Treaty Act and the Endangered Species Act, the United States is party to two other international treaties that afford special protection to migratory birds.

Ramsar Convention (Convention on Wetlands of International Importance Especially as Waterfowl Habitats; I.L.M. 11:963-976; September 1972) -- This Convention was adopted in Ramsar, Iran, on February 3, 1971, and opened for signature at UNESCO headquarters on July 12, 1972. On December 21, 1975, the Convention entered into force after the required signatures of seven countries. The United States Senate consented to ratification of the Convention on October 9, 1986, and the President signed instruments of ratification on November 10, 1986.

The Convention maintains a list of wetlands of international importance and works to encourage the wise use of all wetlands in order to preserve the ecological characteristics from which wetland values derive. The Convention is self-implementing, with the U.S. Fish and Wildlife Service serving as the U.S. administrative authority for the Convention, in consultation with the Department of State. As of the Seventh Meeting of the Conference of the Parties, held in Costa Rica in May, 1999, there were 117 contracting parties.

Antarctic Treaty (Agreed Measures for the Conservation of Antarctic Fauna and Flora) -- These measures, adopted by the Third Antarctic Treaty Consultative Meeting in 1959, are designed to protect the native birds, mammals, and plants of the Antarctic.

Public Law 95-541 of October 28, 1978 (92 Stat. 2048) implements the measures by prohibiting, among other acts, the taking, importing and transporting of birds and mammals native to the Antarctic without a permit by persons subject to the jurisdiction of the United States, and the importing and exporting of such animals into or out of the United States.

Other Domestic Laws

- Bald Eagle Protection Act
- Waterfowl Depredations Prevention Act
- Fish and Wildlife Conservation Act
- Wild Bird Conservation Act

Protecting Bird Habitats: Federal Laws

- Duck Stamp Act
- Wetlands Loan Act
- Emergency Wetlands Resources Act
- Migratory Bird Conservation Act
- North American Wetlands Conservation Act

Duck Stamp Act

Formally known as the Migratory Bird Hunting and Conservation Stamp Act (passed in 1934), it provides a mechanism for generating money for the acquisition and protection of important migratory bird habitats. The habitat protection authorities of this Act have been significantly modified and strengthened in recent years by provisions of the Wetlands Loan Act (1961) and the Emergency Wetlands Resources Act (1986).

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Great Trinity Forest Management Plan

Threatened and Endangered Species

Federal and State Threatened and Endangered Species Regulations

Federal Endangered Species Act

Passed in 1973 and reauthorized in 1988, the Endangered Species Act (ESA) regulates a wide range of activities affecting plants and animals designated as endangered or threatened. By definition, **endangered species** is an animal or plant listed by regulation as being in danger of extinction. A **threatened species** is any animal or plant that is likely to become endangered within the foreseeable future. A species must be listed in the Federal Register as endangered or threatened for the provisions of the act to apply.

The Act prohibits the following activities involving endangered species:

- Importing into or exporting from the United States.
- Taking (includes harassing, harming, pursuing, hunting, shooting, wounding, trapping, killing, capturing, or collecting) within the United States and its territorial seas.
- Taking on the high seas.
- Possessing, selling, delivering, carrying, transporting, or shipping any such species unlawfully taken within the United States or on the high seas.
- Delivering, receiving, carrying, transporting, or shipping in interstate or foreign commerce in the course of a commercial activity.
- Selling or offering for sale in interstate or foreign commerce.

The Act also provides for:

- Protection of **critical habitat** (habitat required for the survival and recovery of the species).
- Creation of a **recovery plan** for each listed species.

Prohibitions apply to endangered species, their parts, and products. Most of these restrictions also apply to species listed as threatened unless the species qualifies for an exception. The Act also requires that wildlife be imported or exported through designated ports and that special declarations be filed. If the value of wildlife imported and/or exported is $25,000 per year or more, importers and exporters must be licensed.

Exceptions

Permits may be granted for scientific or propagation purposes or for economic hardship situations involving endangered or threatened species.

Penalties

Violators of the Endangered Species Act are subject to fines of up to $100,000 and one year's imprisonment. Organizations found in violation may be fined up to $200,000. Fish, wildlife, plants, and vehicles and equipment used in violations may be subject to forfeiture.

Rewards

Individuals providing information leading to a civil penalty or criminal conviction may be eligible for cash rewards.

The Endangered Species Act provides for listing plant and animal species into the following catagories:

Listed **Endangered** Species

Listed **Threatened** Species

Proposed Endangered Species

Proposed Threatened Species

Candidate Species (Category 1 - awaiting listing)

DL

Delisted Species (Species removed from endangered or threatened list)

Removed from list due to extinction
Removed from list due to taxonomic change
Removed from list because of abundance

State of Texas Threatened and Endangered Species Regulations

Animals

In 1973 the Texas legislature authorized the Texas Parks and Wildlife Department to establish a list of endangered animals in the state. **Endangered species** are those species which the Executive Director of the Texas Parks and Wildlife Department has named as being "threatened with statewide extinction". **Threatened species** are those species which the TPW Commission has determined are likely to become endangered in the future. Laws and regulations pertaining to endangered or threatened animal species are contained in Chapters 67 and 68 of the Texas Parks and Wildlife (TPW) Code and Sections 65.171 - 65.176 of Title 31 of the Texas Administrative Code (T.A.C.).

Plants

In 1988 the Texas legislature authorized the Department to establish a list of threatened and endangered plant species for the state. An **endangered plant** is one that is "in danger of extinction throughout all or a significant portion of its range". A **threatened plant** is one which is likely to become endangered within the foreseeable future. Laws and regulations pertaining to endangered or threatened plant species are contained in Chapter 88 of the TPW Code and Sections 69.01 - 69.9 of the T.A.C.

Regulations

TPWD regulations prohibit the taking, possession, transportation, or sale of any of the animal species designated by state law as endangered or threatened without the issuance of a permit. State laws and regulations prohibit commerce in threatened and endangered plants and the collection of listed plant species from public land without a permit issued by TPWD. In addition, some species listed as threatened or endangered under state law are also listed under federal regulations. These animals are provided additional protection by the U.S. Fish and Wildlife Service.

Listing and Recovery

Listing and recovery of endangered species in Texas is coordinated by the Wildlife Division. The Department's Wildlife Permitting Section is responsible for the issuance of permits for the handling of listed species.

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Threatened and Endangered Species

Texas Parks and Wildlife Code: Chapter 67- Nongame Species

CHAPTER 67. NONGAME SPECIES

Sec. 67.001. DEFINITION. In this chapter, "nongame" means those species of vertebrate and invertebrate wildlife indigenous to Texas that are not classified as game animals, game birds, game fish, fur-bearing animals, endangered species, alligators, marine penaeid shrimp, or oysters.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1985, 69th Leg., ch. 267, art. 1, Sec. 63, eff. Sept. 1, 1985; Acts 1997, 75th Leg., ch. 863, Sec. 7, eff. Sept. 1, 1997; Acts 1997, 75th Leg., ch. 1256, Sec. 109, eff. Sept. 1, 1997.

Sec. 67.0011. EXEMPTION OF CRAYFISH. This chapter does not apply to crayfish, other than in public water.

Added by Acts 1981, 67th Leg., p. 399, ch. 161, Sec. 4, eff. May 20, 1981.

Sec. 67.002. MANAGEMENT OF NONGAME SPECIES. (a) The department shall develop and administer management programs to insure the continued ability of nongame species of fish and wildlife to perpetuate themselves successfully.

(b) In managing nongame species of fish and wildlife, the department may:

(1) disseminate information pertaining to nongame species conservation, management, and values;

(2) conduct scientific investigation and survey of nongame species for better protection and conservation;

(3) propagate, distribute, protect, and restore nongame species;

(4) research and manage nongame species;

(5) develop habitats for nongame species; and

(6) acquire habitats for nongame species.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1985, 69th Leg., ch. 267, art. 1, Sec. 64, eff. Sept. 1, 1985.

Sec. 67.003. CONTINUING SCIENTIFIC INVESTIGATIONS. The department shall conduct ongoing investigations of nongame fish and wildlife to develop information on populations, distribution, habitat needs, limiting factors, and any other biological or ecological data to determine appropriate management and regulatory information.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 67.004. ISSUANCE OF REGULATIONS. (a) The commission by regulation shall establish any limits on the taking, possession, propagation, transportation, importation, exportation, sale, or offering for sale of nongame fish or wildlife that the department considers necessary to manage the species.

(b) The regulations shall state the name of the species or subspecies, by common and scientific name, that the department determines to be in need of management under this chapter.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1997, 75th Leg., ch. 1256, Sec. 110, eff. Sept. 1, 1997.

Sec. 67.0041. REGULATIONS AND PERMITS. (a) The department may issue permits for the taking, possession, propagation, transportation, sale, importation, or exportation of a nongame species of fish or wildlife if necessary to properly manage that species.

(b) The department may charge a fee for a permit issued under this section. The fee shall be set by the commission.

Added by Acts 1985, 69th Leg., ch. 267, art. 1, Sec. 65, eff. Sept. 1, 1985. Amended by Acts 1997, 75th Leg., ch. 1256, Sec. 111, eff. Sept. 1, 1997.

Sec. 67.005. PENALTY. (a) A person who violates a regulation of the commission issued under this chapter commits an offense that is a Class C Parks and Wildlife Code misdemeanor.

(b) A person who violates a regulation of the commission issued under this chapter and who has been convicted on one previous occasion of a violation of a commission regulation under this chapter commits an offense that is a Class B Parks and Wildlife Code misdemeanor.

(c) A person who violates a regulation of the commission issued under this chapter and who has been convicted on two or more previous occasions of a violation of commission regulations under this chapter commits an offense that is a Class A Parks and Wildlife Code misdemeanor.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Amended by Acts 1985, 69th Leg., ch. 267, art. 3, Sec. 77, eff. Sept. 1, 1985.

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Threatened and Endangered Species

Texas Parks and Wildlife Code:

Chapter 68-Endangered Species

CHAPTER 68. ENDANGERED SPECIES

Sec. 68.001. DEFINITIONS. In this chapter:

(1) "Fish or wildlife" means any wild mammal, aquatic animal, wild bird, amphibian, reptile, mollusk, or crustacean, or any part, product, egg, or offspring, of any of these, dead or alive.

(2) "Management" means:

(A) the collection and application of biological information for the purpose of increasing the number of individuals within species or populations of fish or wildlife up to the optimum carrying capacity of their habitat and maintaining these numbers;

(B) the entire range of activities constituting a full scientific research program, including census studies, law enforcement, habitat acquisition and improvement, and education; and

(C) when and where appropriate, the protection of and regulation of the taking of fish and wildlife species and populations.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.002. ENDANGERED SPECIES. Species of fish or wildlife indigenous to Texas are endangered if listed on:

(1) the United States List of Endangered Native Fish and Wildlife; or

(2) the list of fish or wildlife threatened with statewide extinction as filed by the director of the department.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1985, 69th Leg., ch. 267, art. 1, Sec. 66, eff. Sept. 1, 1985.

Sec. 68.003. STATEWIDE EXTINCTION LIST. (a) The director shall file with the secretary of state a list of fish or wildlife threatened with statewide extinction.

(b) Fish or wildlife may be classified by the director as threatened with statewide extinction if the department finds that the continued existence of the fish or wildlife is endangered due to:

(1) the destruction, drastic modification, or severe curtailment of its habitat;

(2) its overutilization for commercial or sporting purposes;

(3) disease or predation; or

(4) other natural or man-made factors.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.004. AMENDMENTS TO LIST BY DIRECTOR. (a) If the list of endangered native species issued by the United States is modified, the director shall file an order with the secretary of state accepting the modification. The order is effective immediately.

(b) The director may amend the list of species threatened with statewide extinction by filing an order with the secretary of state. The order is effective on filing.

(c) The director shall give notice of the intention to file a modification order under Subsection (b) of this section at least 60 days before the order is filed. The notice must contain the contents of the proposed order.

(d) If a reclassification petition is filed during the 60-day notice period required by Subsection (c) of this section, the order may not be filed until the conclusion of the proceeding on reclassification.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1985, 69th Leg., ch. 267, art. 1, Sec. 67, eff. Sept. 1, 1985.

Sec. 68.005. PETITION OF RECLASSIFICATION. (a) Three or more persons may petition the department to add or delete species of fish or wildlife from the statewide extinction list.

(b) The petition must present substantial evidence for the addition or deletion.

(c) If fewer than 50 people join in the petition, the department may refuse to review the classification list, but if 50 or more persons join in the petition, the department shall conduct a hearing to review the classification list. The hearing shall be open to the public, and notice of the hearing shall be given in at least three major newspapers of general circulation in the state at least one week before the date of the hearing.

(d) Based on the findings at the hearing, the department may file an order with the secretary of state altering the list of fish or wildlife threatened with statewide extinction. The order takes effect on filing.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.006. PERMIT FOR TAKING ENDANGERED SPECIES. The provisions of Subchapter C, Chapter 43, of this code are applicable to all fish or wildlife classified as endangered, and it is a violation of this chapter to possess, take, or transport endangered fish or wildlife for zoological gardens or scientific purposes or to take or transport endangered fish or wildlife from their natural habitat for propagation for commercial purposes without the permit required by Section 43.022 of this code.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1987, 70th Leg., ch. 607, Sec. 2, eff. Sept. 1, 1987.

Sec. 68.007. PROPAGATION PERMIT REQUIRED. No person may possess endangered fish or wildlife for the purpose of propagating them for sale unless he has first acquired a commercial propagation permit issued by the department under this chapter.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.008. ORIGINAL PROPAGATION PERMIT. (a) A person may apply for an original propagation permit by submitting an application containing information or statements as required by the department and by submitting an original propagation permit fee of $300 or an amount set by the commission, whichever amount is more.

(b) The department shall issue the permit if it determines that the applicant has complied with Subsection (a) of this section, that the initial breeding stock was acquired under a permit issued under Section 43.022 of this code or was otherwise legally acquired, and that the applicant has not violated the laws of the United States, this state, or another state with respect to the acquisition of breeding stock.

(c) An original propagation permit must contain a description of endangered fish and wildlife authorized to be possessed under the permit.

(d) An original propagation permit is valid for one year from the date of its issuance.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1985, 69th Leg., ch. 267, art. 2, Sec. 62, eff. Sept. 1, 1985.

Sec. 68.009. RENEWAL PROPAGATION PERMIT. (a) A person holding an original propagation permit or a renewal propagation permit is entitled to receive from the department a renewal propagation permit on application to the department and on the payment of a renewal propagation permit fee of $550 or an amount set by the commission, whichever amount is more, if the application and fee are received by the department during the period beginning 10 days before the expiration date of the outstanding permit and extending through the expiration date of the permit.

(b) A renewal propagation permit is valid for a period of three years beginning on the date of its issuance.

(c) The department may refuse to renew any permit if it determines that it would be in the best interest of the species of fish or wildlife described in the permit.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1985, 69th Leg., ch. 267, art. 2, Sec. 63, eff. Sept. 1, 1985.

Sec. 68.010. REPORTS BY PERMITTEE. A person holding a commercial propagation permit shall send to the department annually:

(1) a written evaluation by a veterinarian licensed to practice in this state of the physical conditions of the propagation facilities and the conditions of the fish or wildlife held under the permit; and

(2) a written report on forms prepared by the department relating to propagation activities during the previous year.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.011. REFUSAL OR CANCELLATION OF PERMIT. (a) If, on the basis of the reports required by Section 68.010 of this code or an investigation or inspection by an authorized employee of the department, the department finds that a permit holder is improperly caring for or handling the fish or wildlife held under the permit, the department shall give written notice of the objectionable actions or conditions to the permit holder.

(b) If the department finds that the improper caring for or handling of the fish or wildlife is detrimental to the fish or wildlife and immediate protection is needed, the department may seize the fish or wildlife and authorize proper care pending the correction of the improper conditions or actions.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.012. APPEAL. (a) A person aggrieved by the action of the department in refusing to grant or renew a commercial propagation permit or in cancelling a permit may appeal within 20 days of the final action of the department to a district court of Travis County or the county of his residence.

(b) The appeal shall be by trial de novo as are appeals from the justice court to the county court.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.013. DISPOSITION OF FISH OR WILDLIFE. A person who ceases to hold a commercial propagation permit under this chapter shall dispose of endangered fish or wildlife held after the expiration or cancellation of the permit in the manner required by the department.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.014. REGULATIONS. The department shall make regulations necessary to administer the provisions of this chapter and to attain its objectives, including regulations to govern:

(1) permit application forms, fees, and procedures;

(2) hearing procedures;

(3) procedures for identifying endangered fish and wildlife or goods made from endangered fish or wildlife which may be possessed, propagated, or sold under this chapter;

(4) publication and distribution of lists of species and subspecies of endangered fish or wildlife and their products; and

(5) limitations on the capture, trapping, taking, or killing, or attempting to capture, trap, take, or kill, and the possession, transportation, exportation, sale, and offering for sale of endangered species.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1997, 75th Leg., ch. 1256, Sec. 112, eff. Sept. 1, 1997.

Sec. 68.015. PROHIBITED ACTS. (a) No person may capture, trap, take, or kill, or attempt to capture, trap, take, or kill, endangered fish or wildlife.

(b) No person may possess, sell, distribute, or offer or advertise for sale endangered fish or wildlife unless the fish or wildlife have been lawfully born and raised in captivity for commercial purposes under the provisions of this chapter.

(c) No person may possess, sell, distribute, or offer or advertise for sale any goods made from endangered fish or wildlife unless:

(1) the goods were made from fish or wildlife that were born and raised in captivity for commercial purposes under the provisions of this chapter; or

(2) the goods were made from fish or wildlife lawfully taken in another state and the person presents documented evidence to the department to substantiate that fact.

(d) No person may sell, advertise, or offer for sale any species of fish or wildlife not classified as endangered under the name of any endangered fish or wildlife.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1981, 67th Leg., p. 3135, ch. 825, Sec. 1, eff. June 17, 1981; Acts 1987, 70th Leg., ch. 607, Sec. 3, eff. Sept. 1, 1987; Acts 1997, 75th Leg., ch. 1256, Sec. 112, eff. Sept. 1, 1997.

Sec. 68.016. SOLD SPECIES TO BE TAGGED. No person may sell endangered fish or wildlife or goods made from endangered fish or wildlife unless the fish or wildlife or goods are tagged or labeled in a manner to indicate compliance with Section 68.015(a) and (b) of this code.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.017. SEIZURE OF FISH OR WILDLIFE. (a) A peace officer who has arrested a person for a violation of this chapter may seize fish or wildlife or goods made from fish or wildlife taken, possessed, or made in violation of this chapter.

(b) Property taken under this section shall be delivered to the department for holding pending disposition of the court proceedings. If the court determines that the property was taken, possessed, or made in violation of the provisions of this chapter, the department may dispose of the property under its regulations. The costs of the department in holding seized fish or wildlife during the pendency of the proceedings may, in appropriate cases, be assessed against the defendant.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.018. DISPOSITION OF FUNDS; APPROPRIATIONS. All revenue received under this chapter shall be deposited in the state treasury to the credit of the special nongame and endangered species conservation account.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1985, 69th Leg., ch. 267, art. 1, Sec. 68, eff. Sept. 1, 1985; Acts 1993, 73rd Leg., ch. 679, Sec. 45, eff. Sept. 1, 1993.

Sec. 68.019. APPLICABILITY OF CHAPTER. All species and subspecies of wildlife classified as endangered are governed by this chapter to the exclusion of other regulatory and licensing laws.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975.

Sec. 68.020. EXCEPTIONS. (a) This chapter does not apply to:

(1) coyotes (prairie wolves);

(2) cougars;

(3) bobcats;

(4) prairie dogs; or

(5) red foxes.

(b) This chapter does not apply to the possession of mounted or preserved endangered fish or wildlife acquired before August 31, 1973, by public or private nonprofit educational, zoological, or research institutions. The department may require an institution to furnish a list of mounted or preserved fish or wildlife possessed and proof of the time of acquisition.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1987, 70th Leg., ch. 607, Sec. 4, eff. Sept. 1, 1987.

Sec. 68.021. PENALTY. (a) A person who violates any provision of this chapter commits an offense that is a Class C Parks and Wildlife Code misdemeanor.

(b) A person who violates any provision of this chapter and who has been convicted on one previous occasion of a violation of this chapter commits an offense that is a Class B Parks and Wildlife Code misdemeanor.

(c) A person who violates any provision of this chapter and who has been convicted on two or more previous occasions of a violation of this chapter commits an offense that is a Class A Parks and Wildlife Code misdemeanor.

(d) A violation of a regulation of the department issued under the authority of this chapter is a violation of this chapter.

Acts 1975, 64th Leg., p. 1405, ch. 545, Sec. 1, eff. Sept. 1, 1975. Amended by Acts 1985, 69th Leg., ch. 267, art. 3, Sec. 78, eff. Sept. 1, 1985.

Great Trinity Forest Management Plan

Threatened and Endangered Species

Texas Parks and Wildlife Code:

Chapter 88-Endangered Plants

PARKS AND WILDLIFE CODE

SUBTITLE G. PLANTS

CHAPTER 88. ENDANGERED PLANTS

Sec. 88.001. DEFINITIONS. In this chapter:

(1) "Endangered plant" means a species of plant life that is in danger of extinction throughout all or a significant portion of its range.

(2) "Threatened plant" means a species of plant life that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

(3) "Protected plant" means a species of plant life that the director determines is of historical or cultural value to the state or the area in which it is found.

(4) "Native plant" means any tree, shrub, herb, grass, forb, legume, fern, fern ally, or wildflower that is indigenous to the state and that is growing on public or private land.

(5) "Public land" means land that is owned by the state or a local governmental entity.

(6) "Take" means to collect, pick, cut, dig up, or remove.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981.

Sec. 88.002. ENDANGERED, THREATENED, OR PROTECTED NATIVE PLANTS. Species of native plants are endangered, threatened, or protected if listed as such on:

(1) the United States List of Endangered Plant Species as in effect on the effective date of this Act (50 C.F.R. Part 17); or

(2) the list of endangered, threatened, or protected native plants as filed by the director of the department.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept.

1, 1981.

Sec. 88.003. STATEWIDE LIST. The director shall file with the secretary of state a list of endangered, threatened, or protected native plants.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981.

Sec. 88.004. AMENDMENT TO LIST. (a) If the list of endangered or threatened plants issued by the United States is modified, the director shall file an order with the secretary of state accepting the modification unless the director finds that the plant does not occur in this state. The order is effective immediately.

(b) The director may amend the list of endangered, threatened, or protected native plants by filing a modification order with the secretary of state. The order is effective on filing.

(c) The director shall give public notice of the intention to file a modification order under Subsection (b) of this section at least 60 days before the order is filed. The notice must contain the contents of the proposed order.

(d) The director shall hold a public hearing at least 30 days before the modification order authorized by Subsection (b) of this section is filed.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981.

Sec. 88.005. PERMIT. The department shall issue a permit to a qualified person to take endangered, threatened, or protected plants or parts thereof from public land for the purpose of propagation, education, or scientific studies.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981.

Sec. 88.006. REGULATIONS. The department shall adopt regulations to administer the provisions of this chapter, including regulations to provide for:

(1) permit application forms, fees, and procedures;

(2) hearing procedures;

(3) procedures for identifying endangered, threatened, or protected plants; and

(4) publication and distribution of lists of endangered, threatened, or protected plants.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981.

Sec. 88.007. ACTIVITIES BY THE DEPARTMENT. (a) The department may conduct biological research and field investigations to help determine the classification of native plants.

(b) The department may collect and disseminate information about the conservation of native plants and their habitats.

(c) The department may take an endangered, threatened, or protected plant from public land without a permit for the purpose of conservation, education, or scientific studies.

(d) The department shall distribute pictures and other information concerning endangered, threatened, or protected plants to law enforcement agencies and the public as the department determines necessary for educational purposes.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981. Amended by Acts 1985, 69th Leg., ch. 426, Sec. 1, eff. Sept. 1, 1985.

Sec. 88.008. PROHIBITED ACTS. (a) Except as otherwise provided by this chapter, no person may take for commercial sale, possess for commercial sale, or sell all or part of an endangered, threatened, or protected plant from public land.

(b) No contract or common carrier may transport or receive for shipment all or part of an endangered, threatened, or protected native plant taken from public land.

(c) No person may take for commercial sale, possess for commercial sale, transport for commercial sale, or sell all or part of an endangered, threatened, or protected plant from private land unless the person possesses a permit issued under Section 88.0081 of this code and each plant is tagged as provided by Section 88.0081 of this code.

(d) No person may hire or pay another person to take for commercial sale, possess for commercial sale, transport for commercial sale, or sell all or part of an endangered, threatened, or protected plant from private land unless both persons possess a permit issued under Section 88.0081 of this code.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981. Amended by Acts 1985, 69th Leg., ch. 426, Sec. 2, eff. Sept. 1, 1985.

Sec. 88.0081. PERMIT FOR TAKING PLANTS FROM PRIVATE LAND. (a) A person who takes, possesses, or transports for commercial sale or sells an endangered, threatened, or protected plant from private land, or who hires or pays another to perform those activities, shall possess a permit issued by the department. The permit must specify the land from which the taking is permissible, have attached a copy of the landowner's consent, and contain any other information required by the department.

(b) A person applying for a permit under this section must submit to the department:

(1) a copy of the written consent of the landowner from whose land the plant will be taken; and

(2) a permit fee set by the commission in an amount reasonable to defray administrative costs.

(c) In addition to the permit required by this section, a person taking endangered, threatened, or protected plants from private land shall attach to each plant at the time of taking a tag issued to the person by the department. The fee for each tag is $1.

(d) No person may remove the tag from the plant until the plant has been transplanted into its ultimate site for landscaping or beautification purposes. Only the ultimate owner or a department employee may remove the tag.

(e) The commission shall adopt rules specifying the form and information required for permits and tags issued under this section.

(f) The department shall waive the tagging fee if it determines the plants were planted and cultivated for the express purpose of being harvested for commercial purposes.

Added by Acts 1985, 69th Leg., ch. 426, Sec. 3, eff. Sept. 1, 1985.

Sec. 88.009. EXCEPTIONS. (a) This chapter does not apply to the taking, possession, or sale of endangered, threatened, or protected plants if the taking, possession, or sale is incidental to:

(1) the possession or sale of the real property on which the plant is growing;

(2) the possession or acquisition of easements or leases on which the plant is growing; or

(3) the harvest or sale of an agricultural crop if the endangered, threatened, or protected plant grows among that crop.

(b) This chapter does not apply to the possession, transportation, or sale of an endangered, threatened, or protected plant if:

(1) the plant originates in another state; and

(2) the person possessing, transporting, or selling the plant complies with the terms of any required federal permit or with the terms of a state permit required by the laws of the originating state.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981.

Sec. 88.010. INSPECTIONS. A person authorized to enforce this chapter may detain for inspection and inspect a vehicle, package, crate, or other container if the person has probable cause to believe it contains a plant in violation of this chapter.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981.

Sec. 88.011. PENALTIES. (a) Except as otherwise provided by this section, a person who violates any provision of this chapter commits an offense that is a Class C Parks and Wildlife Code misdemeanor.

(b) If it is shown at the trial of the defendant that he has been convicted within the preceding 36 months of a violation of this chapter, on conviction he shall be punished for a Class B Parks and Wildlife Code misdemeanor.

(c) If it is shown at the trial of the defendant that he has been convicted two or more times within the preceding 60 months of a violation of this chapter, on conviction he shall be punished for a Class A Parks and Wildlife Code misdemeanor.

(d) A person who hires or pays another person to take, possess, or transport for commercial sale or sell an endangered, threatened, or protected plant in violation of Subsection (d) of Section 88.008 of this code commits an offense. An offense under this section is a Class B Parks and Wildlife Code misdemeanor.

(e) Each endangered, threatened, or protected plant taken, possessed, transported, or sold in violation of this chapter constitutes a separate offense.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981. Amended by Acts 1985, 69th Leg., ch. 267, art. 3, Sec. 108, eff. Sept. 1, 1985; Acts 1985, 69th Leg., ch. 426, Sec. 4, eff. Sept. 1, 1985; Acts 1991, 72nd Leg., ch. 16, Sec. 15.04, eff. Aug. 26, 1991.

Sec. 88.012. INJUNCTION AGAINST GOVERNMENTAL VIOLATOR. A state or local governmental agency that violates or threatens to violate a provision of this chapter is subject to a civil suit for injunctive relief. The suit shall be brought in the name of the State of Texas.

Added by Acts 1981, 67th Leg., p. 2461, ch. 637, Sec. 1, eff. Sept. 1, 1981.

Great Trinity Forest Management Plan

Threatened and Endangered Species

Texas Administrative Code:

Title 31, Sections 65.171- 65.176 Threatened and Endangered Nongame Species

Texas Administrative Code

TITLE 31	NATURAL RESOURCES AND CONSERVATION
PART 2	TEXAS PARKS AND WILDLIFE DEPARTMENT
CHAPTER 65	WILDLIFE
SUBCHAPTER G	THREATENED AND ENDANGERED NONGAME SPECIES

Rules

RULE §65.171 General Provisions

(a) The provisions of this subchapter apply to any species of wildlife listed in this state as threatened or endangered, living or dead, including parts.
(b) Except as otherwise provided in this subchapter or Parks and Wildlife Code, Chapters 67 or 68, no person may:
(1) take, possess, propagate, transport, export, sell or offer for sale, or ship any species of fish or wildlife listed by the department as endangered; or
(2) take, possess, propagate, transport, import, export, sell, or offer for sale any species of fish or wildlife listed in this subchapter as threatened.
(3) sell or propagate for sale any species of fish or wildlife listed by the department as endangered, unless that person also possesses an endangered species propagation permit.
(c) Any person may possess, transport, import, export, sell, or offer for sale goods made from fish or wildlife listed in this subchapter as threatened, provided the person possesses:
(1) a copy of an out-of-state permit authorizing the possession of the specimens in the state of origin, valid at the time the specimen enters Texas;
(2) a bill of sale identifying the source of the specimen; or
(3) a notarized affidavit stating the source of the specimen and that the specimen(s) was legally obtained.
(d) Any person may possess or transport lawfully obtained live, mounted, or preserved specimens of threatened or endangered species, including specimens acquired in another state, provided the person complies with the provisions of subsection (c)(1)-(3) of this section.

Source Note: The provisions of this §65.171 adopted to be effective November 16, 2000, 25 TexReg 11289

RULE §65.172 Exceptions

(a) Any person may transport threatened or endangered species to the nearest Department of Health or medical facility if the species poses an immediate threat to human safety or welfare.
(b) An enrolled member of a Indian tribe recognized by the Bureau of Indian Affairs may possess parts of birds listed as threatened or endangered, provided the person also possesses a federal permit authorizing such possession.

Source Note: The provisions of this §65.172 adopted to be effective November 16, 2000, 25 TexReg 11289

RULE §65.173 Special Provisions

(a) No person may release a threatened or endangered species except as specifically provided by the department in a letter of authorization issued prior to release.
(b) The department may issue a letter of authorization allowing the temporary possession of threatened and endangered species for relocation purposes.
(1) Letters of authorization shall be issued only to competent persons experienced in the biological sciences who are:
(A) employed by a governmental entity; or
(B) engaged in paid environmental consultancy regarding the activities for which the letter of authorization is sought.
(2) Letters of authorization shall be issued to named persons only.
(3) The activities authorized by a letter of authorization shall be performed only by the person in whose name the letter of authorization is issued.
(4) All animals possessed under a letter of authorization shall be relocated and released as quickly as possible without placing avoidable stress on the animals.
(5) All relocated animals shall be released to suitable habitat.
(6) A letter of authorization does not absolve any person from compliance with any other applicable state or federal law.

Source Note: The provisions of this §65.173 adopted to be effective November 16, 2000, 25 TexReg 11289; amended to be effective October 28, 2002, 27 TexReg 10041

RULE §65.174 Permanent Identification

Every live mammal or turtle possessed under the provisions of this subchapter or the provisions of Parks and Wildlife Code, Chapter 68, shall be marked with a unique four-digit alphanumeric identifier by means of a permanent tag, tattoo, band, or passive inductive transponder (PIT) tag.

RULE §65.175 Threatened Species

A threatened species is any species that the department has determined is likely to become endangered in the future. The following species are hereby designated as threatened species:

Figure: 31 TAC §65.175

Mammals

Bat, Rafinesque's Big-eared	*Corynorhinus rafinesquii*
Bat, Southern Yellow	*Lasiurus ega*
Bat, Spotted	*Euderma maculatum*
Bear, Black	*Ursus americanus*
Coati, White-nosed	*Nasua narica*
Dolphin, Atlantic Spotted	*Stenella frontalis*
Dolphin, Rough-toothed	*Steno bredanensis*
Margay	*Felis wiedii (extirpated)*
Mouse, Palo Duro	*Peromyscus truei comanche*
Rat, Coues' Rice	*Oryzomys couesi*
Rat, Texas Kangaroo	*Dipodomys elator*
Whale, Dwarf Sperm	*Kogia simus*
Whale, False Killer	*Pseudorca crassidens*
Whale, Gervais' Beaked	*Mesoplodon europaeus*
Whale, Goose-beaked	*Ziphius cavirostris*
Whale, Killer	*Orcinus orca*
Whale, Short-finned Pilot	*Globicephala macrorhynchus*
Whale, Pygmy Killer	*Feresa attenuata*
Whale, Pygmy Sperm	*Kogia breviceps*

Birds

Becard, Rose-throated	*Pachyramphus aglaiae*
Eagle, Bald	*Haliaeetus leucocephalus*
Egret, Reddish	*Egretta rufescens*
Falcon, Arctic Peregrine	*Falco peregrinus tundrius*
Hawk, Common Black-	*Buteogallus anthracinus*
Hawk, Gray	*Buteo nitidus*
Hawk, White-tailed	*Buteo albicaudatus*
Hawk, Zone-tailed	*Buteo albonotatus*
Ibis, White-faced	*Plegadis chihi*
Kite, American Swallow-tailed	*Elanoides forficatus*
Owl, Ferruginous Pygmy-	*Glaucidium brasilianum*
Owl, Mexican Spotted	*Strix occidentalis lucida*
Parula, Tropical	*Parula pitiayumi*
Plover, Piping	*Charadrius melodus*
Sparrow, Bachman's	*Aimophila aestivalis*
Sparrow, Botteri's	*Aimophila botterii*
Stork, Wood	*Mycteria americana*
Tern, Sooty	*Sterna fuscata*
Tyrannulet, Northern Beardless-	*Camptostoma imberbe*

Reptiles

Gecko, Reticulated	*Coleonyx reticulatus*
Lizard, Reticulate Collared	*Crotaphytus reticulatus*

Lizard, Texas Horned	*Phrynosoma cornutum*
Lizard, Mountain Short-horned	*Phrynosoma douglasii*
Rattlesnake, Timber	*Crotalus horridus*
Snake, Speckled Racer	*Drymobius margaritiferus*
Snake, Northern Cat-eyed	*Leptodeira septentrionalis*
Snake, Scarlet	*Cemophora coccinea*
Snake, Black-striped	*Coniophanes imperialis*
Snake, Indigo	*Drymarchon corais*
Snake, Brazos Water	*Nerodia harteri*
Snake, Smooth Green	*Liochlorophis vernalis*
Snake, Louisiana Pine	*Pituophis melanoleucus ruthveni*
Snake, Big Bend Blackhead	*Tantilla rubra*
Snake, Texas Lyre	*Trimorphodon biscutatus*
Turtle, Cagle's Map	*Graptemys caglei*
Turtle, Chihuahuan Mud	*Kinosternon hirtipes*
Turtle, Alligator Snapping	*Macroclemys temminckii*
Turtle, Green Sea	*Chelonia mydas*
Turtle, Loggerhead Sea	*Caretta caretta*
Tortoise, Texas	*Gopherus berlandieri*

Amphibians

Frog, Sheep	*Hypopachus variolosus*
Frog, White-lipped	*Leptodactylus labialis*
Newt, Black-spotted	*Notophthalmus meridionalis*
Salamander, Blanco Blind	*Eurycea robusta*

Salamander, Cascade Caverns	*Eurycea latitans*
Salamander, San Marcos	*Eurycea nana*
Salamander, Comal Blind	*Eurycea tridentifera*
Siren, South Texas (Large Form)	*Siren* sp.1
Toad, Mexican Burrowing	*Rhinophrynus dorsalis*
Treefrog, Mexican	*Smilisca baudinii*

Fishes

Blindcat, Toothless	*Trogloglanis pattersoni*
Blindcat, Widemouth	*Satan eurystomus*
Chub, Rio Grande	*Gila pandora*
Chubsucker, Creek	*Erimyzon oblongus*
Darter, Blackside	*Percina maculata*
Darter, Rio Grande	*Etheostoma grahami*
Gambusia, Blotched	*Gambusia senilis (extirpated)*
Goby, Blackfin	*Gobionellus atripinnis*
Goby, River	*Awaous tajasica*
Minnow, Devils River	*Dionda diaboli*
Paddlefish	*Polyodon spathula*
Pipefish, Opossum	*Microphis brachyurus*
Pupfish, Concho	*Cyprinodon eximius*
Pupfish, Pecos	*Cyprinodon pecosensis*
Shiner, Arkansas River	*Notropis girardi*

Shiner, Bluntnose	*Notropis simus (extirpated)*
Shiner, Bluehead	*Notropis hubbsi*
Shiner, Chihuahua	*Notropis chihuahua*
Shiner, Proserpine	*Cyprinella proserpina*
Stoneroller, Mexican	*Campostoma ornatum*
Sturgeon, Shovelnose	*Scaphirhynchus platorynchus*
Sucker, Blue	*Cycleptus elongatus*

Source Note: The provisions of this §65.175 adopted to be effective November 16, 2000, 25 TexReg 11289

RULE §65.176 Violations and Penalties

Penalties for violations of this subchapter involving:

(1) the species listed in §65.172 of this title (relating to Threatened Species) are prescribed by Parks and Wildlife Code, Chapter 67; and
(2) species listed in accordance with Parks and Wildlife Code, Chapter 68, are prescribed by Parks and Wildlife Code, Chapter 68.

Source Note: The provisions of this §65.176 adopted to be effective November 16, 2000, 25 TexReg 11289

Great Trinity Forest Management Plan

Threatened and Endangered Species

Texas Administrative Code:

Title 31, Sections 69.01- 69.9 Endangered, Threatened and Protected Native Plants

Texas Administrative Code

TITLE 31	NATURAL RESOURCES AND CONSERVATION
PART 2	TEXAS PARKS AND WILDLIFE DEPARTMENT
CHAPTER 69	RESOURCE PROTECTION
SUBCHAPTER A	ENDANGERED, THREATENED, AND PROTECTED NATIVE PLANTS

Rules

RULE §69.1 Permit Required

Except as provided in Parks and Wildlife Code, §88.009, no person may:

(1) take, possess, transport, or sell an endangered, threatened, or protected native plant from the public lands of this state unless that person possesses a valid scientific plant permit authorizing such activity.
(2) take, possess, transport, or sell an endangered, threatened, or protected native plant for commercial purposes from private lands unless that person possesses a valid commercial plant permit authorizing such activity.

Source Note: The provisions of this §69.1 adopted to be effective January 30, 1997, 22 TexReg 901.

RULE §69.2 Scientific Plant Permit

(a) Only the individuals named on a scientific plant permit are authorized to conduct the

activities authorized by a permit issued under this chapter.
(b) Qualifications. A scientific plant permit shall be issued only to a person who provides evidence to the department's satisfaction that:
  (1) there exists a legitimate scientific need to conduct research and that the information obtained will benefit the department in the management of the target species;
  (2) the research would not substantially or unnecessarily duplicate existing research conducted under other permits issued under this subchapter;
  (3) the applicant possesses or has access to facilities to properly care for the permitted plants;
  (4) the applicant possesses a degree or certification in a botanical or horticultural discipline or possesses letters of recommendation from two acknowledged authorities in a botanical or horticultural discipline; and
  (5) the proposed research follows generally accepted principles of experimental design.
(c) Application requirements. Prior to permit issuance, an applicant for a scientific plant permit shall submit to the department:
  (1) a completed application on a form supplied by the department;
  (2) a letter of recommendation from each of two people in the field of botany or horticulture attesting to the professional status or competence that qualifies the applicant to conduct the proposed research;
  (3) a letter of permission from an agency or entity to take plants on lands under the jurisdiction of the agency or entity; and
  (4) the name of each person assisting in the collecting and transporting of endangered, threatened, or protected plants.
(d) Special provisions.
  (1) A permit may be amended at any time during the permit year to reflect changes in the propagation, educational, or scientific studies of the permittee, provided the amendment satisfies the criteria set forth in subsection (b) of this section.
  (2) While conducting any permit activities on public lands, each person named on a permit shall carry copies of the permit and the letter of permission required by subsection (b)(3) of this section, and shall produce such documents upon demand by a game warden.
  (3) Specimens collected under a scientific plant permit may not be sold or bartered.
  (4) Persons engaged in the selling or holding for sale of native plants designated as endangered, threatened or protected are prohibited from holding a scientific plant permit.

Source Note: The provisions of this §69.2 adopted to be effective January 30, 1997, 22 TexReg 901.

RULE §69.3 Reporting Requirements

By the date specified on the permit, a permittee shall complete and submit an annual report on a form provided by the department. A copy of any final report and/or publication relating to the permitted activities shall also be submitted to the department.

Source Note: The provisions of this §69.3 adopted to be effective January 30, 1997, 22 TexReg 901.

RULE §69.4 Renewal

The department may require information in addition to that required by paragraphs (1)-(4) of this section. Scientific plant permits shall be renewed, provided:

(1) the permittee has submitted the annual report by the date specified on the permit;
(2) the permittee has complied with all permit provisions;
(3) the permittee has demonstrated reasonable progress toward the completion of research activities authorized by the permit; and
(4) the permittee has not been convicted of a violation of Parks and Wildlife Code.

Source Note: The provisions of this §69.4 adopted to be effective January 30, 1997, 22 TexReg 901.

RULE §69.5 Commercial Plant Permit

(a) A commercial plant permit is required to take, possess, and/or transport protected, threatened, and endangered native plants from private lands for commercial purposes. No permit is required to take, possess, and/or transport protected, threatened and endangered native plants from private lands for non-commercial purposes.
(b) A person applying for a commercial plant permit shall submit an application on a form provided by the department.
(c) By the date specified on the permit, a holder of a commercial plant permit shall complete and submit a report on a form provided by the department.

Source Note: The provisions of this §69.5 adopted to be effective January 30, 1997, 22 TexReg 901; amended to be effective April 4, 2005, 30 TexReg 1953

RULE §69.6 Permit and Tag Fees

The fee for the issuance of a Commercial Plant Permit is $50.

Source Note: The provisions of this §69.6 adopted to be effective January 30, 1997, 22 TexReg 901.

RULE §69.7 Period of Validity

All permits issued under this subchapter expire one year from the date of issuance unless suspended or revoked by the executive director.

Source Note: The provisions of this §69.7 adopted to be effective January 30, 1997, 22 TexReg

901.

RULE §69.8 Endangered and Threatened Plants

(a) The following plants are endangered:

Figure: 31 TAC §69.8(a)

Cacti:	
star cactus	*Astrophytum asterias*
Nellie cory cactus	*Escobaria minima*
Sneed pincushion cactus	*Escobaria sneedii* var. *sneedii*
black lace cactus	*Echinocereus reichenbachii* var. *albertii*
Davis' green pitaya	*Echinocereus viridiflorus* var. *davisii*
Pima pineapple cactus	*Coryphantha scheeri* var. *robustispina*
Tobusch fishhook cactus	*Sclerocactus brevihamatus* ssp. *tobuschii*
Trees, Shrubs, and Subshrubs:	
Johnston's frankenia	*Frankenia johnstonii*
Walker's manioc	*Manihot walkerae*
Texas snowbells	*Styrax platanifolius* ssp. *texanus*
Wildlfowers:	
large-fruited sand verbena	*Abronia macrocarpa*
South Texas ambrosia	*Ambrosia cheiranthifolia*

Texas ayenia	*Ayenia limitaris*
Texas poppy mallow	*Callirhoe scabriuscula*
Terlingua Creek cat's-eye	*Cryptantha crassipes*
slender rush-pea	*Hoffmannseggia tenella*
Texas prairie dawn	*Hymenoxys texana*
white bladderpod	*Lesquerella pallida*
Texas trailing phlox	*Phlox nivalis ssp. texensis*
ashy dogweed	*Thymophylla tephroleuca*
Zapata bladderpod	*Lesquerella thamnophila*
Orchids:	
Navasota ladies'-tresses	*Spiranthes parksii*
Grasses and Grass-like Plants:	
Little Aguja pondweed	*Potamogeton clystocarpus*
Texas wild-rice	*Zizania texana*

(b) The following plants are threatened:

Figure: 31 TAC §69.8(b)

Cacti:	
Bunched cory cactus	*Coryphantha ramillosa* ssp. *ramillosa*
Chisos Mountains hedgehog cactus	*Echinocereus chisoensis* var. *chisoensis*
Lloyd's mariposa cactus	*Sclerocactus mariposensis*

Trees, Shrubs, and Subshrubs:	
Hinckley's oak	*Quercus hinckleyi*
Wildflowers:	
Pecos Sunflower	*Helianthus paradoxus*
Tinytim	*Geocarpon minimum*

(c) Scientific reclassification or change in nomenclature of taxa at any level in the taxonomic hierarchy will not, in and of itself, affect the status of a species as endangered, threatened or protected.

Source Note: The provisions of this §69.8 adopted to be effective January 30, 1997, 22 TexReg 901; amended to be effective April 30, 2001, 26 TexReg 3220; amended to be effective April 4, 2005, 30 TexReg 1953

RULE §69.9 Penalties

The penalties for a violation of any provision of this subchapter are prescribed in Texas Parks and Wildlife Code, §88.011.

Source Note: The provisions of this §69.9 adopted to be effective January 30, 1997, 22 TexReg 901.

Great Trinity Forest Management Plan

Threatened and Endangered Species

Rare, Threatened and Endangered Species of Dallas County, Texas

Rare, Threatened and Endangered Species of Dallas County, Texas

Taxon	Common Name	Scientific Name	Federal Status	State Status	County Range
Birds	Henslow's Sparrow	Ammodramus henslowii			View Map
Birds	Western Burrowing Owl	Athene cunicularia hypugaea			View Map
Birds	Piping Plover	Charadrius melodus	LT	T	View Map
Birds	Golden-cheeked Warbler	Dendroica chrysoparia	LE	E	View Map
Birds	Peregrine Falcon	Falco peregrinus	DL	E T	View Map
Birds	American Peregrine Falcon	Falco peregrinus anatum	DL	E	View Map
Birds	Arctic Peregrine Falcon	Falco peregrinus tundrius	DL	T	View Map
Birds	Whooping Crane	Grus americana	LE	E	View Map
Birds	Bald Eagle	Haliaeetus leucocephalus	DL	T	View Map
Birds	Wood Stork	Mycteria americana		T	View Map
Birds	White-faced Ibis	Plegadis chihi		T	View Map
Birds	Interior Least Tern	Sterna antillarum athalassos	LE	E	View Map
Birds	Black-capped Vireo	Vireo atricapilla	LE	E	View Map
Insects	Black Lordithon rove beetle	Lordithon niger			View Map
Mammals	Cave myotis bat	Myotis velifer			View Map
Mammals	Plains spotted skunk	Spilogale putorius interrupta			View Map
Mollusks	Rock pocketbook	Arcidens confragosus			View Map
Mollusks	Wabash pigtoe	Fusconaia flava			View Map
Mollusks	Sandbank pocketbook	Lampsilis satura			View Map
Mollusks	Louisiana pigtoe	Pleurobema riddellii			View Map
Mollusks	Texas heelsplitter	Potamilus amphichaenus			View Map
Mollusks	Pistolgrip	Tritogonia verrucosa			View Map
Mollusks	Fawnsfoot	Truncilla donaciformis			View Map
Mollusks	Little spectaclecase	Villosa lienosa			View Map
Plants	Warnock's coral-root	Hexalectris warnockii			View Map
Plants	Glen Rose yucca	Yucca necopina			View Map
Reptiles	Timber/Canebrake rattlesnake	Crotalus horridus		T	View Map
Reptiles	Alligator snapping turtle	Macrochelys temminckii		T	View Map

Reptiles	Texas horned lizard	Phrynosoma cornutum		T	View Map
Reptiles	Texas garter snake	Thamnophis sirtalis annectens			View Map

DALLAS COUNTY

BIRDS

		Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	DL	E

year-round resident and local breeder in west Texas, nests in tall cliff eyries; also, migrant across state from more northern breeding areas in US and Canada, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.

Arctic Peregrine Falcon	*Falco peregrinus tundrius*	DL	T

migrant throughout state from subspecies' far northern breeding range, winters along coast and farther south; occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.

Bald Eagle	*Haliaeetus leucocephalus*	DL	T

found primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds

Black-capped Vireo	*Vireo atricapilla*	LE	E

oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous and broad-leaved shrubs and trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level, and required structure; nesting season March-late summer

Golden-cheeked Warbler	*Dendroica chrysoparia*	LE	E

juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests are placed in various trees other than Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees and shrubs; nesting late March-early summer

Henslow's Sparrow	*Ammodramus henslowii*		

wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and brambles; a key component is bare ground for running/walking

Interior Least Tern	*Sterna antillarum athalassos*	LE	E

subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish and crustaceans, when breeding forages within a few hundred feet of colony

Peregrine Falcon	*Falco peregrinus*	DL	E T

DALLAS COUNTY

BIRDS		Federal Status	State Status

both subspecies migrate across the state from more northern breeding areas in US and Canada to winter along coast and farther south; subspecies (F. p. anatum) is also a resident breeder in west Texas; the two subspecies' listing statuses differ, thus the species level shows this dual listing status; because the subspecies are not easily distinguishable at a distance, reference is generally made only to the species level; see subspecies for habitat.

Piping Plover	*Charadrius melodus*	LT	T

wintering migrant along the Texas Gulf Coast; beaches and bayside mud or salt flats

Western Burrowing Owl	*Athene cunicularia hypugaea*		

open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows

White-faced Ibis	*Plegadis chihi*		T

prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats

Whooping Crane	*Grus americana*	LE	E

potential migrant via plains throughout most of state to coast; winters in coastal marshes of Aransas, Calhoun, and Refugio counties

Wood Stork	*Mycteria americana*		T

forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds (i.e. active heronries); breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960

INSECTS		Federal Status	State Status

Black Lordithon rove beetle	*Lordithon niger*		

historically known from Texas

MAMMALS		Federal Status	State Status

Cave myotis bat	*Myotis velifer*		

colonial and cave-dwelling; also roosts in rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (Hirundo pyrrhonota) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore

Plains spotted skunk	*Spilogale putorius interrupta*		

catholic; open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie

DALLAS COUNTY

MOLLUSKS		Federal Status	State Status
Fawnsfoot	*Truncilla donaciformis*		

small and large rivers especially on sand, mud, rocky mud, and sand and gravel, also silt and cobble bottoms in still to swiftly flowing waters; Red (historic), Cypress (historic), Sabine (historic), Neches, Trinity, and San Jacinto River basins.

Little spectaclecase *Villosa lienosa*

creeks, rivers, and reservoirs, sandy substrates in slight to moderate current, usually along the banks in slower currents; east Texas, Cypress through San Jacinto River basins

Louisiana pigtoe *Pleurobema riddellii*

streams and moderate-size rivers, usually flowing water on substrates of mud, sand, and gravel; not generally known from impoundments; Sabine, Neches, and Trinity (historic) River basins

Pistolgrip *Tritogonia verrucosa*

stable substrate, rock, hard mud, silt, and soft bottoms, often buried deeply; east and central Texas, Red through San Antonio River basins

Rock pocketbook *Arcidens confragosus*

mud, sand, and gravel substrates of medium to large rivers in standing or slow flowing water, may tolerate moderate currents and some reservoirs, east Texas, Red through Guadalupe River basins

Sandbank pocketbook *Lampsilis satura*

small to large rivers with moderate flows and swift current on gravel, gravel-sand, and sand bottoms; east Texas, Sulfur south through San Jacinto River basins; Neches River

Texas heelsplitter *Potamilus amphichaenus*

quiet waters in mud or sand and also in reservoirs. Sabine, Neches, and Trinity River basins

Wabash pigtoe *Fusconaia flava*

creeks to large rivers on mud, sand, and gravel from all habitats except deep shifting sands; found in moderate to swift current velocities; east Texas River basins, Red through San Jacinto River basins; elsewhere occurs in reservoirs and lakes with no flow

REPTILES		Federal Status	State Status
Alligator snapping turtle	*Macrochelys temminckii*		T

perennial water bodies; deep water of rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near deep running water; sometimes enters brackish coastal waters; usually in water with mud bottom and abundant aquatic vegetation; may migrate several miles along rivers; active March-October; breeds April-October

Texas garter snake *Thamnophis sirtalis annectens*

wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August

Texas horned lizard	*Phrynosoma cornutum*		T

DALLAS COUNTY

REPTILES		Federal Status	State Status

open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September

Timber/Canebrake rattlesnake	*Crotalus horridus*		T

swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover, i.e. grapevines or palmetto

PLANTS		Federal Status	State Status
Glen Rose yucca	*Yucca necopina*		

grasslands on sandy soils; flowering April-June(?), also found in limestone bedrock, clayey soil on top of limestone, and gravelly limestone alluvium

Warnock's coral-root	*Hexalectris warnockii*		

leaf litter and humus in oak-juniper woodlands in mountain canyons in the Trans Pecos but at lower elevations to the east, often on narrow terraces along creekbeds

Instructions for
County Lists of Texas' Special Species

The Texas Parks and Wildlife (TPWD) county lists **include**:

Vertebrates, Invertebrates, and Vascular Plants identified as being of conservation concern by TPWD within Texas. These special species lists are comprised of species, subspecies, and varieties that are federally listed; proposed to be federally listed; have federal candidate status; are state listed; or carry a global conservation status indicating a species is critically imperiled, very rare, vulnerable to extirpation, or uncommon.

The TPWD county lists **do not include**:

Natural Plant Communities such as Little Bluestem-Indiangrass Series (native prairie remnant), Water Oak-Willow Oak Series (bottomland hardwood community), Saltgrass-Cordgrass Series (salt or brackish marsh), Sphagnum-Beakrush Series (seepage bog).

Other Significant Features such as bird rookeries, migratory songbird fallout areas, comprehensive migratory bird information, bat roosts, bat caves, invertebrate caves, and prairie dog towns.

These lists are not all inclusive for all rare species distributions. The lists were compiled, developed, and are updated based on field guides, staff expertise, scientific publications, and the TPWD Natural Diversity Database (NDD) (formerly the Biological and Conservation Data System) occurrence data. Historic ranges for some state extirpated species, full historic distributions for some extant species, accidentals and irregularly appearing species, and portions of migratory routes for particular species are not necessarily included. Species that appear on county lists do not all share the same probability of occurrence within a county. Some species are migrants or wintering residents only. Additionally, a few species may be historic or considered extirpated within a county.

TPWD includes the Federal listing status for your convenience and makes every attempt to keep the information current and correct. However, the US Fish and Wildlife Service (FWS) is the responsible authority for Federal listing status. The TPWD lists do not substitute for contact with the FWS and federally listed species county ranges may vary from the FWS county level species lists because of the inexact nature of range map development and use.

Status Key:

LE, LT -	Federally Listed Endangered/Threatened
PE, PT -	Federally Proposed Endangered/Threatened
E/SA, T/SA -	Federally Listed Endangered/Threatened by Similarity of Appearance
C -	Federal Candidate for Listing; formerly Category 1 Candidate
DL, PDL -	Federally Delisted/Proposed for Delisting
NL -	Not Federally Listed
E, T -	State Listed Endangered/Threatened
NT -	Not tracked or no longer tracked by the State
“blank” -	Rare, but with no regulatory listing status

This information is specifically for your assistance only; due to continuing data updates, **please do not redistribute the lists**, instead refer all requesters to the web site at: http://www.tpwd.state.tx.us/landwater/land/maps/gis/ris/endangered_species.phtml or to our office for the most current information available. For questions regarding county lists, please call (512) 389-4571.

Please use the following citation to credit the source for this county level information:

Texas Parks and Wildlife Department, Wildlife Division, Diversity and Habitat Assessment Programs. County Lists of Texas' Special Species. [county name(s) and revised date(s)].

Great Trinity Forest Management Plan

Threatened and Endangered Species

Bald Eagle

(Haliaeetus leucocephalus)

Bald Eagle

Scientific Name: *Haliaeetus leucocephalus*

Federal Status: Threatened • State Status: Threatened

Description

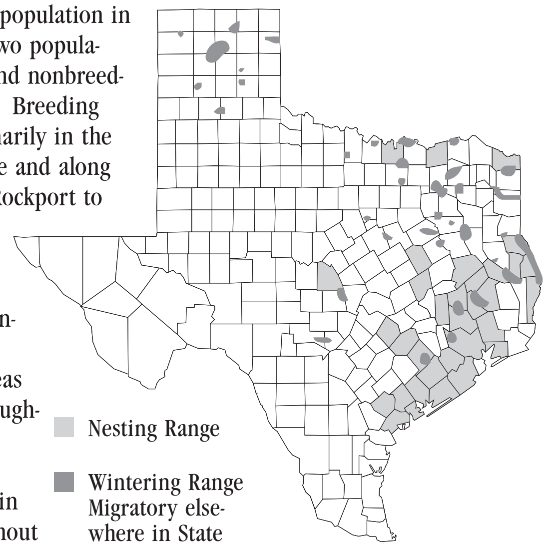
The Bald Eagle is one of nature's most impressive birds of prey. Males generally measure 3 feet from head to tail, weigh 7 to 10 pounds, and have a wingspan of 6 to 7 feet. Females are larger, some reaching 14 pounds with a wingspan of up to 8 feet. Adults have a white head, neck, and tail and a large yellow bill.

Bald Eagle
© TPWD

First year birds are mostly dark and can be confused with immature Golden Eagles. Immature Bald Eagles have blotchy white on the under wing and tail, compared with the more sharply defined white pattern of Golden Eagles. While gliding or soaring, Bald Eagles keep their wings flat, and their wing beats are slow and smooth. In contrast, Turkey Vultures soar with uplifted wings, and they fly with quick, choppy wing beats. Bald Eagles require 4 or 5 years to reach full adult plumage, with distinctive white head and tail feathers.

Distribution and Habitat

The Bald Eagle, our National Symbol, occurs throughout the United States, Canada, and northern Mexico. Bald Eagles are present year-round throughout Texas as spring and fall migrants, breeders, or winter residents. The Bald Eagle population in Texas is divided into two populations; breeding birds and nonbreeding or wintering birds. Breeding populations occur primarily in the eastern half of the state and along coastal counties from Rockport to Houston. Nonbreeding or wintering populations are located primarily in the Panhandle, Central, and East Texas, and in other areas of suitable habitat throughout the state.



The Bald Eagle in Texas formerly nested in the Panhandle, throughout East Texas, and at localized sites in central Texas. Populations declined throughout the lower 48 states during the 1900's with habitat destruction and use of pesticides detrimental to the species. Nesting populations are now increasing in most areas of the country. Active nests in Texas increased from 13 in 1982 to 117 in 2003. Breeding territories are located mostly along rivers and near reservoirs in East Texas, the Post Oak region, and the Gulf Coast. The nesting near reservoirs by Bald Eagles is a rather recent event, since this habitat type was not available to eagles historically. As of 2003, Bald Eagle nests are known to occur in Angelina, Austin, Bastrop, Bell, Bosque, Brazoria, Burleson, Calhoun, Cass, Chambers, Colorado, Fayette, Fort Bend, Freestone, Goliad, Grimes, Harris, Henderson, Jackson, Jasper, Kaufman, Lavaca, Liberty, Limestone, Llano, Marion, Matagorda, Montgomery, Nacogdoches, Navarro, Navasota, Newton, Panola, Polk, Refugio, Robertson, Rusk, Sabine, San Augustine, San Jacinto, Shelby, Smith, Trinity, Victoria, Walker, Wharton, and Wood counties.

In Texas, Bald Eagles nest in areas along river systems, reservoirs or lake shores with large, tall (40-120 ft.) trees for nesting and roosting. Nests are usually located within 1 mile of water, such as lakes, reservoirs, creeks or rivers, and are often located in the ecotone or edge between forest and marsh or water. Bald Eagles often build their nests in the tallest trees in an area, providing an unobstructed view and flight path to the nest. Nests are built in a variety of tree species. Eagles nest primarily in loblolly pine in East Texas. Throughout the rest of it's Texas breeding range, nests are found in a variety of trees, including bald cypress, water oak, live oak, American elm, cottonwood, sycamore, and pecan. Open water or wetland areas located within approximately 1 mile of nesting habitat are needed to provide feeding areas.

Most of the Bald Eagles seen in Texas breed in the northern states and spend the winter (December through March) in Texas. Wintering populations may occur statewide, but generally are found near large lakes and reservoirs, such as Lake Meredith, Buffalo Lake, Lake Texoma, Wright-Patman Lake, Lake O' the Pines, Lake Fork, Lake Tawakoni, Lake Whitney, Lake Fairfield, Toledo Bend Reservoir, Sam Rayburn Reservoir, Lake Livingston, Lake Conroe, Lake Buchanan, Lake Cooper, Lake Palestine, Lake Pat Mayse, Lake Warren, and Palo Duro Lake, or in the rice growing region hunting waterfowl.

Bald Eagle wintering habitat is characterized by abundant, readily available food sources. Most wintering areas are associated with open water or waterfowl concentration areas, where eagles feed on fish or waterfowl. Wintering populations are also found on rangelands of the Davis Mountains, western Edwards Plateau, and the Panhandle, where eagles may take rabbits and feed on carrion.

The availability of night roost sites is often an important characteristic of wintering habitat. Bald Eagles may roost singly or in groups, and the same roosts are used from year to year. Roost trees are usually the oldest and largest trees in an area, and most have large horizontal limbs and open branching that allows plenty of room for takeoff and landing. Eagles generally choose roosts that allow unobstructed visibility to the surrounding areas, with a minimum of human activity in the immediate vicinity. Roost sites are often located near water, but eagles also roost on windbreaks and in secluded canyons well away from water.

Life History

Bald Eagles are opportunistic predators. They feed primarily on fish, but also eat a variety of waterfowl and other birds, small mammals, and turtles, when these foods are readily available. Carrion is also common in the diet, particularly in younger birds. Bottom-dwelling fish tend to occur more frequently in the diet. It is thought that the downward visual orientation of bottom-feeding fish makes them more vulnerable to eagle attacks than surface sight-feeders, which are more aware of movements from above. Eagles capture fish by extending their talons a few inches below the water's surface. Therefore, live fish are vulnerable only when near the surface or in shallows. Studies in Texas have shown that eagles commonly eat coots, catfish, rough fish, and soft-shell turtles.

In Texas, Bald Eagles nest from October to July. Nests are constructed primarily by the female, with the male assisting. The typical nest is constructed of large sticks, with softer materials such as leaves, grass, and Spanish moss used as nest lining. Nests are typically used for a number of years, with the birds adding nest material every year. Bald Eagle nests are often very large, measuring up to 6 feet in width and weighing hundreds of pounds. Eagles often have one or more alternative nests within their territories.

Peak egg-laying occurs in December, with hatching primarily in January. The female lays a clutch of 1 to 3 eggs, but the usual clutch is 2 eggs. A second clutch may be laid if the first is lost. Incubation begins when the first egg is laid and usually lasts 34 to 36 days. The young generally fledge (fly from the nest) in 11 to 12 weeks, but the adults continue to feed them for another 4 to 6 weeks while they learn to hunt. When they are on their own, young Bald Eagles migrate northward out of Texas, returning by September or October.

Nest surveys in Texas from 1981-2003 have shown that greater than 80% of the active nesting territories successfully produced young, with production averaging greater than 1 young per active nest found. Studies show that at least 70% of the juveniles survive their first year. Causes of first year mortality include disease, lack of food, inclement weather, and human interference.

Bald Eagles reach sexual maturity at 4 to 6 years of age; however, they have been known to successfully breed at 3 years. They are monogamous and are believed to mate for life; however, if one of the pair dies, the surviving bird will accept another mate. Bald Eagles are believed to live up to 30 years or more in the wild.

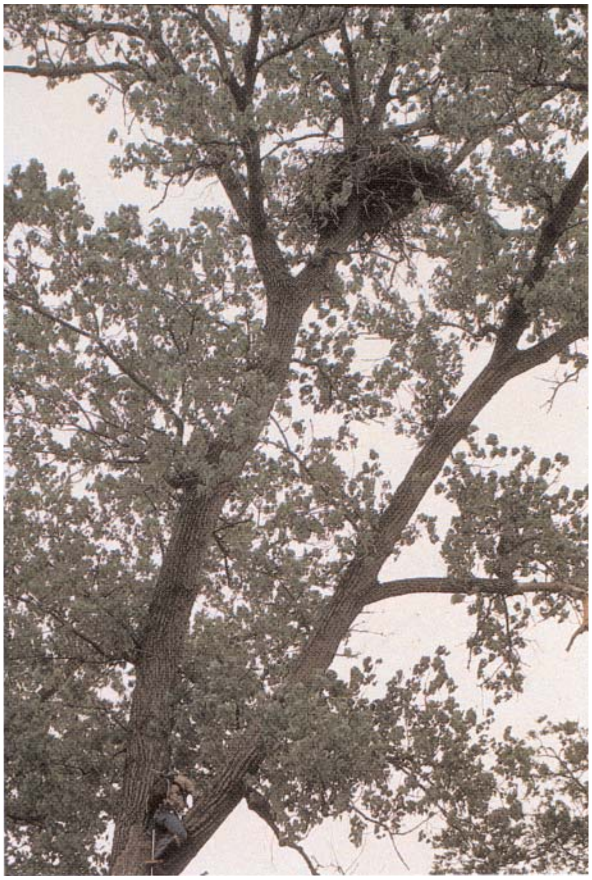
Threats and Reasons for Decline

Habitat loss over the past 200 years is the factor most consistently associated with declines in Bald Eagle populations. Unfortunately for eagles, people also like to live and spend their leisure time near water. In recent decades, the accelerated pace of development along the coast and near inland rivers and waterways is a primary cause of habitat loss. There are, however, encouraging signs in Texas that a significant amount of new habitat has been created in the form of man-made reservoirs. Most reservoirs in eastern Texas, especially those bordered by national forests, are used by nesting eagles, and are also used to some degree by wintering birds. Hopefully, if human disturbance is kept to a minimum, a redistribution of nesting to reservoirs may offset some habitat loss in other areas.

Shooting has long been recognized as a major human-caused factor in the decline of Bald Eagles. Although primarily fish and carrion eaters, eagles were thought to be a major threat to chickens, livestock, and game animals. As a consequence, many were killed by farmers, ranchers, and hunters. In 1940, Congress passed the Bald Eagle Protection Act,

Mature Bald Eagles
© USFWS

Young eagles in nest
© TPWD Jim Whitcomb



Bald Eagle nest
© TPWD Leroy Williamson

Juvenile Bald Eagles
© TPWD Mark Mitchell

which made it illegal to shoot or harass eagles. In 1969, Bald Eagles gained further legal protection under federal endangered species laws. With heightened public awareness and sensitivity to the plight of the Bald Eagle, coupled with strict laws, shooting mortality has declined from 62% of total reported deaths from 1961-1965 to 18% from 1975-1981. Although this downward trend is encouraging, shooting mortality could still be a limiting factor, particularly in remote areas.

Human disturbance can also be a cause of population decline. Activities such as logging, oil exploration and extraction, construction, and recreational activity certainly do disturb eagles in some instances. However, the impact of these disturbances is highly variable, depending on the activity, its frequency and duration, its proximity to areas used by eagles, the extent to which the activity modifies the habitat or its use, and timing in relation to the reproductive cycle. Also, some birds are more tolerant of disturbance than others, with adults generally less tolerant than immature birds. Despite this variability, disturbance near nests has caused nesting failures.

Finally, the most dramatic declines in Bald Eagle populations nationwide resulted from environmental contaminants. Beginning in 1947, reproductive success in many areas of the country declined sharply, and remained at very low levels through the early 1970's. After several years of study, the low reproduction of Bald Eagles and many other birds was linked to widespread use of the insecticides DDT and Dieldren. These insecticides were used extensively in agriculture and forestry beginning in 1947. As DDT entered watersheds, it became part of the aquatic food chain, and was stored as DDE in the fatty tissue of fish and waterfowl. As eagles and other birds of prey fed on these animals, they accumulated DDE in their systems.

Although occasionally causing death, DDE mainly affected reproduction. Some birds affected by the chemical failed to lay eggs, and many produced thin eggshells that broke during incubation. Eggs that did not break were often addled or contained dead embryos, and the young that hatched often died. Dieldren killed eagles directly rather than causing thin eggshells, but compared to DDT, Dieldren was probably not as important in overall Bald Eagle declines. In 1972, the EPA banned the use of DDT in the United States. Since the ban, DDE residues in Bald Eagle eggshells have dropped significantly, and a slow recovery of eagle productivity has occurred. Most populations appear to be producing chicks at the expected rate.

Of more recent concern is evidence that lead poisoning may be a significant cause of death in eagles. Chronic low levels of lead can produce nervous system disorders, affect behavior and learning, cause anemia, and increase susceptibility to disease. As laws requiring the use of steel shot to hunt waterfowl become effective, accumulation of lead in the food chain is expected to decline.

Since 1981, Texas Parks and Wildlife Department has conducted extensive aerial surveys to monitor Bald Eagle nesting activity. The 2003 survey identified 117 active nests which fledged at least 144 young. This compares with only 7 known nest sites in 1971. Midwinter Bald Eagle counts coordinated by TPWD and conducted by birding enthusiasts throughout the state reported 325 eagles in 2002. From 1986-1989, midwinter counts averaged less than 15 Bald Eagles per survey site. Since 1990, the average number of eagles per survey site has increased to 18. These numbers show encouraging trends for Texas. With continued vigilance, protection, and informed management, today's Texans can insure that future generations will have the opportunity to enjoy the sight of our majestic national symbol – the only eagle unique to North America.

Recovery Efforts

During the 1970's and 1980's, major efforts were directed toward captive breeding and reintroducing young birds into the wild. A total of 124 Bald Eagles were hatched at the Patuxent Wildlife Research Center in Maryland from 1976-1988. These captive-hatched eaglets were an important source for restocking wild populations. One successful reintroduction program placed young eaglets in the nests of adults whose own eggs were infertile or failed to hatch. The "foster" parents readily adopted the chicks and raised them as their own. Another method, called "hacking" places young birds on man-made towers in suitable habitat where populations are low. The nestlings are kept in an enclosure and fed by humans that stay out of sight. When they are able to fly, the enclosure is opened and the birds are free to leave. Food is still provided at the release site until no longer used or needed by the young birds. Hacking has been used very successfully in at least 11 states.

In Texas, the greatest challenge for the future will be to prevent further destruction of habitat and retention of sufficient creek and river flows to support a food base for breeding and wintering eagles. The Texas

Parks and Wildlife Department, in cooperation with landowners, other agencies and conservation groups, is continuing to monitor breeding and wintering Bald Eagle populations. Monitoring of nesting success is particularly important in detecting any problems associated with contaminants in the environment.

Finally, appropriate management of nesting, feeding, loafing, and wintering habitat must be a priority if we are to maintain the current upward trend in Bald Eagle numbers in Texas.

Where To See Bald Eagles

There are a number of State Parks where visitors have the opportunity to see and learn more about Bald Eagles. These include Lake Brownwood, Lake Livingston, Lake Texana, Lake Whitney, and Possum Kingdom State Parks. The Vanishing Texas Rivers Cruise, a privately operated excursion boat, also provides visitors with excellent opportunities to see wintering eagles on Lake Buchanan in Burnet and Llano Counties.

Because the Bald Eagle is a protected species and sensitive to human disturbance, birders and other observers should carefully follow certain viewing ethics. Recorded calls of prey species should not be used to attract birds. Also, observers should be careful not to approach too closely or otherwise disturb or stress birds.

How You Can Help

If you see a Bald Eagle nest, remember that eagles are vulnerable to disturbance throughout the nesting period (October to July in Texas), and are easily disturbed particularly during the first 12 weeks of nesting activity. Observers should remain a safe distance away from the nest (at least 750 feet) and keep noise and other human impacts to a minimum. Private landowners are encouraged to report new Bald Eagle nests to Texas Parks and Wildlife Department.

You can be involved in the conservation of Texas' nongame wildlife resources by supporting the Special Nongame and Endangered Species Conservation Fund. Special nongame stamps and decals are available at Texas Parks and Wildlife Department (TPWD) Field Offices, most State Parks, and the License Branch of TPWD headquarters in Austin. Conservation organizations in Texas also welcome your participation and support. Finally, you can encourage and support private landowners who are minimizing nest disturbance and managing their land to protect Bald Eagle habitat.

For More Information Contact

Texas Parks and Wildlife Department
Wildlife Diversity Branch
4200 Smith School Road
Austin, Texas 78744
(512) 912-7011 or (800) 792-1112
or
U.S. Fish and Wildlife Service
Ecological Services Field Office
10711 Burnet Road, Suite 200
Austin, Texas 78758
(512) 490-0057

Management guidelines are available from Texas Parks and Wildlife Department or the U.S. Fish and Wildlife Service for landowners wishing to protect and manage Bald Eagle habitat.

Placing wing tags on Bald Eagles

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Funds for the production of this leaflet were provided by the U.S. Fish and Wildlife Service, under Section 6 of the Endangered Species Act.

Habitat Management Guidelines for Bald Eagles in Texas

The following guidelines were developed to help landowners and managers maintain or improve their land for the benefit of the Bald Eagle. Information is also provided so that landowners may recognize and avoid or minimize human-related disturbance to eagles, particularly nesting pairs.

Nesting Habitat

The protection of an actual nest is important, but so is protection of the nest area and all the surrounding habitat factors that attracted the nesting pair to the area. Once the eagles establish a suitable breeding territory, they will return to the same area year after year, often using several nests within the territory during different years. When a given nest or the tree that it is in falls, a pair generally returns to the same territory to begin another nest. If one member of a pair dies, the nest may go unused for several years and then be recolonized by the surviving member returning with a new mate. Nesting territories can even be inherited by offspring. Therefore, protection of nesting territories should apply to “abandoned” nests for at least five consecutive years of documented nonuse.

The following habitat management guidelines are based on two management zones surrounding each nest site, with certain restrictions recommended for each zone.

Primary Management Zone For Nest Sites

This zone includes an area extending 750 to 1,500 feet outward in all directions from the nest site. It is recommended that the following activities not occur within this zone:

1. Habitat alteration or change in land use, such as would result from residential, commercial, or industrial development; construction projects; or mining operations.
2. Tree cutting, logging, or removal of trees, either living or dead.
3. Use of chemicals labeled as toxic to fish and wildlife.
4. Placement of above-ground electrical transmission or distribution lines. Since collision with powerlines and electrocution on powerline structures remain an important cause of death, placement of underground lines is recommended near Bald Eagle nests and winter concentration sites.
5. Helicopter or fixed-wing aircraft operation within 500 feet vertical distance or 1,000 feet horizontal distance of the nest site during the nesting season (October-July).
6. Activities which create minimal disturbance, such as hiking, fishing, camping, and bird-watching can be carried out safely during the non-nesting season if there is no physical alteration of the habitat within the zone. Traditional farming, ranching, and hunting activites which are existing practices and have occurred historically on the site can be carried out safely during the non-nesting season as long as habitat alteration is avoided.

Human presence within this zone should be minimized during the nesting season, especially during the early nesting period from October-April. Traditional agricultural activities and low impact recreational activities are generally not a problem even during the nesting season as long as they do not appear to be adversely affecting nesting success, there is no increase in the level of disturbance from historic levels, and physical alteration of the habitat is avoided. However, activities of any kind should be stopped if it becomes apparent that the birds are suffering from disturbance. The key point is whether the activities keep the breeding birds away from the nest, eggs, or young for extended periods of time. If they do, they are harmful. In general, it is important to protect the nest from human disturbance during very hot or very cold weather, since the parents’ absence at these times can be particularly deadly for the eggs or young.

Secondary Management Zone For Nest Sites

This zone encompasses an area extending outward from the primary zone an additional 750 feet to 1 mile. Recommended restrictions in this zone are intended to protect the integrity of the primary zone and to protect important feeding areas, including the eagle’s access to these areas. The following activities are likely to be detrimental to Bald Eagles at any time, and in most cases should be avoided within the secondary zone:

1. Development of new commercial or industrial sites.
2. Construction of multi-story buildings or high-density housing developments between the nest and the eagle’s feeding area.
3. Placement of electrical transmission or distribution lines between the nest site and the eagle’s feeding area.
4. Construction of new roads, trails, canals, or rights-of-way which would tend to facilitate human access to the eagle nest.
5. Use of chemicals labeled as toxic to wildlife.

Certain activities that involve only minimal alteration or disturbance to the habitat can be carried out safely in the secondary zone during the non-nesting season. Examples of these activities include: minor logging or land clearing, minor construction, seismographic exploration employing explosives, oil well drilling, and low-level aircraft operation. However, these activites should avoid major alteration or loss of Bald Eagle habitat as much as possible.

If logging is done, it is best to retain as many large trees as possible for roost and perch trees. Retention of at least 10 to 15 live trees per acre is suggested. Ideally, the trees left uncut should be the largest in the stand, preferably those with open crowns and stout lateral limbs. Selective forestry practices such as seedtree, shelterwood, and single tree selection are recommended over clear-cutting.

Minimal disturbance recreational activities (hiking, fishing, camping, picnicking, bird-watching, hunting) and everyday farming and ranching activities that cause no new alteration of habitat can be safely carried out in the secondary zone at any time.

Feeding Areas

The use of toxic chemicals in watersheds and rivers where Bald Eagles feed should be avoided as much as possible. Where agricultural herbicides and pesticides are used within the watershed, label directions should be strictly followed, including those describing proper disposal of rinse water and containers.

Alteration of natural shorelines where Bald Eagles feed should be avoided or minimized as much as possible. Degraded or eroded shorelines should be revegetated whenever possible.

Winter Roost Concentration Areas

Logging or land clearing activity should be avoided within 1,500 feet of a roosting concentration area. Disruptive, noisy, or out-of-the-ordinary land use activities should be avoided near communal roost sites. Normal agricultural activites which have occurred traditionally on the land are generally acceptable near these roost sites as long as they do not appear to be affecting roosting eagles. However, it is best to avoid even normal activities during evening, night, and early morning hours.

For More Information

Landowners and managers can contact the Texas Parks and Wildlife Department, U.S. Fish and Wildlife Service, U.S. Natural Resources Conservation Service (formerly Soil Conservation Service), or Texas Agricultural Extension Service for technical assistance in managing habitat and protecting Bald Eagle nest sites.

Funds for the production of this leaflet were provided by the U.S. Fish and Wildlife Service, under Section 6 of the Endangered Species Act.

U.S. Fish & Wildlife Service

The Bald Eagle's Road to Recovery

1940
Congress passes the Bald Eagle Protection Act, making it illegal to kill, harass, possess (without a permit) or sell bald eagles, including their parts, nests or eggs.

1963
Only 417 nesting pairs of bald eagles remain in the wild in the lower 48 states.

1967
Bald Eagles in the lower 48 states listed as an endangered species under the Endangered Species Preservation Act (precursor to the Endangered Species Act).

1973
Bald Eagle protection continued under the Endangered Species Act.

1978
Bald Eagles listed as endangered in 43 of the lower 48 states except in Michigan, Minnesota, Wisconsin, Oregon, and Washington where they were listed as threatened.

1981
Population slowly increases to 1,188 breeding pairs.

1982-1990
Regional recovery teams develop recovery plans to outline the tasks and actions necessary to recover populations.

1995
Population grows to an estimated 4,500 breeding pairs and recovers to the point they could be upgraded from a status of endangered to threatened.

1999
USFWS proposes to remove the species from the list of threatened and endangered species and proposes a draft post-delisting monitoring plan.

2000
More than 6,400 pairs of bald eagles are breeding in the lower 48 states. USFWS holds a Bald Eagle monitoring workshop with the states.

2006
USFWS re-opens the public comment period on delisting proposal, proposes management guidelines and definition of "disturb" under Bald and Golden Eagle Protection Act to ensure continued eagle conservation.

2007
Delisting finalized and eagle management continues under Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act. Revised monitoring plan made available for public comment.

2007
Bald eagles reach their largest population since post World War II with 9,789 breeding pairs.

2008
Post-delisting monitoring plan finalized. First monitoring period conducted in the Fall of 2008 through the Winter of 2009.

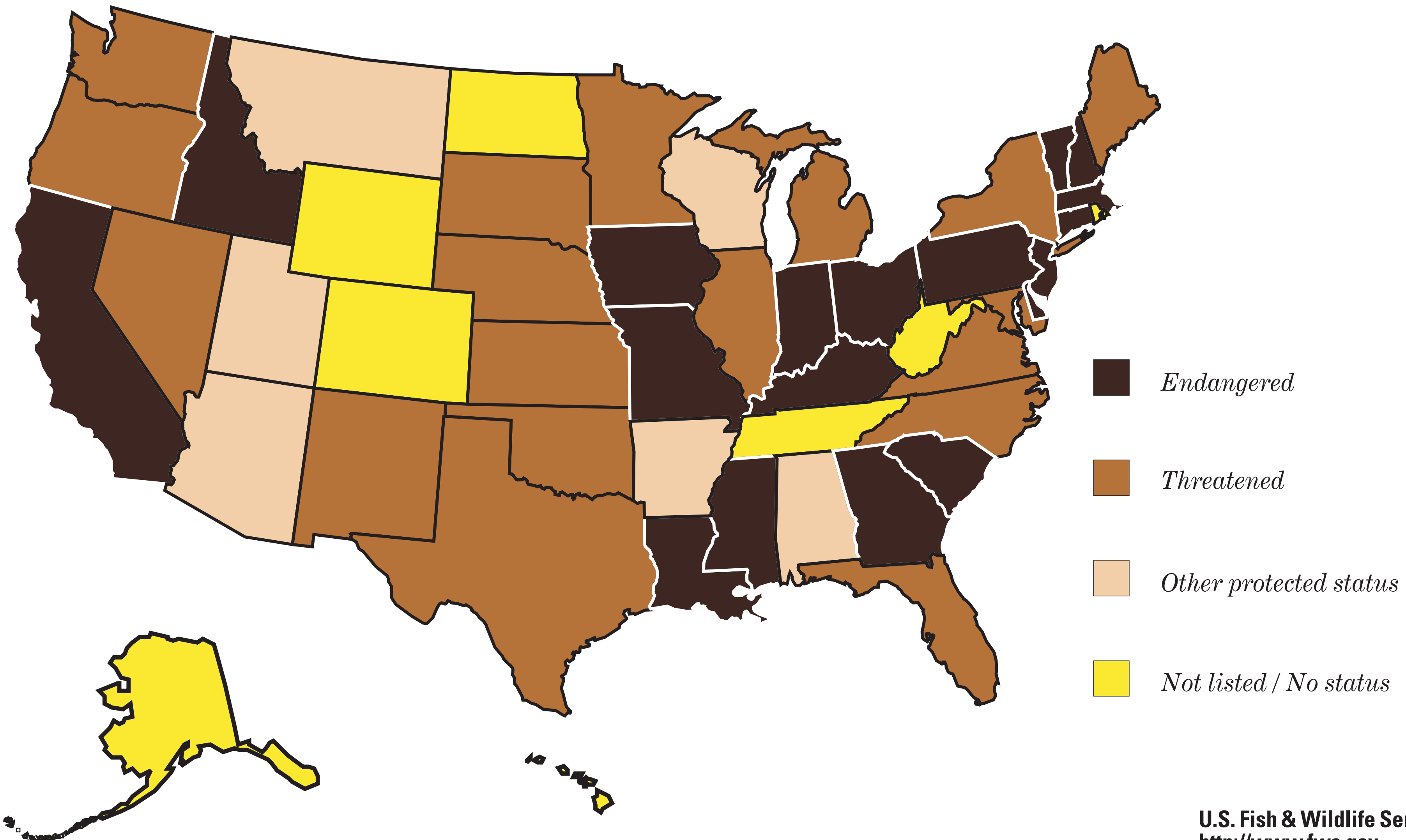
2013/14
First post-delisting monitoring survey and assessment dates.

U.S. Fish & Wildlife Service
http://www.fws.gov

U.S. Fish & Wildlife Service

Bald Eagle State Status

2004



U.S. Fish & Wildlife Service
http://www.fws.gov
December 2004

Great Trinity Forest Management Plan

Threatened and Endangered Species

The Bald Eagle:

Other Protection following Delisting under the Endangered Species Act of 1973

Fact Sheet

The Bald Eagle: Other Protection following Delisting under the Endangered Species Act of 1973

November 5, 2004 draft (revised January 4, 2007)

The Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act will continue to protect the bald eagle following delisting under the Endangered Species Act. Originally passed in 1940 to protect bald eagles, the Eagle Act was amended in 1962 to protect golden eagles as well, by prohibiting the take, possession, sale, purchase, barter, offer to sell, purchase or barter, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit (16 U.S.C 668(a); 50 CFR 22). "Take" includes pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb (16 U.S.C. 668c; 50 CFR 22.3).

A violation of the Eagle Act can result in a fine of $100,000 or imprisonment for one year, or both, for a first offense. An organization may be fined $200,000. Penalties increase for additional offenses. A second violation is a felony and can result in two years' imprisonment and a fine of up to $250,000 for an individual— or $500,000 for an organization. People who provide information leading to an arrest and conviction are eligible for a reward of up to half of the fine.

The Lacey Act

Congress originally passed the Lacey Act in 1900 to help States protect resident species by making it a Federal violation to transport illegally taken wildlife across State lines. Later amending the law, Congress extended its prohibitions to importing, exporting, selling, acquiring, or purchasing fish, wildlife, or plants taken, possessed, transported or sold in violation of U.S. or Indian law or State or foreign law. Prohibitions of the Lacey Act (16 U.S.C. 3371-78) will continue to apply to the bald eagle including its feathers, parts, nests, and eggs—as well as its products—following delisting under the Endangered Species Act. The Lacey Act also prohibits making false records, labels, or identification of shipped wildlife; importing injurious species; and shipping fish or wildlife in an inhumane manner.

Penalties include a maximum of five years in prison and a $250,000 fine for felony convictions, a maximum $10,000 fine for civil violations, and a $250 fine for marking violations. The maximum criminal fine for an organization is

$500,000. People who provide information leading to an arrest, criminal conviction, civil penalty, or forfeiture of property are eligible for a reward. Fish, wildlife, and plants involved in violations are subject to forfeiture. Vessels, vehicles, aircraft, and other equipment used to aid in importing, exporting, transporting, selling, receiving, acquiring, or purchasing fish or wildlife or plants in a criminal violation are subject to forfeiture upon a felony conviction involving commercialization.

The Migratory Bird Treaty Act

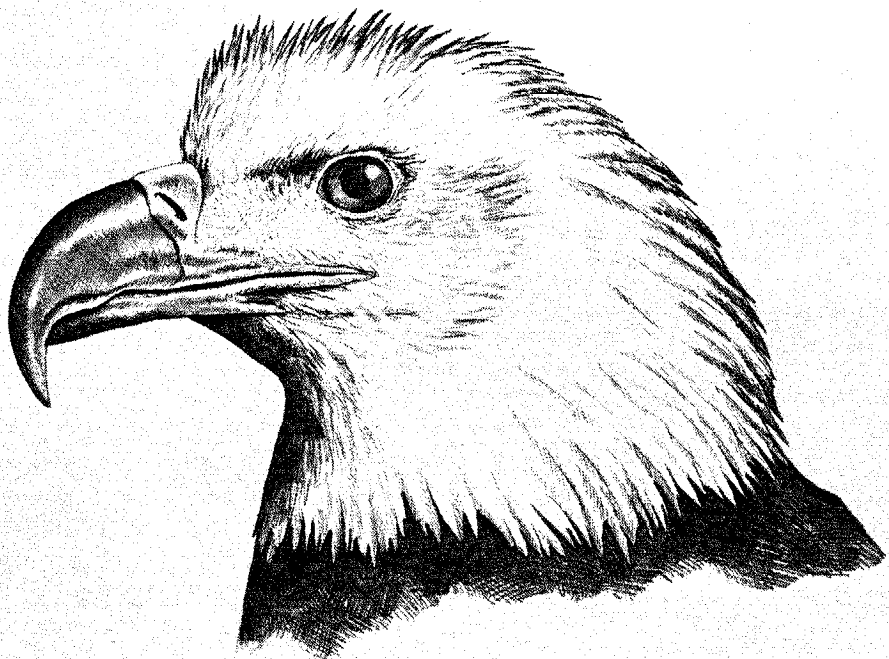
The Migratory Bird Treaty Act is a Federal law that carries out the United States' commitment to four international conventions— with Canada, Mexico, Japan, and Russia. The conventions protect migratory birds as an international resource. The Migratory Bird Treaty Act (16 U.S. C 703-712) and its implementing regulations (50 CFR 21) provide authority to conserve bird species such as the bald eagle, even if Endangered Species Act protections are removed.

Except as allowed by permit (50 CFR 21.11), the Migratory Bird Treaty Act makes it unlawful to pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry or cause to be carried, receive for shipment, or export any migratory bird—including eggs, parts, and nests. In addition, the Act authorizes and directs the Secretary of the Interior to determine if, and by what means, the take of migratory birds should be allowed and to adopt regulations permitting and governing take—for example, hunting seasons for ducks and geese.

Penalties include a maximum of two years' imprisonment and a $250,000 fine for a felony conviction and six months' imprisonment and $15,000 fine for a misdemeanor conviction. A commercial activity is a felony, just as is take with intent to sell. Maximum fines are doubled for any organization convicted of a felony violation.

BIOLOGICAL REPORT 82(10.126)
OCTOBER 1986

HABITAT SUITABILITY INDEX MODELS: BALD EAGLE (BREEDING SEASON)



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[illegible]. Department of the Interior

Biological Report 82(10.126)
October 1986

HABITAT SUITABILITY INDEX MODELS: BALD EAGLE (BREEDING SEASON)

by

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Performed for
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Washington, DC 20240

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PREFACE

This model was developed by the author as a result of his interest in, and experience with, the bald eagle. The U.S. Fish and Wildlife Service provided quality control, content reviews, and publication costs, but the fact that the model was completed is due primarily to the persistence and interest of the author.

This document is part of the Habitat Suitability Index (HSI) Model Series [Biological Report 82(10)], which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. This information provides the foundation for the HSI model and may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model section documents the habitat model and includes information pertinent to its application. The model synthesizes the habitat use information into a framework appropriate for field application and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). The HSI Model section includes information about the geographic range and seasonal application of the model, its current verification status, and a list of the model variables with recommended measurement techniques for each variable.

The model is a formalized synthesis of biological and habitat information published in the scientific literature and may include unpublished information reflecting the opinions of identified experts. Habitat information about wildlife species frequently is represented by scattered data sets collected during different seasons and years and from different sites throughout the range of a species. The model presents this broad data base in a formal, logical, and simplified manner. The assumptions necessary for organizing and synthesizing the species-habitat information into the model are discussed. The model should be regarded as a hypothesis of species-habitat relationships and not as a statement of proven cause and effect relationships. The model may have merit in planning wildlife habitat research studies about a species, as well as in providing an estimate of the relative suitability of habitat for that species. User feedback concerning model improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning are encouraged. Please send suggestions to:

Habitat Evaluation Procedures Group
National Ecology Center
U.S. Fish and Wildlife Service
2627 Redwing Road
Ft. Collins, CO 80526-2899

CONTENTS

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BALD EAGLE (Haliaeetus leucocephalus)

HABITAT USE INFORMATION

General

The bald eagle (Haliaeetus leucocephalus) is a large predatory raptor that occurs "...primarily near seacoasts, rivers and large lakes, breeding in tall trees or on cliffs" (American Ornithologists' Union 1983:106). It is a common breeder throughout southeastern coastal Alaska (Robards and Hodges 1977) and is found in lesser numbers throughout Canada and the United States (DeGraaf et al. 1980). It winters primarily "...from southern Alaska and southern Canada southward" (American Ornithologists' Union 1983:106) near large, ice-free bodies of water (Steenhof 1978). After suffering precipitous declines over much of its range, the bald eagle population has recently exhibited signs of recovery (Hamerstrom et al. 1975; Grier 1982).

Food

The preferred foraging habitats of the bald eagle are rivers, lakes, and estuaries (DeGraaf et al. 1980). Primary feeding areas are large bodies of open water. It is rarely associated with smaller streams or ponds (Leighton et al. 1979). In the Greater Yellowstone Ecosystem, "[a] stable food source, which was available from early spring, appeared to be the most important factor in breeding area selection" (Swenson et al. 1986:5). Swenson et al. (1986:43) further stated that "[d]ifferences in movements, breeding success, nest site selection, and nesting chronology among [the Yellowstone, Continental, and Snake] units were primarily due to differences in the amount and timing of food availability."

The bald eagle consumes a wide range of food items, from pied-billed grebes (Podilymbus podiceps) (Cline and Clark 1981) to bullheads (Ictalurus spp.) (Dunstan and Harper 1975) to sea otter (Enhydra lutris) pups (Sherrod et al. 1975). Bald eagles at Chesapeake Bay have been found to prey upon or take as carrion 45 species of birds, 11 species of mammals, 12 species of fish, and 5 species of turtles (Cline and Clark 1981). Bald eagles in Maine preyed upon or took as carrion at least 34 species of birds, 18 species of fish, 11 species of mammals, and 2 species of invertebrates (Todd et al. 1982). In Oregon, bald eagles fed on 16 species of fish, 46 species of birds, 20 species of mammals, and 2 invertebrate species (Frenzel 1984).

Although the staple of the bald eagle diet is fish (DeGraaf et al. 1980), their prey may be classified into three main types: live fish, live sea or water birds, and carrion. Fish composed 77% of the food item remains collected at bald eagle nests in interior Maine (Todd et al. 1982). Bald eagles nesting on offshore coastal islands fed primarily on seabirds and waterfowl. In northcentral Minnesota, the diet of breeding eagles was 90% fish (Dunstan and Harper 1975). Studies in Ohio showed that nesting bald eagles fed primarily on fish (Herrick 1924). At San Juan Island, Washington, fish composed 51% of the breeding season diet (Retfalvi 1970). Fish were also the most frequent prey of bald eagles in Chesapeake Bay (LeFranc and Cline 1983) and in Oregon (Frenzel 1984). In southeast New York, wintering bald eagles fed almost entirely on dead and dying alewives (Alosa pseudoharengus) that had passed through the turbines of hydroelectric generating stations (Nye and Suring 1978). In contrast, wintering eagles in Missouri fed primarily on dead and crippled Canada geese (Branta canadensis) (Griffin et al. 1982).

Bald eagle prey selection is determined largely by availability. Birds accounted for 68% and 47% of the diet of bald eagles in the Yellowstone and Continental Units, respectively, of the Greater Yellowstone Ecosystem, but fish made up 67% of the diet in the Snake Unit, in response to habitat differences and prey availability (Swenson et al. 1986). In Maine, eagles focused on the chain pickerel (Esox niger) spawning run in April, then on the sucker (Catostomus spp.) spawning run in May (Todd et al. 1982). Bald eagles in Missouri abandoned their primary prey, dead or crippled waterfowl, in favor of fish during years of heavy fish kill (Griffin et al. 1982). In Oregon, bald eagle diets varied both seasonally and geographically (Frenzel 1984). Wintering bald eagles in southeast New York readily fed upon deer (Odocoileus virginianus) carcasses on frozen reservoirs (A. Peterson, N.Y. State Department Environmental Conservation, Albany; unpubl.). In Washington, eagles fed heavily on road-killed animals (Retfalvi 1970).

Bald eagle nesting densities depend, in part, on total prey availability. At Besnard Lake, Saskatchewan, nesting densities were higher in areas of higher lake productivity (Gerrard et al. 1983), and eagle nesting densities in central Saskatchewan were significantly correlated with the commercial fish catch per hectare of surface water (Whitfield and Gerrard 1985). In California, there also appears to be a positive relationship between bald eagle nesting densities and lake or reservoir productivity (Detrich 1985).

Total prey availability is a function not only of foraging habitat productivity but also the size of the foraging habitat (i.e., total available prey = prey biomass/ha x size of foraging habitat). This is exemplified by the bald eagle's preference for large areas of open water for foraging. Bald eagles nesting in marine environs in New Brunswick were more successful than those occupying lake or river sites (Stocek and Pearce 1981). Lake habitats were also clearly preferred over river habitats. At the Pit River hydroelectric complex in California, bald eagles nested exclusively along reservoirs, although riverine habitats were available (BSAI 1985). Leighton et al. (1979) concluded that lakes <11 km in circumference did not constitute primary breeding habitat. Whitfield et al. (1974) concluded that lakes with <11.3 km of shoreline did not provide primary breeding habitat. The surface area of lakes with a circumference of 11 km varies with shoreline configuration, but cannot exceed 9.6 km^2 (for a circular lake). The smallest body of water reported to support one nesting pair of bald eagles is 8 ha (J. Mathisen, Chippewa National Forest, Cass Lake, MN; pers. comm.). It should be noted that bald eagles nesting on smaller water bodies may require other nearby lakes for additional foraging areas.

Although larger bodies of water appear to provide superior habitat to smaller ones (Whitfield et al. 1974; Leighton et al. 1979; Stoceck and Pearce 1981), increasing surface area beyond the 9.6 km^2 threshold does not appear to affect habitat suitability. For example, Lake Britton in northern California is a long and narrow reservoir with only 5.2 km^2 of surface area (BSAI 1985); however, it supports the highest density of nesting bald eagles in that state (if it were not so narrow, i.e., had a larger surface area, the same shoreline length could be more effectively used and might support an even greater density) (BSAI 1985; Detrich 1985). Also, in New York State, historical bald eagle nesting densities along Oneida Lake (207 km^2) were at least as great as along the eastern shore of Lake Ontario (>15,000 km^2) (Nye and Peterson 1980). Therefore, lakes with surface areas >10 km^2 (rounded from 9.6) appear to be of optimal size.

Water

No information pertaining to dietary water needs of the bald eagle was found in the literature.

Cover

Wintering bald eagles depend on suitable night and severe weather roosts in sheltered timber stands (Steenhof 1976). Although proximity to food sources is an important attribute (Keister and Anthony 1983), these roosts need not be close to water (Steenhof 1978). Roosts appear to be selected for protection from the wind (Steenhof 1978; Keister et al. 1985). However, the literature does not mention a dependence on cover during the breeding season. Cover requirements during the breeding season are assumed to be identical to reproduction requirements.

Reproduction

Although bald eagles will nest on the ground on isolated, treeless islands (Troyer and Hensel 1965) and occasionally on cliffs (Bull 1974; Brazil 1985), they prefer larger, dominant trees of a variety of species (Murphy 1965; Jaffee 1980; Lehman et al. 1980; Anthony and Isaacs 1981; Mosher and Andrew 1981; Mathisen 1983). The bald eagle prefers to nest in areas that are primarily mature or old-growth timber (Lehman et al. 1980; Anthony and Isaacs 1981; Anthony et al. 1982). Most nests in southeast Alaska were in old-growth forest where the average nest tree height was 29.4 m; no nests were found in second-growth trees (Robards and Hodges 1977). A mature vegetation structure was considered to be an important component of bald eagle breeding habitat in Maryland (Mosher and Andrew 1981). There, the average nest tree height was

29 m. The average nest tree height in Virginia was 30.1 m (Jaffee 1980). Nest trees were of an open, stable form providing easy access; the form was more important than the tree species in nest site selection.

Bald eagles in the Greater Yellowstone Ecosystem were flexible in their selection of nest sites, as long as a dependable food source was available in early spring (Swenson et al. 1986). Once this criterion was met, the eagles "... would nest...near either lakes or rivers, in either large, strong trees ...or small, weak trees..." (Swenson et al. 1986:41), although they tended to select the most desirable trees available. In comparison to surrounding trees, 38%, 44%, and 19% of the nest trees were categorized as larger (in diameter or height) in the Yellowstone, Continental, and Snake Units, respectively (Swenson et al. 1986). Sixty-two percent, 56%, and 71% of the nest trees were categorized as similar to surrounding trees in the three Units, respectively. Only 2 of the 56 nest trees were categorized as smaller than the surrounding trees.

Second-growth forest with a remnant (5% to 10%) old-growth component also may provide breeding areas. In Minnesota, State forestry laws of 1902 and 1908 required that 5% to 10% of the trees in the original forest stands be retained as seed trees (Juenemann and Frenzel 1972). These retained trees currently provide canopy discontinuity from the surrounding second-growth hardwoods and are strongly selected for by breeding bald eagles (Juenemann and Frenzel 1972; Mathisen 1983).

Some deforestation may occur without apparently affecting bald eagle densities. For example, in southern British Columbia, 21% of the study area had no old-growth trees, yet eagle density was not reduced from levels in northern British Columbia where 10% of the study area lacked old-growth (Hodges et al. 1984). Eagle densities in both areas matched those of undisturbed southeast Alaska. Although nesting density was greatly reduced in those plots of the study area without old-growth trees, densities in areas with at least some old-growth trees were higher than expected.

One of the most important characteristics of bald eagle nesting habitat is an open forest structure (Lehman et al. 1980; Anthony and Isaacs 1981; Mosher and Andrew 1981; Anthony et al. 1982). The average percent canopy closure at nests in Maryland was 61% (Mosher and Andrew 1981). In California, the canopy closure of the timber stand associated with the nest was usually <40% (Lehman 1979) and often <20% (Lehman et al. 1980). Bald eagles in the Pacific Northwest also nested in fairly open forests (Anthony et al. 1982) where the mean crown closure was <50% (Anthony and Isaacs 1981).

Bald eagles are primarily shoreline nesters (Hensel and Troyer 1964; Robards and King 1966; King et al. 1972; Gerrard et al. 1975; Grier 1977; Lehman et al. 1980; Hodges 1982; Mathisen 1983; Barber et al. 1985; Brazil 1985; Koonz 1985; Stocek 1985). Murphy (1965) listed proximity to water as the first requirement of an area as nesting habitat. The mean distance from water, however, varies between populations, from 36 m on Admiralty Island, Alaska (Robards and Hodges 1977), to over 707 m in Virginia (Jaffee 1980) to over 1.2 km in Oregon (Anthony and Isaacs 1981). Whitfield et al. (1974)

found that over 90% of all nests in their Manitoba and Saskatchewan study areas were within 182 m of a lake or river. Very few nests were found over 728 m from water. In this study and in Alaska (Robards and Hodges 1977), the number of nests dropped off sharply beyond 46 m from water. Bald eagles nested an average of 97.5 m, 199.8 m, and 552.5 m from water in the Yellowstone, Snake, and Continental Units, respectively, of the Greater Yellowstone Ecosystem (Swenson et al. 1986). In Maryland, Taylor and Therres (1981) did not consider land over 1.6 km from water to be suitable nesting habitat. Over 90% of all Maryland bald eagle nests were within 1.5 km of water. None of these studies, however, established a mean distance of land to water. Therefore, nest site preference may have been confounded with land and water distribution.

Bald eagles may show some reluctance to nest right at the shoreline. Even in relatively undisturbed areas of Alaska, the average distance of nest to water was 36 m (Robards and Hodges 1977). In addition, nests within 10 m of shore had a tendency to be used less than those nests over 10 m from shore. Both Robards and Hodges (1977) and Dixon (1909 cited by Bent 1937) suggested that protection from storms may be a reason for this avoidance of the immediate shoreline.

Special Considerations

Although the level of human disturbance often has no effect on the productivity of bald eagles at existing nest sites (Mathisen 1968; Grier 1969; Jaffee 1980; Stocek and Pearce 1981), eagles clearly prefer to nest in areas with little or no human disturbance (Fraser 1985). For example, bald eagle populations are densest in areas without significant human disturbance, such as southeast Alaska (Robards and Hodges 1977), and there they did not use areas of heavy human use. In Manitoba, there were significant numbers of nesting bald eagles on Lakes Winnipeg and Manitoba, except near extensive cottage development (Hatch 1985). Bald eagle densities on Besnard Lake, Saskatchewan, decreased in areas opened to recreational activity (Gerrard et al. 1985). The distance to a water body from bald eagle nests in the Greater Yellowstone Ecosystem tended to increase as the recreational use of the water body increased (Swenson et al. 1986). In Minnesota, human disturbance was related to lowered nest occupancy and productivity (Juenemann and Frenzel 1972). In coastal British Columbia, bald eagles were abundant except in heavily disturbed areas (Hodges et al. 1984). Bald eagles tended to nest away from human residential areas in Maryland (Taylor and Therres 1981). There, only two of 123 nests had residential development as the primary land use within 0.6 km of the nest. Taylor and Therres (1981) suggested that nesting bald eagles will tolerate low-density residential disturbance at distances greater than 1.2 km and medium- to high-density residential disturbances at greater than 1.8 km. A tendency of bald eagles to nest away from human activity was also noted in another quantitative study of bald eagle nesting habitat in Maryland (Mosher and Andrew 1981). Successful nest sites were located in more dense forest stands set back further from open water and forest openings than unsuccessful nests. All the bald eagle nests on Yellowstone Lake, Wyoming, were on the roadless south shore (Murphy 1965). The north shore is paralleled by a heavily traveled highway that permits access for a wide range of human recreational activities. The majority of bald eagle nests in Virginia were located in areas of light human use (Jaffee 1980). Jaffee (1980) suggested that bald eagles were relocating their nests in Virginia to avoid human disturbance associated with shorelines. Lehman et al. (1980) made a similar suggestion about bald eagles in California. These studies indicated that, although nesting bald eagles were not affected by low degrees of human disturbance, habitat suitability decreased as human disturbance increased. There were few reported instances of bald eagles nesting in medium- to high-density human residential areas, and the greatest densities were always reported in areas of minimal human activity.

Logging operations can be very intensive, and this degree of human activity may lower nesting productivity (Anthony and Isaacs 1981). Carefully controlled selective timber harvest, however, need not lower habitat suitability (Lehman et al. 1980). Selective logging during the fall and winter was considered a necessary and appropriate bald eagle management tool in California because eagles there preferred to nest in ponderosa pine (*Pinus ponderosa*), a shade intolerant species (Lehman et al. 1980; Burke 1983).

Bald eagles may be more prone to nest desertion early in the nesting cycle than late in the cycle (Mathisen 1968) and will react differently to different types of disturbance. For example, existing cropland was considered an acceptable component of bald eagle nesting habitat in Maryland (Taylor and Therres 1981). However, the authors noted that cropland itself is unsuitable bald eagle nesting habitat. Intensive agriculture in Ohio was not thought to disturb some nesting bald eagles (D. Case, Ohio Department of Natural Resources, Columbus, Ohio; pers. comm.). In addition, disturbances that eagles may not directly recognize as human, such as railroads, planes, and unused buildings, may be tolerated.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Purpose. This model differs from the standard HSI model. Most HSI models are designed to quantify the impacts of development projects for mitigation planning or to predict benefits of various habitat management programs. The bald eagle HSI model may be used for assessment of impacts, but will be of little use in mitigation or management studies due to the model variables. Variables used in this model to assess habitat suitability either are not likely to change due to management (e.g., area of water body, morphoedaphic index), or are likely to change slowly over time as a result of management (e.g., the amount of mature forest available for nest sites). Management of bald eagle nesting habitat currently consists primarily of nest site protection. For example, the management strategy for the bald eagle at Chippewa National Forest in Minnesota is primarily land-use restrictions in the vicinity of nests, along with biological monitoring (Mathisen et al. 1977). Therefore, the primary uses of this model may differ from those of other HSI models. This model may be most useful in comparing the suitability of many different areas at one point in time for site protection, or as a tool in recovery planning to locate optimum areas for bald eagle reintroduction or protection.

Geographic area. This HSI model has been developed for application to habitats in that portion of North America north of the 37th parallel, which runs from Norfolk, Virginia, to San Jose, California (Figure 1). Because the bald eagle nests across the continent in a variety of ecoregions, and is so mobile, no attempt was made to delineate a discrete breeding range within this area.

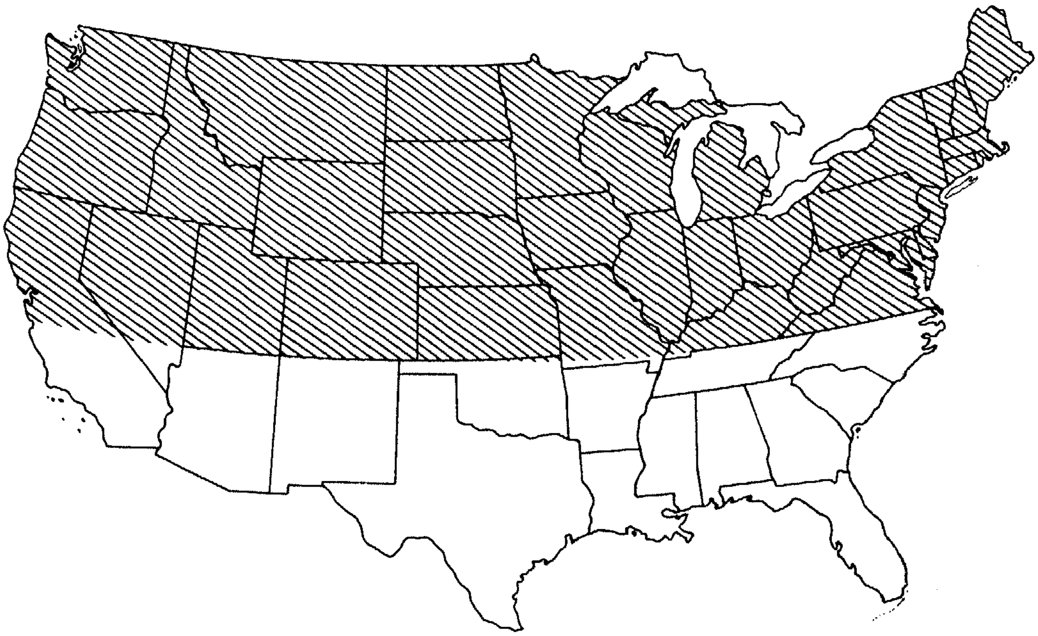


Figure 1. Geographic applicability of the bald eagle HSI model.

Season. This model was developed to evaluate the potential quality of nesting habitat for the bald eagle. It is not intended to assess the quality of fall and winter habitat.

Cover types. This model was developed to evaluate habitat in the Lacustrine (L) and Estuarine (E) cover types (terminology follows that of U.S. Fish and Wildlife Service 1981). These cover types include a 1.5-km strip of land that borders the open water or adjoining emergent or scrub-shrub wetlands. This model does not provide a means of evaluating riverine and marine cover types because data on the morphoedaphic index (a major factor in determining food suitability with this model) was not found for these cover types.

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before an area will be occupied by a species. The smallest body of water occupied by one pair of nesting bald eagles is 8 ha. Therefore, the minimum size of an evaluation area is assumed to be a body of water with a surface area of 8 ha surrounded by a 1.5-km strip of land.

Verification level. Earlier drafts of this model were reviewed by the following individuals:

Dr. Robert Anthony, Oregon Cooperative Wildlife Research Unit, Corvallis, OR

Mr. Denis Case, Ohio Department of Natural Resources, Columbus, OH

Mr. Keith Cline, Raptor Information Center, Washington, DC

Dr. Daniel James, U.S. Fish and Wildlife Service, Arlington, VA

Mr. John Mathisen, U.S. Forest Service, Cass Lake, MN

Mr. Brian Millsap, Raptor Information Center, Washington, DC

Ms. Karen Steenhof, U.S. Bureau of Land Management, Boise, ID

Mr. Stanley Wiemeyer, U.S. Fish and Wildlife Service, Laurel, MD

Comments by the reviewers were incorporated into the model and resulted in several significant improvements. The current model has not been field tested and empirical relationships between model outputs and measures of bald eagle habitat suitability are unknown.

Model Description

Overview. The breeding season HSI model for the bald eagle considers food, reproduction, and human disturbance as the primary components of breeding habitat. The HSI value considers the quality and availability of nesting sites and the availability of prey. Because eagle prey is primarily derived from aquatic systems, total prey availability is assumed to depend upon the size and productivity of the associated water body. Optimal nesting habitat is assumed to be characterized by: (1) a large foraging area with high fish production, (2) the presence of mature trees for nest sites, and (3) minimal human disturbance. Cover requirements during the breeding season are assumed to be adequately evaluated by the criteria used to evaluate reproductive requirements.

The following sections describe the logic used and the assumptions made to translate the habitat information for the bald eagle to the variables and equations used in the model. The suitability levels of variables and relationships between variables are also described.

Food component. Bald eagle breeding habitat suitability is strongly influenced by the availability of live or carrion prey, primarily fish or aquatic birds. Specifically, the amount of open water in the evaluation area and its productivity are of major importance in determining the total amount of food available to a population of eagles.

Since nesting bald eagles prey largely on aquatic or aquaphilic species, habitat suitability generally increases with the amount of open water. It was noted previously that areas with <8 ha ($0.08\ km^2$) of open water are not known to constitute bald eagle habitat. Habitat suitability increases from zero below this size to optimal for bodies of water with surface areas $\geq 10\ km^2$ (Figure 2a). For estuarine cover types, the suitability index (SIV1) is assumed to be optimal (=1.0) for the amount of foraging habitat.

For the purposes of this model, emergent and scrub-shrub wetlands adjacent to open water also should be considered foraging habitat (as opposed to nesting habitat) due to documented eagle use of these habitats. Foraging in emergent or scrub-shrub wetlands, however, is apparently coincidental to the primary feeding strategies of fishing and shoreline scavenging, because bald eagles have not been observed hunting in emergent or scrub-shrub wetlands that are located far from large, open water bodies. Therefore, emergent or scrub-shrub wetlands that are not associated with open water should not be considered foraging habitat.

The productivity of the water body is the second aspect that is of importance in determining food availability. Specifically, food availability and, hence, habitat suitability, increase with productivity. A reasonable measure of the productivity of lentic aquatic systems can be obtained from the morphoedaphic index (Ryder 1965, 1978, 1980; Jenkins 1982) in terms of fish biomass density or potential fish yield (lbs/acre). The morphoedaphic index (MEI), where

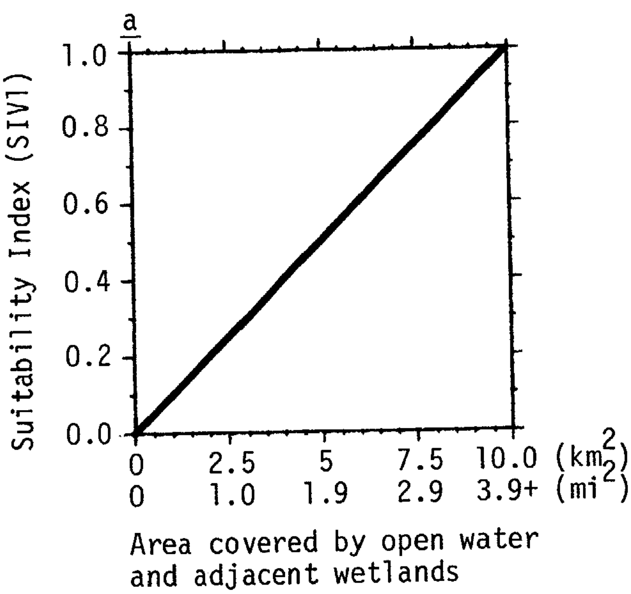
$$MEI = \frac{\text{total dissolved solids (ppm)}}{\text{mean depth (feet)}}$$

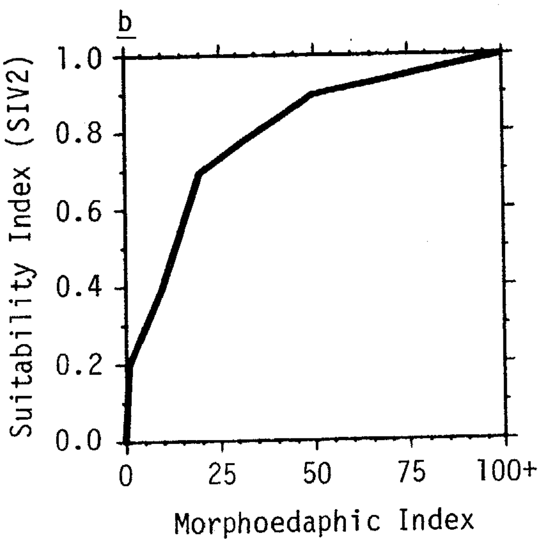
has been used to explain differences in bald eagle nesting densities (Gerrard et al. 1983; Detrich 1985). Detrich (1985) used a modified form where

$$MEI = \frac{\text{conductivity (micromhos)}}{\text{mean depth (cm)}}$$

Fish biomass density and, hence, habitat suitability are assumed to increase with the MEI as a function of the data curves generated by Ryder (1965) and Jenkins (1982) and as described by Ryder (R. A. Ryder, Ontario Ministry of Natural Resources, Thunder Bay, Ontario; pers. comm.) (Figure 2b).

Ryder et al. (1974) note that certain conditions may cause the MEI to yield misleading results. Very shallow lakes, with a mean depth <3 m, may contain lowered fish biomass because of winterkill. Also, lakes with very high TDS levels often have limited fish populations, although the precise reason for this is unclear (Schlesinger and Regier 1982). It is often thought,





Coordinates

X	Y
0.0	0.0
1.0	0.2
10.0	0.4
20.0	0.7
50.0	0.9
100.0	1.0

Figure 2. Relationships between variables used to evaluate suitability of water bodies as bald eagle habitat and suitability indices for the variables.

however, that highly productive systems have marginal habitat for some fish species because of anoxic hypolimnions or reduction of "liebensraum" (Ryder, pers. comm.). Ryder states that fish crops increase rapidly with the MEI to about 40, and show little improvement between MEI's of 40 and 100. Beyond an MEI of 100, Ryder states that the MEI-fish crop relationship often breaks down because of the conditions noted above.

Provided that all criteria for use are heeded, the MEI can be applied to freshwater or brackish ecosystems (Ryder, pers. comm.). However, in this model, comparisons of HSI between the two types may not be made because the salinity of estuaries and, therefore, TDS differs from that of lake water.

The suitability of the food component (SIF) is assumed to be best represented by the geometric mean of the two variables used to evaluate this component, as in Equation 1. This is intended to reflect the compensatory nature between lake size and lake productivity. Specifically, it is assumed that the food resources in lakes from 0.08 - 10 km^2 are not most efficiently used by eagles due to their territorial requirements. It is assumed, following the discussion of Detrich (1985), that smaller lakes often have opposing shorelines <0.5 km apart and that the presence of a pair of eagles on one shore may preclude use of the other shore by other eagles. On larger lakes (>10 km^2), it is assumed that lake geometry does not affect habitat use and that the SI is primarily determined by the MEI. Equation 1 yields a food suitability index of 0.0 for lakes ≤ 8 ha. For lakes >8 ha, the food suitability index determined by Equation 1 is a function both of area and MEI, but the index will be closer to the lower of the two inputs (i.e., SIV1 and SIV2). Note that the area of foraging habitat in estuarine cover types is assumed to be optimal (i.e., SIV1 = 1.0).

$$SIF = (SIV1 \times SIV2)^{1/2} \qquad (1)$$

<u>Reproduction component</u>. Although individual pairs or remnant populations of bald eagles will nest in second-growth timber or largely deforested areas, the species clearly prefers, and reaches its greatest densities in, large areas of undisturbed, mature or old-growth timber, with an open and discontinuous canopy. This habitat type provides an abundance of the eagle's preferred nesting sites, i.e., tall, dominant trees, regardless of species, with an open structure and stable limbs allowing easy approach from the air. Second-growth forests, with a remnant (5% to 10%) old-growth component intermixed, also can provide for nesting requirements. Dense stands of even-aged, small, second-growth timber without a remnant old-growth component do not provide the relatively open canopy structure bald eagles need. The species rarely nests in this seral stage. Productivity of more exposed nests may be affected by increased vulnerability to storm damage. Susceptibility to human disturbance also may increase with visibility or accessibility of the nest.

Suitable bald eagle nesting habitat within lacustrine or estuarine habitats is assumed to be a function of the amount of mature, open canopy forest cover within the evaluation area. Because the majority of bald eagle nests of all populations are within 1.5 km of shore, the evaluation area for this component is the land area within 1.5 km of the edge of the water or associated herbaceous or shrub wetland. Optimum conditions for reproduction are assumed to occur when mature timber exceeds 75% of the land area. Smith (1974) defined undisturbed (i.e., mature) temperate forest generally as uneven aged, having a discontinuous canopy >20 m high. However, the height and structure of mature forests will vary with the forest type. Hence, the user should establish a definition of maturity for the forest cover in the evaluation area. The silvicultural definition of rotation age maturity is not appropriate for the purposes of this model, because it refers to the concepts of financial maturity and return on investment (Smith 1962). Habitats where mature forest cover is <75% of the land area are assumed to be suboptimal (Figure 3). Because bald eagles are territorial, with widely spaced nests even under optimum conditions, it is assumed that some deforestation within an evaluation area may occur without reducing the suitability index for the reproduction component. In this model, the suitability index for bald eagle reproduction (SIR) is estimated by only one variable, the proportion of potential nesting area in mature timber, and is equal, therefore, to SIV3 (from Figure 3).

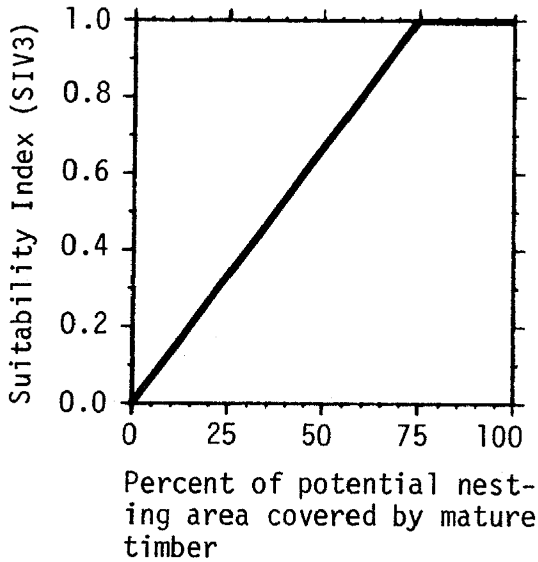


Figure 3. The assumed relationship between the amount of mature timber within 1.5 km of a shoreline and suitability of the habitat for bald eagle nesting.

Human disturbance component. Bald eagle populations reach their greatest densities in areas of minimal human activity. They are found in reduced densities in areas of moderate human use and are not found at all in areas of heavy human use. They prefer to nest at least 1.0 km from human residences and will nest farther from shore to avoid shoreline disturbances. Where human disturbance is severe, nesting success may be affected, and the area may be abandoned entirely. Although remnant populations often are not affected by existing levels of human disturbance, the potential carrying capacity of their habitat has been reduced through human presence and activities. The precise effect of human disturbance on bald eagle carrying capacity is not known and is, therefore, difficult to evaluate.

Human presence in bald eagle nesting habitat falls primarily into four categories: (1) agriculture, (2) urbanization, (3) recreational development, and (4) logging. Most agricultural operations are not human intensive and their effect on carrying capacity most likely is felt via attendant deforestation, not via the human presence *per se*. For this reason, agriculture is considered to be an impact upon the reproduction component. Urbanization and recreational development can both be measured by the density of houses, buildings, or campsites. Medium- and high-density residential areas are defined as areas where lot frontage is ≤33 m (New York State 1974). Medium-density residential areas along a lakeshore would then have buildings at a density of 30 per kilometer of shoreline (Figure 4). This corresponds to 20 buildings per square kilometer of the reproduction area. Habitat suitability is assumed to be optimal where there are no buildings or campsites and unsuitable where there are >20 buildings or campsites per square kilometer of upland (Figure 4).

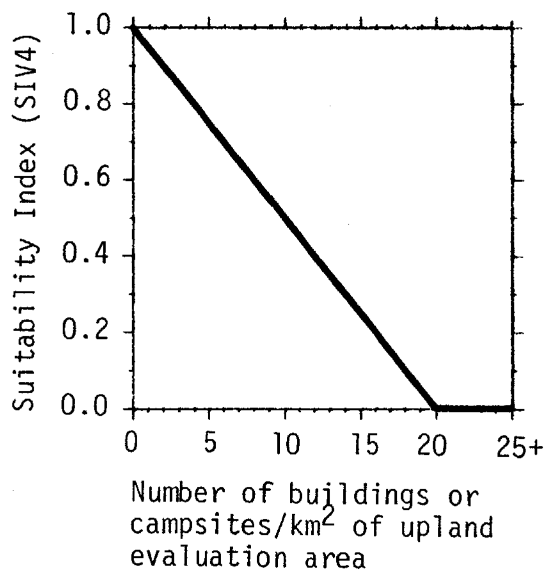


Figure 4. Assumed relationship between housing or campsite density and habitat suitability for the bald eagle.

The distribution and uses of the buildings or campsites, as well as the season of use, will affect the amount of their disturbance. If all the buildings or campsites are distributed evenly along the shoreline, so as to preempt the most desired nesting and perching sites, their impact will be greater than if they are tightly clustered and removed from the shoreline.

The human presence associated with logging may be significant and could cause large reductions in habitat suitability. However, this form of human disturbance has been studied only with respect to impacts upon productivity at individual nest sites. Because productivity varies between and within eagle populations, regardless of nesting density, productivity data alone cannot be used to reliably support habitat suitability models that are based upon nesting density. No information was located in the literature that documented a correlation between logging intensity over a large area (i.e., more than a single nest site) and nesting density in the same area. For this reason, the human disturbance associated with logging operations, although important, cannot be reliably included in this model and must be considered as a separate process.

The overall suitability index for the human disturbance (SIHD) component is estimated by the suitability index determined for building or campsite density (i.e., SIHD = SIV4).

Building density may not be the most precise indicator of human disturbance under certain conditions (e.g., heavy boat traffic only). To be a useful habitat assessment tool, however, the model variables must be easily measurable and applicable to the range of conditions within the model's geographic area of applicability. Building density, therefore, is used as a surrogate measure of human disturbance, because it is an easily measured indicator of long-term human land use.

HSI determination. The overall habitat suitability index is a function of the food, reproductive, and human disturbance components. Any of the components may be the most limiting factor in a given situation. Under pristine conditions, where the reproductive and human disturbance components are optimum, the overall habitat suitability will be determined by the food component which is, in turn, a function of the foraging area and the MEI. Under other conditions, the potential food base may be capable of supporting a higher density of bald eagles than is actually realized, as a result of less than optimum conditions for nesting sites and disturbance potential. It is assumed that the food component is of greater importance alone than either of the other components alone, unless one of the other components is 0.0. The reproductive and human disturbance components are combined via a geometric mean which yields a combined suitability value of 0.0 if either of the inputs is 0.0, and a value closer to the lower of the input values if both are >0.0. The resulting suitability value is multiplied by the food suitability index to yield the overall habitat suitability index (Equation 2). This relationship is based on the assumption that the food suitability value defines the upper level of potential suitability that will be realized only when the reproductive and human disturbance components are optimum. Values less than optimum for the reproductive and human disturbance components will lower the overall value from the maximum set by the food component suitability. In the extreme situation, none of the potential food will be used by eagles when either or both of the reproductive or human disturbance components equals 0.0. It should be noted that the product resulting from Equation 2 will be lower than any individual input if the combined reproductive/disturbance input and the food input are <1.0, because decimals are being multiplied. This is intended and follows the logic that the combined reproductive/disturbance component is a modifier of the maximum suitability determined by the food component.

$$HSI = (SIR \times SIHD)^{1/2} \times (SIF) \quad (2)$$

Because the HSI equation is geometric, and uses values <1.0, the HSI score will generally be <1.0, and will often be <0.5. This will be particularly true when cold, oligotrophic lakes are evaluated. The assignment of an HSI value <0.5 to a wilderness lake with perhaps a healthy eagle population may seem illogical. However, it should be remembered that the HSI is designed to reflect habitat suitability by the density of eagles along the shoreline. Oligotrophic, wilderness lakes may have quite healthy populations of eagles, but at lower densities than can be expected around more productive lakes.

Application of the Model

Summary of model variables. This model provides criteria to evaluate the suitability of bald eagle nesting habitat in lacustrine or estuarine cover types. The relationships of the habitat variables to an HSI are shown in Figure 5. Definitions of habitat variables and suggested measurement techniques (Hays et al. 1981, unless noted otherwise) are shown in Figure 6.

The presumed relationship between each habitat variable and habitat suitability has been described and documented. This provides some insights that can be used to tailor the model to fit study constraints and local bald eagle breeding characteristics. Due to the large breeding range of the bald eagle, it is expected that model alterations will be necessary.

Because many of the data used in applying this model are derived from remote sensing, it is essential that the user visit the evaluation area to ensure that all remote sensing data are accurate. This is necessary to properly define the occurrence and limits of mature forest and to accurately record the type and intensity of human disturbance. This model should not be applied solely on the basis of remote sensing data, no matter how recently collected.

Model assumptions. A number of significant assumptions were made in the development of this HSI model for the bald eagle. The major assumptions are as follows:

1. Mature forested stands with minimal human disturbance are required for nesting by bald eagles. However, optimal nesting conditions can exist as long as >75% of potential nesting area is in mature timber.

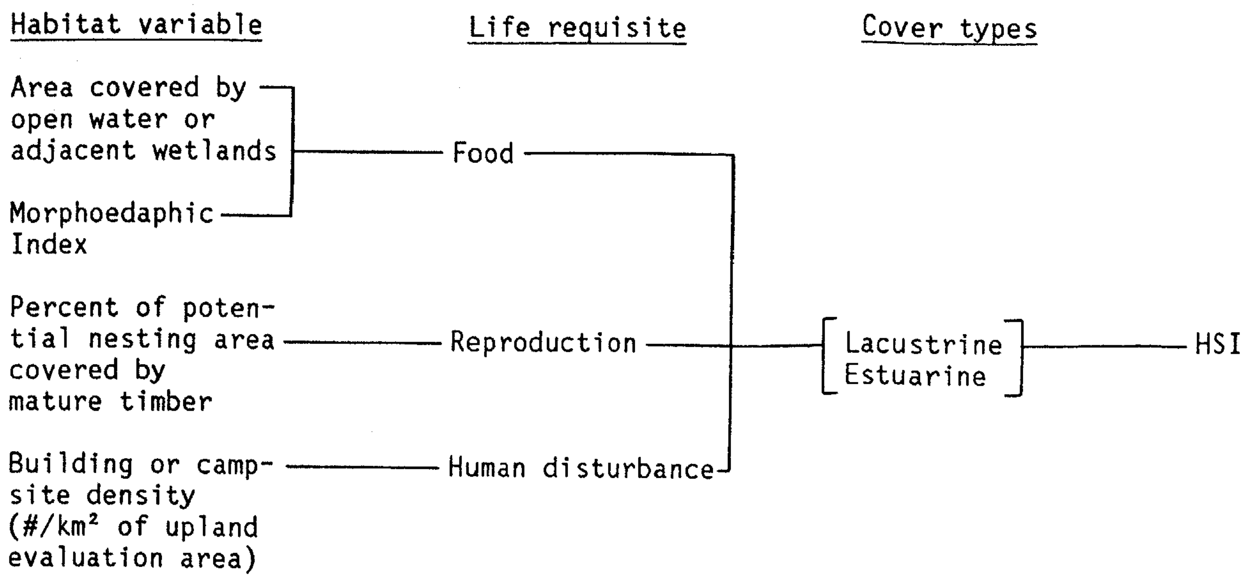


Figure 5. Relationships of habitat variables, life requisites, and cover types in the bald eagle HSI model.

2. Mature forest stands within 1.5 km of a body of water ≥8 ha provide optimal nesting conditions regardless of stand composition.

3. Immature forest stands provide no nesting habitat.

4. The extent and influence of human disturbance can be estimated by an estimate of building or campsite density.

The first assumption will probably be valid in most applications of this model. Under certain conditions, however, bald eagles will nest on the ground or on cliffs. This typically occurs on isolated, uninhabited islands where trees are scarce or absent. Under these circumstances, the model should be modified to include potential cliff or ground nests.

The second and third assumptions also should be valid in most applications of this model. However, certain monotypic stands may not provide optimal nesting conditions at maturity, if the tree species' terminal branching structure is too fine or fragile to support eagle nests. Some immature forest stands that are approaching maturity may contain scattered individual trees that, due to site advantage, possess size and form suitable for nesting. If either circumstance occurs, the model should be modified to reflect the relative presence or absence of nesting sites.

Variable (definition)	Cover types	Suggested technique
Area covered by open water or adjacent wetlands (the absolute area being evaluated that consists of open water plus the herbaceous and shrub wetlands that are immediately adjacent to open water; herbaceous and shrub wetlands that are not adjacent to open water should not be included in determination of area for this variable.)	L	Remote sensing, topographic map, dot grid, published data.
Morphoedaphic Index [A ratio relating the productivity of a water body as measured by total dissolved solids to the mean depth of that water body using the following formula: Morphoedaphic Index (MEI) = $\frac{\text{total dissolved solids}}{\text{mean depth}}$ where total dissolved solids (TDS) is measured in parts per million and mean depth is measured in feet].	L,E	TDS meter, conductivity meter, laboratory analysis, soundings, published data, (Hamilton and Bergersen, n.d.). (NOTE: Conductivity measurements must be converted to TDS before determination of MEI.)
Percent of potential nesting area covered by mature timber (an estimate of the proportion of a 1.5 km wide band of land, surrounding the cover type being evaluated, that is covered by mature forest; characteristics defining mature forest, such as height and density of trees, must be defined by the model user).	L,E	Remote sensing, direct observation, dot grid, topographic map.

Figure 6. Definitions of habitat variables and suggested measurement techniques.

Variable (definition)	Cover types	Suggested technique
Building or campsite density (the number of campsites, houses, or other permanent dwellings per km^2 of upland evaluation area based on the 1.5 km wide strip of land surrounding the aquatic cover type being evaluated).	L,E	Remote sensing.

Figure 6. (Concluded)

The fourth assumption is perhaps the assumption that will most often be invalid. The impact of humans on nesting bald eagles involves many types and intensities of disturbances. The use of building or campsite density as the single estimator of the impact of human disturbance obviously simplifies a very complex problem. Other means of assessing human disturbance on a local basis may be preferable to building or campsite density.

There are factors other than habitat that affect the carrying capacity of an area for bald eagles, including climate and environmental contaminants. These factors should be considered as possible sources of variation when model outputs are compared to populations in different habitats in widely separated areas.

Climate affects virtually all living organisms. As the mean temperature decreases, breeding seasons become shortened and energetics becomes an increasingly important factor. Wetmore and Gillespie (1976) found a significant correlation between mean April temperature and osprey (Pandion haliaetus) productivity in Labrador and northeastern Quebec. Leighton et al. (1979) found a significant correlation between April temperature and bald eagle nesting density in Saskatchewan. Their data indicated that, whereas local climatic and geographic features may cause variation, in general, bald eagle reproduction becomes difficult, if not impossible, where the mean April temperature is <-7 °C. Where mean April temperature is >10 °C, bald eagles begin nesting earlier to avoid extreme summer temperatures; this behavior is exhibited by bald eagles nesting in the southeastern United States (Bent 1937).

Climate also affects bald eagle prey availability. Total annual fish production is positively correlated with annual temperature on a global basis (Schlesinger and Regier 1982). Although climate was not a significant factor in fish production within the north-temperate climatic region (Matuszek 1978), there can be large differences in annual fish production between north-temperate and south-temperate lakes with similar morphoedaphic indices (Schlesinger and Regier 1982).

Persistent environmental contaminants are another factor, but are not included as a habitat component in this model for two reasons. First, the contaminant burden in eagle populations is a function of wintering habitat as well as breeding habitat and cannot be accurately measured by analysis of breeding habitat alone. Second, the effect of persistent environmental contaminants on eagles has been measured by its effect upon nesting productivity, not directly on nesting density. However, nesting density has been affected where contamination was severe for prolonged periods (S. N. Wiemeyer, Patuxtent Wildlife Research Center, Laurel, MD; pers. comm.). In these cases, reproduction was inadequate to maintain stable populations and contaminants caused direct mortality to eagles. For the same reasons discussed earlier concerning logging impacts, the impact of persistent environmental contaminants upon habitat suitability cannot be reliably included in this model and must be considered as a separate process. Persistent environmental contaminants, however, have had marked effects on many raptor populations (Hickey 1969; Porter and Wiemeyer 1969; Redig 1979), including the bald eagle (Hamerstrom et al. 1975; Wiemeyer et al. 1984). Thus, the level of environmental contaminants in the nesting area should be considered in conjunction with any habitat analysis. Few controlled studies of the relationships between dietary levels of contaminants and reproductive success have been conducted. However, a very general pattern has been observed regarding dietary concentrations of DDE, which is now the most frequent source of chemically-induced reproductive disruptions (Wiemeyer, pers. comm.). This pattern can be used as a preliminary guide to suggest effects on productivity. When the wet weight dietary concentration of DDE in prey tissue is <0.1 ppm, no effect on raptor productivity is expected. Between 0.1 and 0.5 ppm, there may be some residue accumulation and minor effects. Between 0.5 and 3 ppm, there may be some eggshell thinning and reproductive problems. When DDE concentrations in prey tissues are consistently above 3 ppm, there may be occasional adult mortality and a severe reduction or complete failure in productivity. Other persistent contaminants also may cause adverse effects on bald eagle populations (Wiemeyer, pers. comm.). Contaminant ecologists should be consulted when such contaminants are detected in prey items. The potential effects of nonpersistent but moderately to highly toxic contaminants should not be overlooked.

SOURCES OF OTHER MODELS

Two HSI models have been developed for Alaska (Steenhof, in press). Both models rely on subjective characterization of habitat types and appear to measure the suitability of individual nest sites, rather than larger areas of habitat.

Taylor and Therres (1981) used the physical characteristics of known bald eagle nesting habitat in Maryland to construct a computer-generated prediction of suitable habitat in Maryland. They evaluated land use, cover type, disturbance, and distance to feeding areas. Their system measured many different areas at a single point in time. The biological data used in their model supports this HSI model and was used to document some of the assumptions contained herein.

Two additional HSI models are currently being developed for use in Montana (Steenhof, in press).

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A review and synthesis of existing information were used to develop a Habitat Suitability Index (HSI) model for the bald eagle (Haliaeetus leucocephalus). The model consolidates habitat use information into a framework appropriate for field application, and is scaled to produce an index between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). HSI models are designed to be used with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

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NATIONAL BALD EAGLE MANAGEMENT GUIDELINES

U.S. Fish and Wildlife Service

May 2007

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INTRODUCTION

The bald eagle (*Haliaeetus leucocephalus*) is protected by the Bald and Golden Eagle Protection Act (Eagle Act) and the Migratory Bird Treaty Act (MBTA). The MBTA and the Eagle Act protect bald eagles from a variety of harmful actions and impacts. The U.S. Fish and Wildlife Service (Service) developed these National Bald Eagle Management Guidelines to advise landowners, land managers, and others who share public and private lands with bald eagles when and under what circumstances the protective provisions of the Eagle Act may apply to their activities. A variety of human activities can potentially interfere with bald eagles, affecting their ability to forage, nest, roost, breed, or raise young. The Guidelines are intended to help people minimize such impacts to bald eagles, particularly where they may constitute "disturbance," which is prohibited by the Eagle Act.

The Guidelines are intended to:

(1) Publicize the provisions of the Eagle Act that continue to protect bald eagles, in order to reduce the possibility that people will violate the law,

(2) Advise landowners, land managers and the general public of the potential for various human activities to disturb bald eagles, and

(3) Encourage additional nonbinding land management practices that benefit bald eagles (see Additional Recommendations section).

While the Guidelines include general recommendations for land management practices that will benefit bald eagles, the document is intended primarily as a tool for landowners and planners who seek information and recommendations regarding how to avoid disturbing bald eagles. Many States and some tribal entities have developed state-specific management plans, regulations, and/or guidance for landowners and land managers to protect and enhance bald eagle habitat, and we encourage the continued development and use of these planning tools to benefit bald eagles.

Adherence to the Guidelines herein will benefit individuals, agencies, organizations, and companies by helping them avoid violations of the law. However, the Guidelines themselves are not law. Rather, they are recommendations based on several decades of behavioral observations, science, and conservation measures to avoid or minimize adverse impacts to bald eagles.

The U.S. Fish and Wildlife Service strongly encourages adherence to these guidelines to ensure that bald and golden eagle populations will continue to be sustained. The Service realizes there may be impacts to some birds even if all reasonable measures are taken to avoid such impacts. Although it is not possible to absolve individuals and entities from liability under the Eagle Act or the MBTA, the Service exercises enforcement discretion to focus on those individuals, companies, or agencies that take migratory birds without regard for the consequences of their actions and the law, especially when conservation measures, such as these Guidelines, are available, but have not been implemented. The Service will prioritize its enforcement efforts to focus on those individuals or entities who take bald eagles or their parts, eggs, or nests without implementing appropriate measures recommended by the Guidelines.

The Service intends to pursue the development of regulations that would authorize, under limited circumstances, the use of permits if “take” of an eagle is anticipated but unavoidable. Additionally, if the bald eagle is delisted, the Service intends to provide a regulatory mechanism to honor existing (take) authorizations under the Endangered Species Act (ESA).

During the interim period until the Service completes a rulemaking for permits under the Eagle Act, the Service does not intend to refer for prosecution the incidental “*take*” of any bald eagle under the MBTA or Eagle Act, if such take is in full compliance with the terms and conditions of an incidental take statement issued to the action agency or applicant under the authority of section 7(b)(4) of the ESA or a permit issued under the authority of section 10(a)(1)(B) of the ESA.

The Guidelines are applicable throughout the United States, including Alaska. The primary purpose of these Guidelines is to provide information that will minimize or prevent violations only of *Federal* laws governing bald eagles. In addition to Federal laws, many states and some smaller jurisdictions and tribes have additional laws and regulations protecting bald eagles. In some cases those laws and regulations may be more protective (restrictive) than these Federal guidelines. If you are planning activities that may affect bald eagles, we therefore recommend that you contact both your nearest U.S. Fish and Wildlife Service Field Office (see the contact information on p.16) and your state wildlife agency for assistance.

LEGAL PROTECTIONS FOR THE BALD EAGLE

The Bald and Golden Eagle Protection Act

The Eagle Act (16 U.S.C. 668-668c), enacted in 1940, and amended several times since then, prohibits anyone, without a permit issued by the Secretary of the Interior, from “taking” bald eagles, including their parts, nests, or eggs. The Act provides criminal and civil penalties for persons who “take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any bald eagle ... [or any golden eagle], alive or dead, or any part, nest, or egg thereof.” The Act defines “take” as “pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb.” “Disturb’’ means:

> "Disturb means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior."

In addition to immediate impacts, this definition also covers impacts that result from human-induced alterations initiated around a previously used nest site during a time when eagles are not present, if, upon the eagle=s return, such alterations agitate or bother an eagle to a degree that injures an eagle or substantially interferes with normal breeding, feeding, or sheltering habits and causes, or is likely to cause, a loss of productivity or nest abandonment.

A violation of the Act can result in a criminal fine of $100,000 ($200,000 for organizations), imprisonment for one year, or both, for a first offense. Penalties increase substantially for additional offenses, and a second violation of this Act is a felony.

The Migratory Bird Treaty Act

The MBTA (16 U.S.C. 703-712), prohibits the taking of any migratory bird or any part, nest, or egg, except as permitted by regulation. The MBTA was enacted in 1918; a 1972 agreement supplementing one of the bilateral treaties underlying the MBTA had the effect of expanding the scope of the Act to cover bald eagles and other raptors. Implementing regulations define "take" under the MBTA as "pursue, hunt, shoot, wound, kill, trap, capture, possess, or collect."

Copies of the Eagle Act and the MBTA are available at: http://permits.fws.gov/ltr/ltr.shtml.

State laws and regulations

Most states have their own regulations and/or guidelines for bald eagle management. Some states may continue to list the bald eagle as endangered, threatened, or of special concern. If you plan activities that may affect bald eagles, we urge you to familiarize yourself with the regulations and/or guidelines that apply to bald eagles in your state. Your adherence to the Guidelines herein does not ensure that you are in compliance with state laws and regulations because state regulations can be more specific and/or restrictive than these Guidelines.

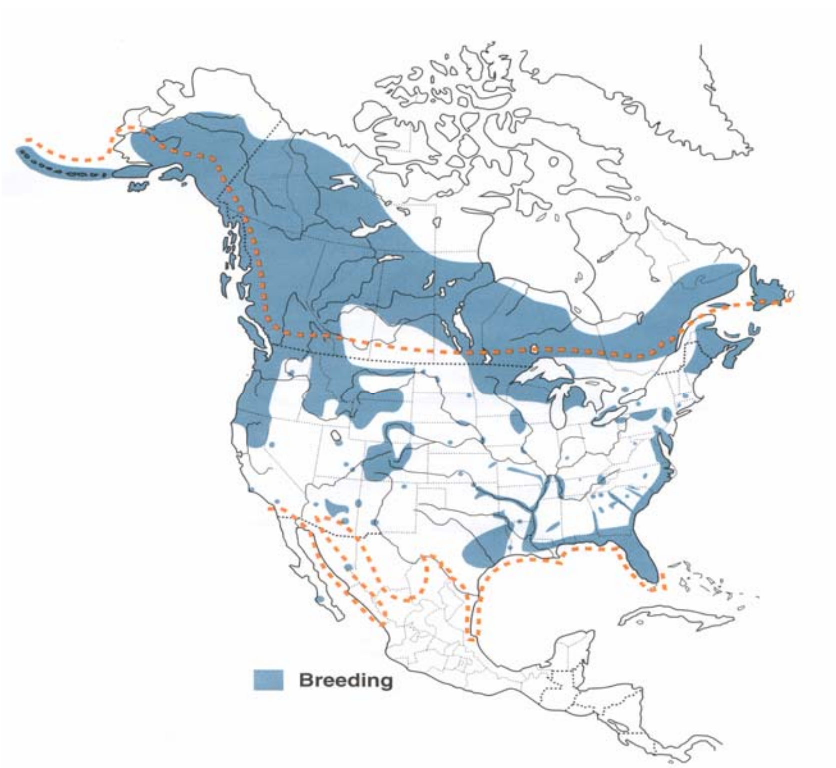
NATURAL HISTORY OF THE BALD EAGLE

Bald eagles are a North American species that historically occurred throughout the contiguous United States and Alaska. After severely declining in the lower 48 States between the 1870s and the 1970s, bald eagles have rebounded and re-established breeding territories in each of the lower 48 states. The largest North American breeding populations are in Alaska and Canada, but there are also significant bald eagle populations in Florida, the Pacific Northwest, the Greater Yellowstone area, the Great Lakes states, and the Chesapeake Bay region. Bald eagle distribution varies seasonally. Bald eagles that nest in southern latitudes frequently move northward in late spring and early summer, often summering as far north as Canada. Most eagles that breed at northern latitudes migrate southward during winter, or to coastal areas where waters remain unfrozen. Migrants frequently concentrate in large numbers at sites where food is abundant and they often roost together communally. In some cases, concentration areas are used year-round: in summer by southern eagles and in winter by northern eagles.

Juvenile bald eagles have mottled brown and white plumage, gradually acquiring their dark brown body and distinctive white head and tail as they mature. Bald eagles generally attain adult plumage by 5 years of age. Most are capable of breeding at 4 or 5 years of age, but in healthy populations they may not start breeding until much older. Bald eagles may live 15 to 25 years in the wild. Adults weigh 8 to 14 pounds (occasionally reaching 16 pounds in Alaska) and have wingspans of 5 to 8 feet. Those in the northern range are larger than those in the south, and females are larger than males.

Where do bald eagles nest?
Breeding bald eagles occupy "territories," areas they will typically defend against intrusion by other eagles. In addition to the active nest, a territory may include one or more alternate nests (nests built or maintained by the eagles but not used for nesting in a given year). The Eagle Act prohibits removal or destruction of both active and alternate bald eagle nests. Bald eagles exhibit high nest site fidelity and nesting territories are often used year after year. Some territories are known to have been used continually for over half a century.

Bald eagles generally nest near coastlines, rivers, large lakes or streams that support an adequate food supply. They often nest in mature or old-growth trees; snags (dead trees); cliffs; rock promontories; rarely on the ground; and with increasing frequency on human-made structures such as power poles and communication towers. In forested areas, bald eagles often select the tallest trees with limbs strong enough to support a nest that can weigh more than 1,000 pounds. Nest sites typically include at least one perch with a clear view of the water where the eagles usually forage. Shoreline trees or snags located in reservoirs provide the visibility and accessibility needed to locate aquatic prey. Eagle nests are constructed with large sticks, and may be lined with moss, grass, plant stalks, lichens, seaweed, or sod. Nests are usually about 4-6 feet in diameter and 3 feet deep, although larger nests exist.



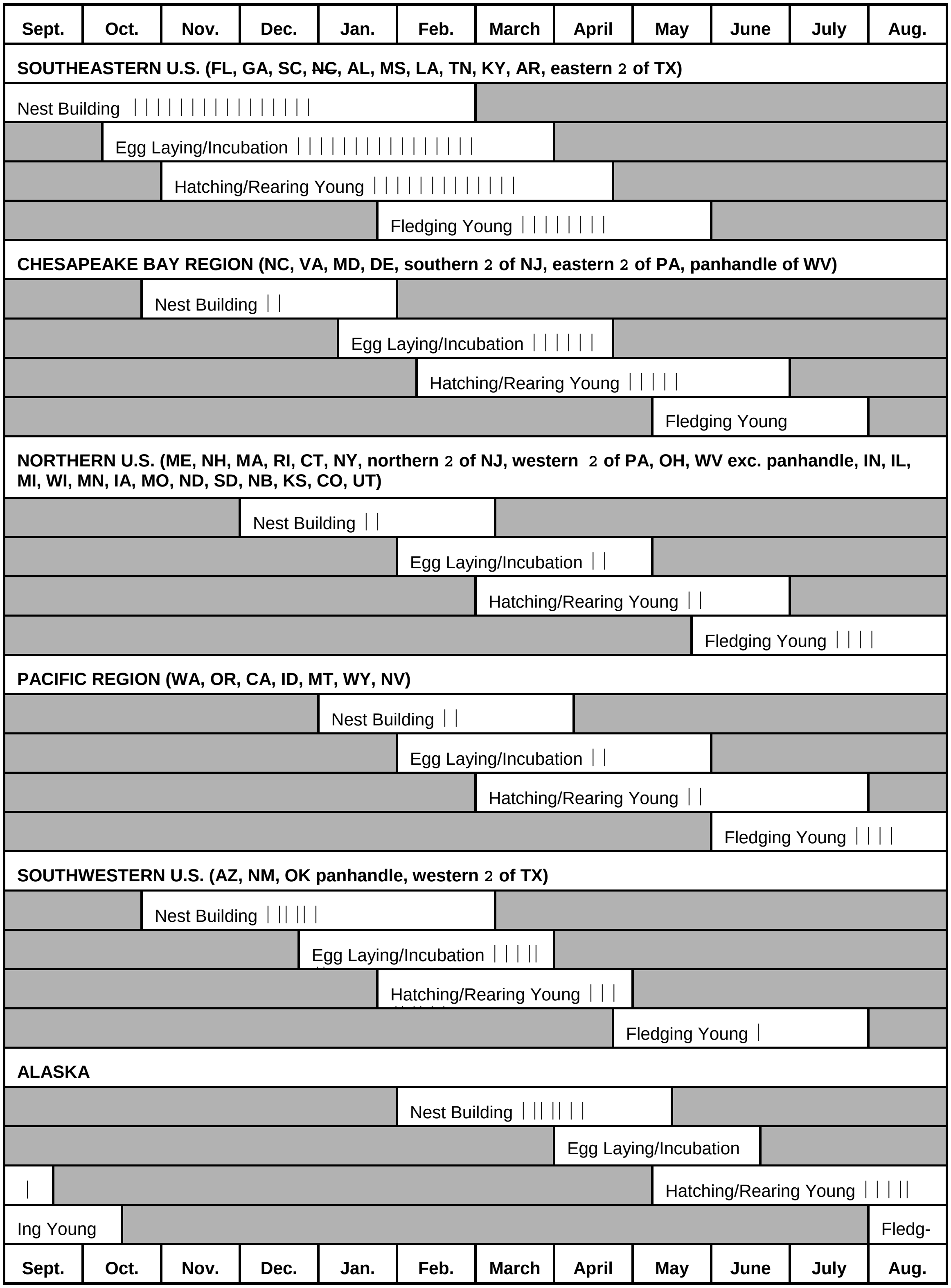
The range of breeding bald eagles in 2000 (shaded areas). This map shows only the larger concentrations of nests; eagles have continued to expand into additional nesting territories in many states. The dotted line represents the bald eagle's wintering range.

When do bald eagles nest?

Nesting activity begins several months before egg-laying. Egg-laying dates vary throughout the U.S., ranging from October in Florida, to late April or even early May in the northern United States. Incubation typically lasts 33-35 days, but can be as long as 40 days. Eaglets make their first unsteady flights about 10 to 12 weeks after hatching, and fledge (leave their nests) within a few days after that first flight. However, young birds usually remain in the vicinity of the nest for several weeks after fledging because they are almost completely dependent on their parents for food until they disperse from the nesting territory approximately 6 weeks later.

The bald eagle breeding season tends to be longer in the southern U.S., and re-nesting following an unsuccessful first nesting attempt is more common there as well. The following table shows the timing of bald eagle breeding seasons in different regions of the country. The table represents the range of time within which the majority of nesting activities occur in each region and does not apply to any specific nesting pair. Because the timing of nesting activities may vary within a given region, you should contact the nearest U.S. Fish and Wildlife Service Field Office (see page 16) and/or your state wildlife conservation agency for more specific information on nesting chronology in your area.

Chronology of typical reproductive activities of bald eagles in the United States.



How many chicks do bald eagles raise?
The number of eagle eggs laid will vary from 1-3, with 1-2 eggs being the most common. Only one eagle egg is laid per day, although not always on successive days. Hatching of young occurs on different days with the result that chicks in the same nest are sometimes of unequal size. The overall national fledging rate is approximately one chick per nest, annually, which results in a healthy expanding population.

What do bald eagles eat?
Bald eagles are opportunistic feeders. Fish comprise much of their diet, but they also eat waterfowl, shorebirds/colonial waterbirds, small mammals, turtles, and carrion. Because they are visual hunters, eagles typically locate their prey from a conspicuous perch, or soaring flight, then swoop down and strike. Wintering bald eagles often congregate in large numbers along streams to feed on spawning salmon or other fish species, and often gather in large numbers in areas below reservoirs, especially hydropower dams, where fish are abundant. Wintering eagles also take birds from rafts of ducks at reservoirs and rivers, and congregate on melting ice shelves to scavenge dead fish from the current or the soft melting ice. Bald eagles will also feed on carcasses along roads, in landfills, and at feedlots.

During the breeding season, adults carry prey to the nest to feed the young. Adults feed their chicks by tearing off pieces of food and holding them to the beaks of the eaglets. After fledging, immature eagles are slow to develop hunting skills, and must learn to locate reliable food sources and master feeding techniques. Young eagles will congregate together, often feeding upon easily acquired food such as carrion and fish found in abundance at the mouths of streams and shallow bays and at landfills.

The impact of human activity on nesting bald eagles
During the breeding season, bald eagles are sensitive to a variety of human activities. However, not all bald eagle pairs react to human activities in the same way. Some pairs nest successfully just dozens of yards from human activity, while others abandon nest sites in response to activities much farther away. This variability may be related to a number of factors, including visibility, duration, noise levels, extent of the area affected by the activity, prior experiences with humans, and tolerance of the individual nesting pair. The relative sensitivity of bald eagles during various stages of the breeding season is outlined in the following table.

Nesting Bald Eagle Sensitivity to Human Activities

Phase	Activity	Sensitivity to Human Activity	Comments
I	Courtship and Nest Building	Most sensitive period; likely to respond negatively	Most critical time period. Disturbance is manifested in nest abandonment. Bald eagles in newly established territories are more prone to abandon nest sites.
II	Egg laying	Very sensitive period	Human activity of even limited duration may cause nest desertion and abandonment of territory for the breeding season.
III	Incubation and early nestling period (up to 4 weeks)	Very sensitive period	Adults are less likely to abandon the nest near and after hatching. However, flushed adults leave eggs and young unattended; eggs are susceptible to cooling, loss of moisture, overheating, and predation; young are vulnerable to elements.
IV	Nestling period, 4 to 8 weeks	Moderately sensitive period	Likelihood of nest abandonment and vulnerability of the nestlings to elements somewhat decreases. However, nestlings may miss feedings, affecting their survival.
V	Nestlings 8 weeks through fledging	Very sensitive period	Gaining flight capability, nestlings 8 weeks and older may flush from the nest prematurely due to disruption and die.

If agitated by human activities, eagles may inadequately construct or repair their nest, may expend energy defending the nest rather than tending to their young, or may abandon the nest altogether. Activities that cause prolonged absences of adults from their nests can jeopardize eggs or young. Depending on weather conditions, eggs may overheat or cool too much and fail to hatch. Unattended eggs and nestlings are subject to predation. Young nestlings are particularly vulnerable because they rely on their parents to provide warmth or shade, without which they may die as a result of hypothermia or heat stress. If food delivery schedules are interrupted, the young may not develop healthy plumage, which can affect their survival. In addition, adults startled while incubating or brooding young may damage eggs or injure their young as they abruptly leave the nest. Older nestlings no longer require constant attention from the adults, but they may be startled by loud or intrusive human activities and prematurely jump from the nest before they are able to fly or care for themselves. Once fledged, juveniles range up to ¼ mile from the nest site, often to a site with minimal human activity. During this period, until about six weeks after departure from the nest, the juveniles still depend on the adults to feed them.

The impact of human activity on foraging and roosting bald eagles

Disruption, destruction, or obstruction of roosting and foraging areas can also negatively affect bald eagles. Disruptive activities in or near eagle foraging areas can interfere with feeding, reducing chances of survival. Interference with feeding can also result in reduced productivity (number of young successfully fledged). Migrating and wintering bald eagles often congregate at specific sites for purposes of feeding and sheltering. Bald eagles rely on established roost sites because of their proximity to sufficient food sources. Roost sites are usually in mature trees where the eagles are somewhat sheltered from the wind and weather. Human activities near or within communal roost sites may prevent eagles from feeding or taking shelter, especially if there are not other undisturbed and productive feeding and roosting sites available. Activities that permanently alter communal roost sites and important foraging areas can altogether eliminate the elements that are essential for feeding and sheltering eagles.

Where a human activity agitates or bothers roosting or foraging bald eagles to the degree that causes injury or substantially interferes with breeding, feeding, or sheltering behavior and causes, or is likely to cause, a loss of productivity or nest abandonment, the conduct of the activity constitutes a violation of the Eagle Act's prohibition against disturbing eagles. The circumstances that might result in such an outcome are difficult to predict without detailed site-specific information. If your activities may disturb roosting or foraging bald eagles, you should contact your local Fish and Wildlife Service Field Office (see page 16) for advice and recommendations for how to avoid such disturbance.

RECOMMENDATIONS FOR AVOIDING DISTURBANCE AT NEST SITES

In developing these Guidelines, we relied on existing state and regional bald eagle guidelines, scientific literature on bald eagle disturbance, and recommendations of state and Federal biologists who monitor the impacts of human activity on eagles. Despite these resources, uncertainties remain regarding the effects of many activities on eagles and how eagles in different situations may or may not respond to certain human activities. The Service recognizes this uncertainty and views the collection of better biological data on the response of eagles to disturbance as a high priority. To the extent that resources allow, the Service will continue to collect data on responses of bald eagles to human activities conducted according to the recommendations within these Guidelines to ensure that adequate protection from disturbance is being afforded, and to identify circumstances where the Guidelines might be modified. These data will be used to make future adjustments to the Guidelines.

To avoid disturbing nesting bald eagles, we recommend (1) keeping a distance between the activity and the nest (distance buffers), (2) maintaining preferably forested (or natural) areas between the activity and around nest trees (landscape buffers), and (3) avoiding certain activities during the breeding season. The buffer areas serve to minimize visual and auditory impacts associated with human activities near nest sites. Ideally, buffers would be large enough to protect existing nest trees and provide for alternative or replacement nest trees.

The size and shape of effective buffers vary depending on the topography and other ecological characteristics surrounding the nest site. In open areas where there are little or no forested or topographical buffers, such as in many western states, distance alone must serve as the buffer. Consequently, in open areas, the distance between the activity and the nest may need to be larger than the distances recommended under Categories A and B of these guidelines (pg. 12) if no landscape buffers are present. The height of the nest above the ground may also ameliorate effects of human activities; eagles at higher nests may be less prone to disturbance.

In addition to the physical features of the landscape and nest site, the appropriate size for the distance buffer may vary according to the historical tolerances of eagles to human activities in particular localities, and may also depend on the location of the nest in relation to feeding and roosting areas used by the eagles. Increased competition for nest sites may lead bald eagles to nest closer to human activity (and other eagles).

Seasonal restrictions can prevent the potential impacts of many shorter-term, obtrusive activities that do not entail landscape alterations (e.g. fireworks, outdoor concerts). In proximity to the nest, these kinds of activities should be conducted only outside the breeding season. For activities that entail both short-term, obtrusive characteristics and more permanent impacts (e.g., building construction), we recommend a combination of both approaches: retaining a landscape buffer *and* observing seasonal restrictions.

For assistance in determining the appropriate size and configuration of buffers or the timing of activities in the vicinity of a bald eagle nest, we encourage you to contact the nearest U.S. Fish and Wildlife Service Field Office (see page 16).

Existing Uses

Eagles are unlikely to be disturbed by routine use of roads, homes, and other facilities where such use pre-dates the eagles' successful nesting activity in a given area. Therefore, in most cases *ongoing* existing uses may proceed with the same intensity with little risk of disturbing bald eagles. However, some *intermittent, occasional, or irregular* uses that pre-date eagle nesting in an area may disturb bald eagles. For example: a pair of eagles may begin nesting in an area and subsequently be disturbed by activities associated with an annual outdoor flea market, even though the flea market has been held annually at the same location. In such situations, human activity should be adjusted or relocated to minimize potential impacts on the nesting pair.

ACTIVITY-SPECIFIC GUIDELINES

The following section provides the Service=s management recommendations for avoiding bald eagle disturbance as a result of new or intermittent activities proposed in the vicinity of bald eagle nests. Activities are separated into 8 categories (A – H) based on the nature and magnitude of impacts to bald eagles that usually result from the type of activity. Activities with similar or comparable impacts are grouped together.

In most cases, impacts will vary based on the visibility of the activity from the eagle nest and the degree to which similar activities are already occurring in proximity to the nest site. Visibility is a factor because, in general, eagles are more prone to disturbance when an activity occurs in full view. For this reason, we recommend that people locate activities farther from the nest structure in areas with open vistas, in contrast to areas where the view is shielded by rolling topography, trees, or other screening factors. The recommendations also take into account the existence of similar activities in the area because the continued presence of nesting bald eagles in the vicinity of the existing activities indicates that the eagles in that area can tolerate a greater degree of human activity than we can generally expect from eagles in areas that experience fewer human impacts. To illustrate how these factors affect the likelihood of disturbing eagles, we have incorporated the recommendations for some activities into a table (categories A and B).

First, determine which category your activity falls into (between categories A – H). If the activity you plan to undertake is not specifically addressed in these guidelines, follow the recommendations for the most similar activity represented.

If your activity is under A or B, our recommendations are in table form. The vertical axis shows the degree of visibility of the activity from the nest. The horizontal axis (header row) represents the degree to which similar activities are ongoing in the vicinity of the nest. Locate the row that best describes how visible your activity will be from the eagle nest. Then, choose the column that best describes the degree to which similar activities are ongoing in the vicinity of the eagle nest. The box where the column and row come together contains our management recommendations for how far you should locate your activity from the nest to avoid disturbing the eagles. The numerical distances shown in the tables are the closest the activity should be conducted relative to the nest. In some cases we have included additional recommendations (other than recommended *distance* from the nest) you should follow to help ensure that your activity will not disturb the eagles.

Alternate nests
For activities that entail permanent landscape alterations that may result in bald eagle disturbance, these recommendations apply to both active and alternate bald eagle nests. Disturbance becomes an issue with regard to alternate nests if eagles return for breeding purposes and react to land use changes that occurred while the nest was inactive. The likelihood that an alternate nest will again become active decreases the longer it goes unused. If you plan activities in the vicinity of an alternate bald eagle nest and have information to show that the nest has not been active during the preceding 5 breeding seasons, the recommendations provided in these guidelines for avoiding disturbance around the nest site may no longer be warranted. The nest itself remains protected by other provisions of the Eagle Act, however, and may not be destroyed.

If special circumstances exist that make it unlikely an inactive nest will be reused before 5 years of disuse have passed, and you believe that the probability of reuse is low enough to warrant disregarding the recommendations for avoiding disturbance, you should be prepared to provide all the reasons for your conclusion, including information regarding past use of the nest site. Without sufficient documentation, you should continue to follow these guidelines when conducting activities around the nest site. If we are able to determine that it is unlikely the nest will be reused, we may advise you that the recommendations provided in these guidelines for avoiding disturbance are no longer necessary around that nest site.

This guidance is intended to minimize disturbance, as defined by Federal regulation. In addition to Federal laws, most states and some tribes and smaller jurisdictions have additional laws and regulations protecting bald eagles. In some cases those laws and regulations may be more protective (restrictive) than these Federal guidelines.

Temporary Impacts
For activities that have temporary impacts, such as the use of loud machinery, fireworks displays, or summer boating activities, we recommend seasonal restrictions. These types of activities can generally be carried out outside of the breeding season without causing disturbance. The recommended restrictions for these types of activities can be lifted for alternate nests within a particular territory, including nests that were attended during the current breeding season but not used to raise young, after eggs laid in another nest within the territory have hatched (depending on the distance between the alternate nest and the active nest).

In general, activities should be kept as far away from nest trees as possible; loud and disruptive activities should be conducted when eagles are not nesting; and activity between the nest and the nearest foraging area should be minimized. If the activity you plan to undertake is not specifically addressed in these guidelines, follow the recommendations for the most similar activity addressed, or contact your local U.S. Fish and Wildlife Service Field Office for additional guidance.

If you believe that special circumstances apply to your situation that increase or diminish the likelihood of bald eagle disturbance, or if it is not possible to adhere to the guidelines, you should contact your local Service Field Office for further guidance.

Category A:
Building construction, 1 or 2 story, with project footprint of ½ acre or less.
Construction of roads, trails, canals, power lines, and other linear utilities.
Agriculture and aquaculture – new or expanded operations.
Alteration of shorelines or wetlands.
Installation of docks or moorings.
Water impoundment.

Category B:
Building construction, 3 or more stories.
Building construction, 1 or 2 story, with project footprint of more than ½ acre.
Installation or expansion of marinas with a capacity of 6 or more boats.
Mining and associated activities.
Oil and natural gas drilling and refining and associated activities.

	If there is no similar activity within 1 mile of the nest	***If there is similar activity closer than 1 mile from the nest***
If the activity will be visible from the nest	660 feet. Landscape buffers are recommended.	660 feet, or as close as existing tolerated activity of similar scope. Landscape buffers are recommended.
If the activity will not be visible from the nest	Category A: 330 feet. Clearing, external construction, and landscaping between 330 feet and 660 feet should be done outside breeding season. Category B: 660 feet.	330 feet, or as close as existing tolerated activity of similar scope. Clearing, external construction and landscaping within 660 feet should be done outside breeding season.

The numerical distances shown in the table are the closest the activity should be conducted relative to the nest.

Category C. Timber Operations and Forestry Practices

- Avoid clear cutting or removal of overstory trees within 330 feet of the nest at any time.

- Avoid timber harvesting operations, including road construction and chain saw and yarding operations, during the breeding season within 660 feet of the nest. The distance may be decreased to 330 feet around alternate nests within a particular territory, including nests that were attended during the current breeding season but not used to raise young, after eggs laid in another nest within the territory have hatched.

- Selective thinning and other silviculture management practices designed to conserve or enhance habitat, including prescribed burning close to the nest tree, should be undertaken outside the breeding season. Precautions such as raking leaves and woody debris from around the nest tree should be taken to prevent crown fire or fire climbing the nest tree. If it is determined that a burn during the breeding season would be beneficial, then, to ensure that no take or disturbance will occur, these activities should be conducted only when neither adult eagles nor young are present at the nest tree (i.e., at the beginning of, or end of, the breeding season, either before the particular nest is active or after the young have fledged from that nest). Appropriate Federal and state biologists should be consulted before any prescribed burning is conducted during the breeding season.

- Avoid construction of log transfer facilities and in-water log storage areas within 330 feet of the nest.

Category D. Off-road vehicle use (including snowmobiles). No buffer is necessary around nest sites outside the breeding season. During the breeding season, do not operate off-road vehicles within 330 feet of the nest. In open areas, where there is increased visibility and exposure to noise, this distance should be extended to 660 feet.

Category E. Motorized Watercraft use (including jet skis/personal watercraft). No buffer is necessary around nest sites outside the breeding season. During the breeding season, within 330 feet of the nest, (1) do not operate jet skis (personal watercraft), and (2) avoid concentrations of noisy vessels (e.g., commercial fishing boats and tour boats), except where eagles have demonstrated tolerance for such activity. Other motorized boat traffic passing within 330 feet of the nest should attempt to minimize trips and avoid stopping in the area where feasible, particularly where eagles are unaccustomed to boat traffic. Buffers for airboats should be larger than 330 feet due to the increased noise they generate, combined with their speed, maneuverability, and visibility.

Category F. Non-motorized recreation and human entry (e.g., hiking, camping, fishing, hunting, birdwatching, kayaking, canoeing). No buffer is necessary around nest sites outside the breeding season. If the activity will be visible or highly audible from the nest, maintain a 330-foot buffer during the breeding season, particularly where eagles are unaccustomed to such activity.

Category G. Helicopters and fixed-wing aircraft.
Except for authorized biologists trained in survey techniques, avoid operating aircraft within 1,000 feet of the nest during the breeding season, except where eagles have demonstrated tolerance for such activity.

Category H. Blasting and other loud, intermittent noises.
Avoid blasting and other activities that produce extremely loud noises within 1/2 mile of active nests, unless greater tolerance to the activity (or similar activity) has been demonstrated by the eagles in the nesting area. This recommendation applies to the use of fireworks classified by the Federal Department of Transportation as Class B explosives, which includes the larger fireworks that are intended for licensed public display.

RECOMMENDATIONS FOR AVOIDING DISTURBANCE AT FORAGING AREAS AND COMMUNAL ROOST SITES

1. Minimize potentially disruptive activities and development in the eagles' direct flight path between their nest and roost sites and important foraging areas.

2. Locate long-term and permanent water-dependent facilities, such as boat ramps and marinas, away from important eagle foraging areas.

3. Avoid recreational and commercial boating and fishing near critical eagle foraging areas during peak feeding times (usually early to mid-morning and late afternoon), except where eagles have demonstrated tolerance to such activity.

4. Do not use explosives within ½ mile (or within 1 mile in open areas) of communal roosts when eagles are congregating, without prior coordination with the U.S. Fish and Wildlife Service and your state wildlife agency.

5. Locate aircraft corridors no closer than 1,000 feet vertical or horizontal distance from communal roost sites.

ADDITIONAL RECOMMENDATIONS TO BENEFIT BALD EAGLES

The following are additional management practices that landowners and planners can exercise for added benefit to bald eagles.

1. Protect and preserve potential roost and nest sites by retaining mature trees and old growth stands, particularly within ½ mile from water.

2. Where nests are blown from trees during storms or are otherwise destroyed by the elements, continue to protect the site in the absence of the nest for up to three (3) complete breeding seasons. Many eagles will rebuild the nest and reoccupy the site.

3. To avoid collisions, site wind turbines, communication towers, and high voltage transmission power lines away from nests, foraging areas, and communal roost sites.

4. Employ industry-accepted best management practices to prevent birds from colliding with or being electrocuted by utility lines, towers, and poles. If possible, bury utility lines in important eagle areas.

5. Where bald eagles are likely to nest in human-made structures (e.g., cell phone towers) and such use could impede operation or maintenance of the structures or jeopardize the safety of the eagles, equip the structures with either (1) devices engineered to discourage bald eagles from building nests, or (2) nesting platforms that will safely accommodate bald eagle nests without interfering with structure performance.

6. Immediately cover carcasses of euthanized animals at landfills to protect eagles from being poisoned.

7. Do not intentionally feed bald eagles. Artificially feeding bald eagles can disrupt their essential behavioral patterns and put them at increased risk from power lines, collision with windows and cars, and other mortality factors.

8. Use pesticides, herbicides, fertilizers, and other chemicals only in accordance with Federal and state laws.

9. Monitor and minimize dispersal of contaminants associated with hazardous waste sites (legal or illegal), permitted releases, and runoff from agricultural areas, especially within watersheds where eagles have shown poor reproduction or where bioaccumulating contaminants have been documented. These factors present a risk of contamination to eagles and their food sources.

CONTACTS

The following U.S. Fish and Wildlife Service Field Offices provide technical assistance on bald eagle management:

Alabama	Daphne	(251) 441-5181
Alaska	Anchorage	(907) 271-2888
	Fairbanks	(907) 456-0203
	Juneau	(907) 780-1160
Arizona	Phoenix	(602) 242-0210
Arkansas	Conway	(501) 513-4470
California	Arcata	(707) 822-7201
	Barstow	(760) 255-8852
	Carlsbad	(760) 431-9440
	Red Bluff	(530) 527-3043
	Sacramento	(916) 414-6000
	Stockton	(209) 946-6400
	Ventura	(805) 644-1766
	Yreka	(530) 842-5763
Colorado	Lakewood	(303) 275-2370
	Grand Junction	(970) 243-2778
Connecticut	(See New Hampshire)	
Delaware	(See Maryland)	
Florida	Panama City	(850) 769-0552
	Vero Beach	(772) 562-3909
	Jacksonville	(904) 232-2580
Georgia	Athens	(706) 613-9493
	Brunswick	(912) 265-9336
	Columbus	(706) 544-6428
Idaho	Boise	(208) 378-5243
	Chubbuck	(208) 237-6975
Illinois/Iowa	Rock Island	(309) 757-5800
Indiana	Bloomington	(812) 334-4261
Kansas	Manhattan	(785) 539-3474
Kentucky	Frankfort	(502) 695-0468
Louisiana	Lafayette	(337) 291-3100
Maine	Old Town	(207) 827-5938
Maryland	Annapolis	(410) 573-4573
Massachusetts	(See New Hampshire)	
Michigan	East Lansing	(517) 351-2555
Minnesota	Bloomington	(612) 725-3548
Mississippi	Jackson	(601) 965-4900
Missouri	Columbia	(573) 234-2132
Montana	Helena	(405) 449-5225
Nebraska	Grand Island	(308) 382-6468
Nevada	Las Vegas	(702) 515-5230
	Reno	(775) 861-6300
New Hampshire	Concord	(603) 223-2541
New Jersey	Pleasantville	(609) 646-9310
New Mexico	Albuquerque	(505) 346-2525
New York	Cortland	(607) 753-9334
	Long Island	(631) 776-1401
North Carolina	Raleigh	(919) 856-4520
	Asheville	(828) 258-3939
North Dakota	Bismarck	(701) 250-4481
Ohio	Reynoldsburg	(614) 469-6923
Oklahoma	Tulsa	(918) 581-7458
Oregon	Bend	(541) 383-7146
	Klamath Falls	(541) 885-8481
	La Grande	(541) 962-8584
	Newport	(541) 867-4558
	Portland	(503) 231-6179
	Roseburg	(541) 957-3474
Pennsylvania	State College	(814) 234-4090
Rhode Island	(See New Hampshire)	
South Carolina	Charleston	(843) 727-4707
South Dakota	Pierre	(605) 224-8693
Tennessee	Cookeville	(931) 528-6481
Texas	Clear Lake	(281) 286-8282
Utah	West Valley City	(801) 975-3330
Vermont	(See New Hampshire)	
Virginia	Gloucester	(804) 693-6694
Washington	Lacey	(306) 753-9440
	Spokane	(509) 891-6839
	Wenatchee	(509) 665-3508
West Virginia	Elkins	(304) 636-6586
Wisconsin	New Franken	(920) 866-1725
Wyoming	Cheyenne	(307) 772-2374
	Cody	(307) 578-5939

National Office
U.S. Fish and Wildlife Service
Division of Migratory Bird Management
4401 North Fairfax Drive, MBSP-4107
Arlington, VA 22203-1610
(703) 358-1714
http://www.fws.gov/migratorybirds

State Agencies

To contact a state wildlife agency, visit the Association of Fish & Wildlife Agencies' website at http://www.fishwildlife.org/where_us.html

GLOSSARY

The definitions below apply to these National Bald Eagle Management Guidelines:

Communal roost sites – Areas where bald eagles gather and perch overnight – and sometimes during the day in the event of inclement weather. Communal roost sites are usually in large trees (live or dead) that are relatively sheltered from wind and are generally in close proximity to foraging areas. These roosts may also serve a social purpose for pair bond formation and communication among eagles. Many roost sites are used year after year.

Disturb – To agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.

In addition to immediate impacts, this definition also covers impacts that result from human-caused alterations initiated around a previously used nest site during a time when eagles are not present, if, upon the eagle=s return, such alterations agitate or bother an eagle to a degree that injures an eagle or substantially interferes with normal breeding, feeding, or sheltering habits and causes, or is likely to cause, a loss of productivity or nest abandonment.

Fledge – To leave the nest and begin flying. For bald eagles, this normally occurs at 10-12 weeks of age.

Fledgling – A juvenile bald eagle that has taken the first flight from the nest but is not yet independent.

Foraging area – An area where eagles feed, typically near open water such as rivers, lakes, reservoirs, and bays where fish and waterfowl are abundant, or in areas with little or no water (i.e., rangelands, barren land, tundra, suburban areas, etc.) where other prey species (e.g., rabbit, rodents) or carrion (such as at landfills) are abundant.

Landscape buffer – A natural or human-made landscape feature that screens eagles from human activity (e.g., strip of trees, hill, cliff, berm, sound wall).

Nest – A structure built, maintained, or used by bald eagles for the purpose of reproduction. An **active** nest is a nest that is attended (built, maintained or used) by a pair of bald eagles during a given breeding season, whether or not eggs are laid. An **alternate** nest is a nest that is not used for breeding by eagles during a given breeding season.

Nest abandonment – Nest abandonment occurs when adult eagles desert or stop attending a nest and do not subsequently return and successfully raise young in that nest for the duration of a breeding season. Nest abandonment can be caused by altering habitat near a nest, even if the alteration occurs prior to the breeding season. Whether the eagles migrate during the non-breeding season, or remain in the area throughout the non-breeding season, nest abandonment can occur at any point between the time the eagles return to the nesting site for the breeding season and the time when all progeny from the breeding season have dispersed.

Project footprint – The area of land (and water) that will be permanently altered for a development project, including access roads.

Similar scope – In the vicinity of a bald eagle nest, an existing activity is of similar scope to a new activity where the types of impacts to bald eagles are similar in nature, and the impacts of the existing activity are of the same or greater magnitude than the impacts of the potential new activity. Examples: (1) An existing single-story home 200 feet from a nest is similar in scope to an additional single-story home 200 feet from the nest; (2) An existing multi-story, multi-family dwelling 150 feet from a nest has impacts of a greater magnitude than a potential new single-family home 200 feet from the nest; (3) One existing single-family home 200 feet from the nest has impacts of a lesser magnitude than three single-family homes 200 feet from the nest; (4) an existing single-family home 200 feet from a communal roost has impacts of a lesser magnitude than a single-family home 300 feet from the roost but 40 feet from the eagles' foraging area. The existing activities in examples (1) and (2) are of similar scope, while the existing activities in example (3) and (4) are not.

Vegetative buffer – An area surrounding a bald eagle nest that is wholly or largely covered by forest, vegetation, or other natural ecological characteristics, and separates the nest from human activities.

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Great Trinity Forest Management Plan

Threatened and Endangered Species

Black-capped Vireo

(Vireo atricapilla)

Black-capped Vireo

Scientific Name: *Vireo atricapillus*

Federal Status: Endangered, 10/6/87 • State Status: Endangered

Description

The Black-capped Vireo is a 4.5 inch insect-eating songbird. Mature males are olive green above and white below with faint greenish-yellow flanks. The crown and back of the head is black with a partial white eye-ring. The iris is brownish-red and the bill black. The plumage on the back of the female is duller than the male. Females have a medium to dark gray head with a blackish ring around the white surrounding the eye (this generally distinguishes the female from the second year male).

Male Black-capped Vireo
© TPWD

Female Black-capped Vireo
© USFWS A. Shull

Distribution and Habitat

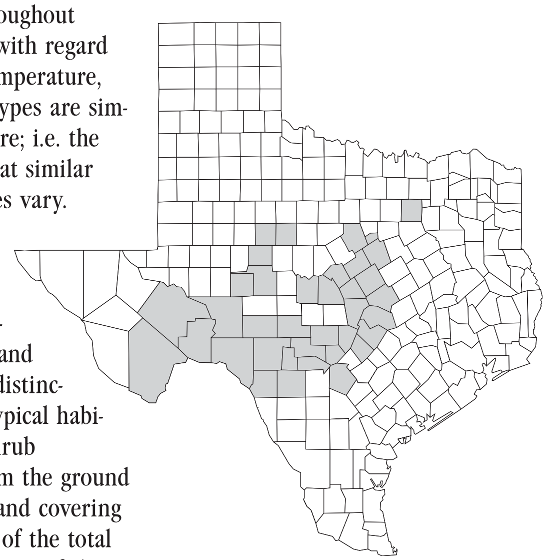
Historical records from 1852-1956 show that the Black-capped Vireo once occurred and nested from central Kansas, Oklahoma, Texas and into northern Mexico. Today, Black-capped Vireos are known to nest in central and southwest Texas, a few counties in central Oklahoma, and in Coahuila and Nuevo Leon, Mexico, although less is known of their status in Mexico. Black-capped Vireos winter along the western coast of Mexico.

The descriptions of habitat presented in this document are intended to help landowners determine if they have Black-capped Vireo habitat on their property. Not all sites within the habitat types described will be used by Black-capped Vireos. It is only where individuals of this species occupy the identified habitat types during the breeding season that special management considerations such as those provided in these guidelines need to be considered.

In Texas, vireo habitat is found on rocky limestone soils of the Edwards Plateau, Cross Timbers and Prairies, eastern Trans-Pecos and, to a limited extent, on igneous soils in the Chisos Mountains. Although Black-capped Vireo habitat throughout Texas is highly variable with regard to plant species, soils, temperature, and rainfall, all habitat types are similar in vegetation structure; i.e. the “overall look” is somewhat similar although the plant species vary. Vireos require broadleaf shrub vegetation reaching to ground level for nesting cover. They typically nest in shrublands and open woodlands with a distinctive patchy structure. Typical habitat is characterized by shrub vegetation extending from the ground to about 6 feet or more and covering about 30-60% or greater of the total area. In the eastern portion of the vireo’s range, the shrub layer is often combined with an open, sparse to moderate tree canopy. Patches of open grass or bare rock separate the clumps of shrubs and trees. In central Texas, this habitat is often regrowth from disturbances such as clearing, fire, and browsing.

In the Edwards Plateau and Cross Timbers Regions, vireo habitat occurs where soils, topography, and land use produce scattered hardwoods with abundant low cover. Common broad-leaved plants in vireo habitat in these regions include: Texas (Spanish) oak, Lacey oak, shin oak, Durand (scaley-bark) oak, live oak, mountain laurel, evergreen sumac, skunkbush sumac, flameleaf sumac, redbud, Texas persimmon, Mexican buckeye, elbowbush and agarita. Although Ashe juniper is often part of the plant composition in vireo habitat, preferred areas usually have a low density and cover of juniper.

In the western Edwards Plateau and Trans-Pecos Regions, on the western edge of the vireo’s range, the birds are often found in canyon bottoms and slopes where sufficient moisture is available to support diverse shrub vegetation. Dominant woody plants in this habitat type include sandpaper oak, Vasey oak, Texas kidneywood, Mexican walnut, Texas persimmon, lotebush, brasil, wafer ash, mountain laurel, cenizo, whitebrush, and guajillo.



For all habitat types, the plant composition appears to be less important than the presence of adequate broad-leaved shrubs, foliage to ground level, and mixture of open grassland and woody cover. Deciduous and broad-leaved shrubs and trees throughout the vireo’s range are also important in providing habitat for insects on which the vireo feeds.

Life History

Black-capped Vireos arrive in Texas from mid-March to mid-April. Adult males often arrive before females and first-year males to select their territories. Vireos' territories are often clustered in patches of suitable habitat. Although territories range in size from 1 to 16 acres, most territories are 5 to 10 acres. Males sing to attract mates and defend territories. Many males can be heard singing throughout the breeding season, but singing begins to decline by July. The vireo's song is described as hurried and harsh, composed of numerous phrases separated from one another by pauses of 1 to 3 seconds.

Nesting begins after the females arrive in late March to early April. Both the male and female select the nest site and build the nest, but the female often completes it. First nests are built in about 6 to 9 days, but subsequent nests can be built in one day. The cup-shaped nest is suspended from its rim in a fork of a branch about 1 to 6 feet above the ground. However, most Black-capped Vireos nest at about "door-knob" height. Nests have been found in a variety of species including shin oak, scalybark oak, Texas oak, Vasey oak, sumac, Texas persimmon, juniper, Texas redbud, Mexican buckeye and Texas mountain laurel.

The vireo usually nests more than once in the same year. A new nest is constructed each time. Three to four eggs are usually laid in the first nesting attempt, but later clutches may contain only 2 to 3 eggs. The first egg is usually laid one day after completion of the nest, with one egg being laid each subsequent day. Incubation takes 14 to 17 days, and is shared by the male and female.

Vireo chicks are fed insects by both adults. The young leave the nest 10 to 12 days after hatching. Fledglings are cared for by the female alone, the male alone, or by both adults. Sometimes the parents split the brood and each care for one or more young. Occasionally, males or females will leave the care of the young to their mate, and attempt another nesting effort.

Vireos may live for more than five years, and usually return year after year to the same territory, or one nearby. The birds migrate to their wintering grounds on Mexico's western coast beginning in July, and are gone from Texas by mid-September.

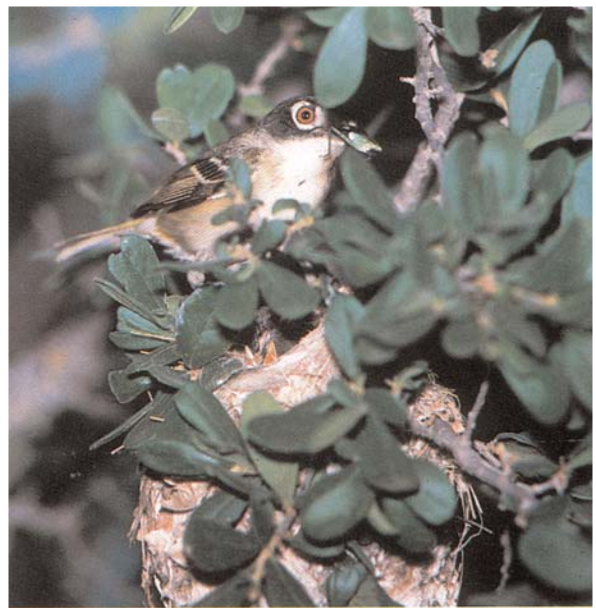
Threats and Reasons for Decline

The Black-capped Vireo is vulnerable to changes in the abundance and quality of its habitat. Habitat may become unsuitable for vireos because of natural plant succession, sustained brood parasitism by the Brown-headed Cowbird, or because of human activities. Factors that can adversely affect vireo habitat include broad-scale or improper brush clearing, fire suppression, over browsing by deer and livestock, and urbanization. Loss of tropical wintering habitat is also a concern, but requires further study.

Poorly planned brush management practices on rangeland may remove too much low growing woody cover, especially when large acreages are treated at one time. This eliminates or reduces habitat value for vireos and for other wildlife, such as White-tailed deer, quail, small mammals, and various songbirds. Over browsing of broad-leaved shrubs by goats, deer, and exotic animals reduces the vegetation in the 2- to 4-foot zone, making it unsuitable for vireo nesting. Continued overuse of these preferred browse plants over many years may eventually eliminate them from the plant community, thus permanently altering the habitat.

In the absence of natural processes, active, well-planned land management is often required to maintain good vireo habitat, especially in the eastern portion of its range. Disturbance, particularly fire, plays an important role in maintaining, improving, or creating vireo habitat. The rangelands of central Texas, and the various plant communities these lands support, evolved under the influence of periodic fires. Historically, these natural and man-made fires maintained a matrix of open grassland, shrubland and woodland. Fire stimulated shrubs to sprout multiple stems at the base, thus providing areas of dense foliage at the 2- to 4-foot level, required by vireos. In the past, fire was responsible for maintaining or periodically returning some areas to vireo habitat. Today, prescribed burning, a valuable range and wildlife management tool occurs on many ranches throughout Texas. However, the combination of overgrazing, brush clearing, and lack of fire in the recent past has reduced vireo habitat in many other areas. Natural plant succession is less of a concern in the western portion of its range where suitable habitat persists for long periods.

Black-capped Vireo nest
© TPWD Glen Mills



Nesting vireo
© Greg W. Lasley

Human activities have provided favorable habitat for the Brown-headed Cowbird, which parasitizes vireo nests. The cowbird is usually associated with livestock, farms, dairies, and grain fields, where it benefits from waste grain and insects. They may also be attracted to backyard bird feeders, trash dumps, or other urban areas where food and water are available. Cowbirds lay their eggs in other birds' nests, leaving the host bird to raise their young. The female cowbird often removes an

Habitat at Kickapoo Caverns State Park
© Matt Wagner

Habitat with low-growing shrubs
© Matt Wagner

Habitat in Big Bend National Park
© USFWS A. Shull

egg or a nestling from the host nest before she lays an egg in it. Cowbird chicks hatch earlier than most hosts's young and are thus able to out-compete the smaller vireo nestlings for food and, consequently, the young vireos typically starve. While some birds remove cowbird eggs from their nest, the vireo does not, although it is known to abandon parasitized nests. Thus parasitized nests usually fail to produce vireos. The amount of brood parasitism varies greatly from one population to another throughout the state, ranging from 10 to over 90% of the nests. Brown-headed Cowbirds are also known to remove vireo chicks from active nests. Evidence indicates that sustained parasitism pressure may lead to local extinctions of vireo populations.

Direct habitat loss and fragmentation due to urban and suburban development is a major threat in expanding urban areas of Travis, McLennan, Dallas, Bexar, and Kerr counties. Problems associated with suburban expansion, such as increases in predation by dogs, cats, raccoons, skunks, and jays, have also impacted the vireo.

Recovery Efforts

Research is underway to better understand the distribution, life history, habitat requirements, and land management practices affecting the Black-capped Vireo. Population surveys during the breeding season are being conducted in known and potential habitat areas. Efforts to provide information and educational opportunities to landowners and the public regarding life history and habitat requirements of the vireo are also a vital part of the recovery effort. Major research and/or recovery efforts are being conducted on Department of Defense's Fort Hood and Camp Bullis, Travis County and the City of Austin's Balcones Canyonlands Preserve, the U.S. Fish and Wildlife Services' Balcones Canyonlands National Wildlife Refuge, TPWD's Kerr Wildlife Management Area, properties owned and/or managed by The Nature Conservancy of Texas, and in Mexico. Additionally, Environmental Defense through their Safe Harbor Agreement with the U.S. Fish and Wildlife Service is assisting many landowners with thousands of acres to manage and/or create habitat for the benefit of the vireo. Research is ongoing regarding the impact of cowbirds on vireo populations in Texas. Research efforts in Mexico are also underway to gather information concerning life history, habitat requirements, and conservation threats on the wintering range. TPWD biologists are monitoring populations on both state and private lands, and voluntary cowbird trapping is being conducted by more than 400 landowners in counties throughout the range of the vireo.

Habitat conservation planning is underway in counties such as Travis and Bexar to allow for urban expansion and development while still conserving endangered species habitat. Intensive monitoring of a large population at the U.S. Army Fort Hood Military Installation is on-going. Finally, efforts to provide information, technical assistance, and incentives for private landowners to incorporate management for Black-capped Vireos into their livestock and wildlife operations are an essential part of the recovery process.

Where To See the Black-capped Vireo

A number of state lands offer opportunities to see and learn more about the Black-capped Vireo. These include Colorado Bend State Park State Park (SP), Devils River State Natural Area (SNA), Kerr Wildlife Management Area, Kickapoo Cavern SP, Lost Maples SNA, and Hill Country SNA. Also, the Balcones Canyonlands National Wildlife Refuge near Austin offers additional opportunities to see Black-capped Vireos.

Because the Black-capped Vireo is an endangered species, birders and other observers should carefully follow certain viewing ethics. Observers should be careful not to flush birds from the nest or disturb nests or young. Black-capped Vireos should be viewed only from a distance with binoculars. Do not use recorded calls of the Black-capped Vireo or the Screech Owl to attract birds, and be careful that your presence does not unduly disturb or stress the birds.

How You Can Help

You can help by learning more about the habitat requirements of the Black-capped Vireo and incorporating management practices which create or maintain habitat for these birds. You can also encourage and support private landowners who are managing their land to protect and provide habitat for endangered species.

The Black-capped Vireo is a beautiful songbird and is much sought after among people who enjoy birdwatching and nature study. Possibilities exist for landowners to take advantage of the growing demand for natural history tours and vacations. Landowners interested in more information concerning nature-based tourism opportunities should contact the Wildlife Diversity Branch, Texas Parks and Wildlife Department, Austin (800) 792-1112; Environmental Defense, Austin (512) 478-5161; the Nature Conservancy, San Antonio (210) 224-8774.

You can also be involved with the conservation of Texas' nongame wildlife resources by supporting the Special Nongame and Endangered Species Conservation Fund. Special nongame stamps and decals are available at Texas Parks and Wildlife Department (TPWD) field offices, most state parks, and the License Branch of TPWD headquarters in Austin. Part of the proceeds from the sale of these items is used to conserve habitat and provide information to the public concerning endangered species. Conservation organizations in Texas also welcome your participation and support.

For More Information Contact

Texas Parks and Wildlife Department
Wildlife Diversity Branch
4200 Smith School Road
Austin, Texas 78744
(512) 912-7011 or (800) 792-1112
or
U.S. Fish and Wildlife Service
Ecological Services Field Office
10711 Burnet Road, Suite 200
Austin, Texas 78758
(512) 490-0057

Management guidelines are available from the Texas Parks and Wildlife Department and U.S. Fish and Wildlife Service for landowners and managers wishing to know more about rangeland management practices which improve habitat for the Black-capped Vireo.

Cowbird egg (spotted) in Black-Capped Vireo nest
© Glen Mills

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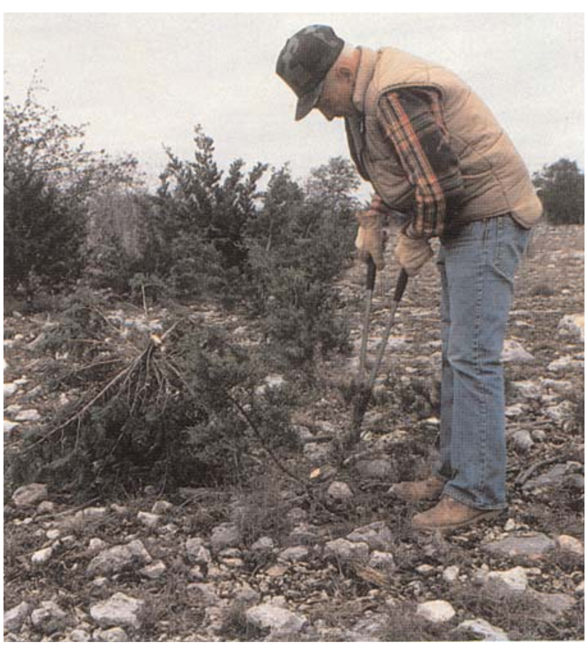
Management Guidelines for Black-capped Vireo

The following guidelines address land management practices that can be used to maintain, enhance, or create Black-capped Vireo habitat. They are intended primarily to serve as general guidance for rural landowners and others managing land for livestock and/or wildlife in Texas. The guidelines are based on our current understanding of the biology of this species.

Private landowners have a tremendous opportunity to conserve and manage the fish and wildlife resources of Texas. The objective of these guidelines is to provide landowners with recommendations about how typically-used land management practices could be conducted so that it would be unlikely that Black-capped Vireos would be impacted. The guidelines will be updated periodically to make them more practical and useful to rural landowners. The guidelines are based on the best available information and current understanding about the biology of the vireo, but may be refined as additional biological data are collected. TPWD biologists have prepared these guidelines in consultation with USFWS biologists to assure landowners who carry out land management practices within the guidelines that they would know, with the greatest certainty possible, that they would not be in violation of the Endangered Species Act.

Prescribed burning
© Matt Wagner



Selective handcutting of juniper
© TPWD Glen Mills

This document also provides information on land management practices that are appropriate for protection and/or enhancement of habitat. The categories were chosen to represent commonly encountered vegetation types and to address common questions regarding the effect of management practices on Black-capped Vireos. In addition, suggestions are offered that promote conservation of soil, water, plant, and wildlife resources.

Prescribed Burning

Fire is a natural component of Texas rangelands, and prescribed burning has many range and wildlife management benefits. These include improved forage quality and availability for livestock and deer, and maintenance of desirable plant composition and structure. Prescribed burning in some portions of the vireos range can be an excellent tool used to maintain or create the desired vegetation structure for vireo nesting; i.e. a mosaic of shrubs and open grassland with abundant woody foliage below 10 feet. If planning these activities in Bandera, Kerr, Kimble, Real, and Uvalde counties, landowners should avoid impacts to Tobusch fishhook cactus (*Ancistrocactus tobuschii*), a federally listed endangered plant, which occurs on similar soils as the vireo. Cool season burns that are patchy and low intensity, conducted prior to March 15, are often recommended to control small juniper, thus maintaining the relatively open shrublands preferred by vireos. Care should be taken to burn under appropriate humidity and wind conditions to maintain the proper black-capped vireo vegetation profile. Prescribed burns conducted during late spring and early fall, under hotter conditions, can be used to set back plant succession to create vireo habitat; however, warm season burns should be done only in areas that do not currently support Black-capped Vireos. On grazed rangeland, prescribed burns should be coordinated with livestock rotation to allow for needed deferments. It is best to avoid burning relatively small areas within large pastures to prevent heavy grazing pressure by livestock and/or deer on burned areas.

Desirable burn intervals for cool season burns vary throughout the state, depending on rainfall and vegetation type. Field experience shows that, for much of the Hill Country, a burning interval of 5 to 7 years is considered desirable to keep Ashe juniper (cedar) invasion in check and to allow regrowth of broad-leaved shrubs. Maintaining open grassland areas between clumps of shrubs is important for good vireo habitat. Research is needed to better understand the use of prescribed burning to maintain and create vireo habitat, and to develop guidelines on desirable burn intervals throughout the vireo's range in Texas, especially in the western Edwards Plateau and eastern Trans-Pecos.

Assistance from people experienced with the use of prescribed burning is highly recommended. Landowners are encouraged to have a complete written prescribed burn plan addressing the objectives of the burn, required weather conditions, grazing deferments, fireguard preparations, personnel and equipment needed, a detailed map showing how the burn will be conducted, and notification and safety procedures. Landowners are advised to contact local representatives of the Texas Parks and Wildlife Department, USDA Natural Resources Conservation Service, or Texas Cooperative Extension for help in developing and implementing a prescribed burning program designed specifically for your property and management objectives.

Selective Brush Management

In some portions of the vireos range, particularly the central and eastern segment, increases in juniper (cedar) and other woody species can cause the vegetation to grow out of the patchy, low shrub cover that provides suitable habitat. In these communities, good nesting habitat generally has between 30-60% shrub canopy. Selective brush removal with herbicides or mechanical means during the non-breeding season (September-February) can be used to keep the habitat favorable for vireo nesting. For example, the selective removal of juniper, mesquite, or pricklypear (less desirable to the vireo and to the rancher) serves to maintain the proper shrub canopy and encourages growth of associated broad-leaved shrubs. Selective brush removal should strive to maintain the desired low shrubby structure. Radical changes in shrub canopy from one year to the next over large areas should be avoided, since this may alter vireo habitat too drastically within a short time-frame. However, moderate thinning of dense (>60%) shin oak so that the low canopy is maintained at 30-60% shrub canopy can enhance habitat. Western Edwards Plateau rangelands comprised primarily of mesquite, often referred to as mesquite flats, are not considered Black-capped Vireo habitat; therefore, mesquite control in these areas will not affect vireos.

When using herbicides, careful attention to the kinds, amounts, timing, and application technique will achieve the best control of target species at minimum cost. Precise application also reduces the risk of environmental contamination and off-site effects. It is best to choose highly selective individual plant treatment methods, whenever practical, to avoid damage to desirable shrubs such as live oak, shin oak, Texas oak, hackberry, Texas persimmon, sumac, redbud, and elm. Herbicides should always be used in strict accordance with label directions, including those for proper storage and disposal of containers and rinse water. Herbicide applications should not occur during the breeding season, except for basal applications or individual plant treatment of prickly pear pads.

Carefully planned mechanical methods of brush management such as chaining, roller chopping, shredding, hand cutting, hydraulic shearing, grubbing, and tree dozing can be used to achieve desirable shrub composition and to stimulate basal sprouting of key woody species in order to maintain, enhance, or create vireo habitat. If planning these activities in Bandera, Kerr, Kimble, Real, and Uvalde counties landowners should avoid impacts to Tobusch fishhook cactus (*Ancistrocactus tobuschii*), a federally listed endangered plant, which occurs on similar soils as the vireo. As with other habitat manipulation procedures, mechanical methods should only be used during the non-breeding season (September-February) and done in such a way as to maintain the proper black-capped vireo vegetation profile. Remember that good grazing management and moderate stocking rates can reduce woody plant invasion and therefore the need for expensive brush control practices.

Finally, although brush management practices can be used to change the structure and composition of vegetation so that vireos may occupy the habitat, landowners should seek technical assistance when planning brush management practices in habitat that is known to be occupied by Black-capped Vireos. Since brush management activities can affect habitat for the Golden-cheeked Warbler as well as the Black-capped Vireo, landowners are encouraged to learn about the habitat requirements of both endangered songbirds (see TPWD leaflet on the Golden-cheeked Warbler).

Grazing and Browsing Management

Excessive browsing by goats, exotic animals, and white-tailed deer destroys the thick woody growth needed for nest concealment. Livestock and deer management, which allows woody plants such as live oak, shin oak, sumac, Texas persimmon, elbowbush, redbud, and hackberry to make dense growth from zero to at least 8 feet, is needed. On ranches throughout Texas, moderate stocking, rotation of livestock, controlling deer and exotic ungulate numbers and proper use of desirable browse plants will benefit deer and livestock as well as Black-capped Vireos.

To provide adequate nesting cover for vireos, woody plants should receive only limited browsing during the spring and summer. If animals (livestock, deer, and exotics) are well-managed and kept within recommended stocking rates, this can be achieved. Experience has shown that, in general, ranges stocked with cattle and deer tend to maintain better vireo nesting cover than ranges stocked with goats and exotic animals. Limit browsing pressure, especially during the growing season, to no more than 50% of the total annual growth (current year twigs and leaves) within reach of animals on any given plant. This will maintain plants that are already vigorous and allow for improvement of those with less than ideal structure. As a rule of thumb, if you can "see through" a

Cattle rotation
© TPWD

Overgrazed range with low-growing cover removed
© TPWD

Cowbird trap
© TPWD

browse plant at "door knob" to "eye level", then too much stem and leaf growth has been removed. Installation of structures needed to facilitate good grazing management; i.e., fencing, pipelines, water troughs, water tanks, and ponds, need to avoid removing vireo habitat, should include only enough space to allow for proper operation and maintenance, and need to conduct activities during the non-nesting period (September-February).

Careful management of woody plants will not only provide for the habitat needs of Black-capped Vireos, but will also create high quality habitat for deer and other wildlife as well as livestock. Technical assistance in identifying browse plants and determining proper use is available from the Texas Parks and Wildlife Department and USDA Natural Resources Conservation Service.

Reducing Impacts From Cowbirds

Brood parasitism by Brown-headed Cowbirds poses a serious threat to successful reproduction in some populations of Black-capped Vireos. Research is currently underway to better understand the impacts of cowbirds on vireos. Because livestock attract cowbirds, management to reduce cowbird impacts is important on grazed land.

Because cowbirds are attracted to easily available sources of food, avoid spilling or scattering grain. Supplemental feeding areas should be moved frequently and kept free from accumulations of waste grain. This would help to prevent sparsely vegetated areas of compacted soils, which also tend to attract cowbirds.

Because cowbirds can be attracted by the presence of livestock, grazing management can be used to remove grazing animals from areas where vireos nest. For example, livestock can be rotated away from prime nesting habitat during the breeding season. Another option is to graze stocker cattle during the fall and winter, resting pastures during the spring/summer nesting season. Resting pastures periodically improves range condition and may also help reduce nest parasitism.

Finally, trapping and/or shooting cowbirds can be very effective in reducing vireo brood parasitism, since a single female cowbird can parasitize hosts over a sizeable area (4-5 acres, or more). Mounted mobile traps, placed near watering sites as livestock are rotated through pastures, have been used successfully to reduce cowbird numbers. Properly placed stationary traps have also proven effective in reducing cowbird numbers and parasitism in a local area. Shooting cowbirds at places where they congregate is another option, although this method is often not selective for the cowbirds responsible for the parasitism. Shooting female cowbirds within Black-capped Vireo nesting habitat for as little as one hour a week can reduce parasitism. Persons trapping cowbirds need to be certified for the handling of non-target birds under the general trapping permit held by TPWD. Preventing mortality of non-target birds is very important, so traps must be carefully monitored and checked frequently. Contact Texas Parks and Wildlife Department for information and assistance in implementing a cowbird control program.

Habitat Restoration

For landowners in central Texas wishing to restore or create habitat for the Black-capped Vireo in areas currently unoccupied by vireos, the following suggestions are offered. One type of restorable habitat is an open shrubland capable of growing a diversity of woody plants, where much of the low-growing cover has been removed through overbrowsing by livestock or deer. Controlling browsing pressure by reducing animal numbers and providing pasture rest will allow the natural reestablishment of low-growing shrub cover needed by vireos. Prescribed burning and or mechanical methods described under the Selective Brush Management section may be needed to jump start the resprouting and root sprouting of trees and shrubs.

Habitat restoration may also be possible in areas where the shrub layer has become too tall or dense to provide good vireo habitat. In these areas, well-planned use of controlled fire or other brush management techniques listed above can reduce overall shrub height, stimulate basal sprouting of shrubs, and reduce shrub density to produce more favorable habitat for vireos. The goal is to maintain the critical low growing canopy cover of 30-60%.

Also, in areas where the brush has become too dense, selective thinning conducted during the non-nesting period (September through February) could be done to produce a more open habitat. Carefully planned brush management could be used to encourage regeneration and lateral branching of desirable shrubs by allowing sunlight to reach the ground. The idea is to restore areas to relatively open, low-growing shrub/grassland vegetation that may provide habitat preferred by vireos. If planning any of these activities in Bandera, Kerr, Kimble, Real, and Uvalde counties landowners should avoid impacts to Tobusch fishhook cactus (*Ancistrocactus tobuschii*), a federally listed endangered plant, which occurs on similar soils as the vireo.

Currently, there is no strong evidence to suggest that habitat manipulation will be necessary on many parts of the drier western and southwestern Texas range (western Edwards Plateau and eastern Trans-Pecos) as mature vegetation communities in these areas are used successfully by vireos. Unless browsing pressure or other catastrophic disturbances have eliminated desirable shrub land in these areas, the only requirement needed is time. Fire is of limited use in lower rainfall areas devoid of fine fuels and the plant density required for cost-effective prescribed burns.

There are a number of agencies and organizations conducting management activities benefiting the vireo that can provide useful information and/or assistance to landowners. These include Texas

Parks and Wildlife Department, USFWS, The Nature Conservancy, USDA Natural Resources Conservation Service, and Environmental Defense.

Summary

In the Edwards Plateau and other parts of the range supporting woodland or savanna, periodic prescribed burning and selective brush management are very effective in maintaining and creating Black-capped Vireo habitat. In all parts of the range, control of deer and exotic wildlife numbers, and good grazing management practices, including proper stocking and rotational grazing, are management options that can be used to maintain and enhance habitat for Black-capped Vireos. These same management tools will also maintain diverse and productive rangelands. In addition to providing food, fiber, and support for rural landowners, well-managed rangelands provide habitat for a wide variety of wildlife, and benefits such as clean water, natural diversity, and recreational opportunities for all Texans.

Technical assistance in range and wildlife management, including grazing management, determination of proper stocking rates, prescribed burning, brush management, and management for endangered species, is available to landowners and managers by contacting the Texas Parks and Wildlife Department, USDA Natural Resources Conservation Service, or Texas Cooperative Extension. Further guidance and specific questions concerning Black-capped Vireo research, endangered species management and recovery, and the Endangered Species Act, should be directed to the U.S. Fish and Wildlife Service or Texas Parks and Wildlife Department. If, after reading this leaflet, you are still unsure whether or not your management plans will adversely affect the Vireo or its habitat, please contact the U.S. Fish and Wildlife Service for assistance.

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Population Status and Threat Analysis for the Black-capped Vireo

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May 2006

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1.0 Introduction

The black-capped vireo (BCVI; *Vireo atricapilla*) is a migratory bird with a known breeding occurrence throughout portions of central Texas, the state of Coahuila in Mexico, and isolated areas in Oklahoma. The former breeding range includes a portion of north-central Texas, most of central Oklahoma, and south-central Kansas. The bird's wintering range is on the Pacific slope in western Mexico. On November 5, 1987, the species was listed as Endangered under the Endangered Species Act (ESA) of 1973, as amended. The primary threats supporting the decision to list the species were habitat loss from development; habitat destruction from the grazing of sheep, goats and exotic livestock; and nest parasitism by brown-headed cowbirds (*Molothrus ater*), as determined by the U.S. Fish and Wildlife Service (USFWS) (Ratzlaff 1987). A recovery plan was developed in 1991 (USFWS 1991), but critical habitat has not been designated, and a status review has not been conducted since the listing.

The USFWS initiated the review process for the BCVI in February 2005 by issuing a notice of review and request for information on the species. The purpose of the scientific review effort is to evaluate all scientific and commercial information available on the present status of the BCVI. This evaluation will provide the USFWS with the data needed for making determinations under a status review as required by Section 4(c)(2) of the ESA.

1.1 Objectives

According to Section 4(c)(2) of the ESA, the purpose of a 5-year status review is to assess the following: (a) whether the present population appears to be declining, stable or increasing since the time of listing; (b) whether the threats identified at listing are increased, unchanged, reduced or eliminated; and (c) whether there are any new threats to the species.

1.2 Approach

The overall approach taken was to accumulate, summarize and evaluate the existing information on the species. This information is in the form of peer-reviewed scientific literature, published reports, expert opinion, unpublished manuscripts, archives of published and unpublished data, and a variety of public records. No new data was collected under this effort, and new analyses were not conducted beyond the basic and summary statistics required to gain a range-wide perspective on the central issues addressed in the status review. Where existing data were not adequate for reaching reliable conclusions, that fact is stated and the apparent gaps in information noted.

This report does not make any recommendations concerning the listing status of the species or changes in the listing status. This remains the responsibility of the USFWS.

1.2.1 Review panel

An eight-person review panel was assembled to assist in identifying relevant information and to provide review during the information collection and evaluation process.

The project principal investigator and staff selected review panel members, who included land managers, wildlife biologists and other scientists with expertise appropriate to one or more of the issues being evaluated. Members of the review panel are:

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The review panel helped the project staff identify data sources and interpret the data collected. Panel members developed preliminary assessments in their areas of expertise and provided critical review of the evaluations and conclusions contained in the final report. The panel met several times in the course of this project.

1.2.2 External peer review

The status review process calls for the principal investigator and project staff to seek external peer review of the draft final report. Thus, we sought 3 external reviews of our January 2006 “Final Draft” from wildlife researchers recommended by the review panel and other wildlife professionals. The detailed reviews were provided to USFWS personnel, and this document includes revisions as suggested by those reviews. We acknowledge the contributions from the critical external reviews provided by J.D. Brawn, D. Buehler, and M. Morrison.

2.0 Life History

2.1 Introduction

This section describes the basic life history of the BCVI, including a summary of the species' documented geographic range, food habits, reproduction and mortality.

2.2 Species Description

The BCVI is a small, migratory songbird 10 to 12 cm long (Graber 1957, Grzybowski 1995, Howell and Webb 1995). It is unique among vireos in being sexually dichromatic (Graber 1957) and in showing delayed plumage maturation in first-year males (Rohwer et al. 1980). Mature males are mostly olive green above and white below with faint greenish-yellow flanks (Oberholser 1974, Campbell 1995). The crown and upper half of the head are black, and the partial white eye-ring connects with white lores to form "spectacles." The bill is black, and the iris is red in mature males and brownish red or amber in females and immatures (Graber 1957, Howell and Webb 1995, Pyle 1997). The plumage of females is duller overall than that of males. The heads of females are dark slate gray (USFWS 1991, Campbell 1995, Grzybowski 1995).

2.3 Geographic Range

In 1986, the known breeding range of the BCVI included portions of Kansas, Oklahoma, Texas and central Coahuila, Mexico (Shull 1986). Today, the breeding range no longer appears to extend farther north than central Oklahoma, but it apparently extends farther south than was previously known (Farquhar and Gonzalez 2005). The information collected for this status assessment indicates that the boundaries of the breeding range should be modified to exclude Kansas and extend southward through the Mexican state of Nuevo Leon and into the southwestern part of Tamaulipas (Fig. 2.1). The information collected for the succeeding sections supports this description of the bird's present range. Since its listing, the species has not been known to occur outside this range. The wintering range for the species is not as well documented but appears to be along the Pacific coast of Mexico from approximately 27 degrees to 16 degrees latitude (Fig. 2.1). For reference throughout this document, the species' U.S. breeding range is divided into geographic units (Fig. 2.1) as suggested by the Population and Habitat Viability Assessment Report (USFWS 1996).

Breeding range in Mexico. Prior to recent observations by Farquhar and Gonzalez (2005), the species was not confirmed to breed farther south than central Coahuila, Mexico (Renardo 1886, Moore 1938, Miller 1955, Van Hoose 1955, Graber 1961, Wauer and Ligon 1977, Benson and Benson 1990). Until recently, the only evidence of breeding south of Coahuila was unconfirmed single records from Tamaulipas (Phillips 1911), San Luis Potosi (Davis *in* Graber 1961), and Nuevo Leon (compiled in Marshall et al. 1984 and Marshall et al. 1985). Recent records document breeding in Nuevo Leon (in Bustamante; the first confirmed Mexican breeding records outside of Coahuila; Farquhar et al. 2003) and in southwestern Tamaulipas (Palmillas; Farquhar and Gonzalez 2005). The Tamaulipas records (approximately 20 adult BCVIs and four fledglings) are at least 700 km south of the previous confirmed southern records from Coahuila; they are also the first documented breeding records for this species south of the Tropic of Cancer (Farquhar and Gonzalez 2005). Based on these recent reports from northeastern Mexico, the known breeding range in Mexico has been extended southward, producing a distribution map as seen in Figure 2.1.

Winter range in Mexico. The known non-breeding, winter range consists of an elongated and patchily distributed area along the Pacific slopes of the Sierra Madre Occidental Mountains in Mexico, extending from southern Sonora to Oaxaca (Fig. 2.1). Marshall et al. (1985) discussed the winter range as including the Mexican states of Sonora, Durango, Sinaloa, Nayarit, Jalisco, Michoacan, Guerrero, Oaxaca and possibly Hidalgo. There is no evidence that BCVIs winter in Hidalgo (the lone record was of a probable migrant in mid-October [Marshall et al. 1985]), but the other states listed by Marshall et al. (1985) are accurate, although one additional state where the species is known to winter (Colima) is absent from their list. Mexican states where occurrence has been documented include Sonora (Russell and Morrison 1996), Sinaloa (Graber 1957, Graber 1961, Marshall et al. 1985, Howell 1999, Powell unpublished data), Durango (Graber 1957, Howell and Webb 1995, Powell unpublished data), Nayarit (Marshall et al. 1985, Howell 1999, Powell unpublished data), Jalisco (Hutto 1989, Hutto 1994, Howell 1999, Powell unpublished data), Colima (Howell 1999, Powell unpublished data), Michoacan (Howell and Webb 1995), Mexico (probable migrant; Escalona et al. 1995), Guerrero (Howell and Webb 1995), and Oaxaca (Binford 1989, Howell 1999). With the exception of Sonora, there are also specimen records from the same states (Appendix B).

Most of the non-breeding records are concentrated in Sinaloa and Nayarit, and this area has been described as the center of the wintering grounds (Graber 1961). However, Sinaloa and Nayarit were the states most heavily surveyed during previous studies, so the large proportion of records in those states may largely be an artifact of sampling effort. Recent research indicates that the birds may be most heavily distributed in the states of Sinaloa, Nayarit, Jalisco and Colima (Powell, unpublished data).

Migration. Moore (1938) commented that the scarcity of BCVI records from Sonora suggests that the birds cross the tableland through Chihuahua and descend through the canyons of southwestern Chihuahua and Durango to the coast. Graber (1961) agreed with the idea of such a route, but she visited the area and found no evidence of habitat suitable for BCVIs. Marshall et al. (1985) and Farquhar and Gonzalez (2005) also doubted the likelihood of this migratory route because of the mountainous terrain and the xeric conditions along the way, even though it would be the shortest linear route between the wintering areas and the breeding grounds in Texas and Oklahoma. Graber (1961) stated that scattered records of BCVIs from high elevations (one as high as 9,500 feet) suggest the possibility of a migratory route over the mountains. Moore's (1938) proposal was made prior to the discovery of the currently known breeding range in Mexico. Farquhar and Gonzalez (2005) thus suggested that these southern populations might instead migrate across the shrubby, submontane vegetation associated with the Volcanic Belt Pine-Oak Forests. Similarly, Marshall et al. (1985) examined specimen and site records of BCVIs during migration and proposed the possibility of a route around the edge of the plateau to the south, along or parallel to the Sierra Madre Oriental.

Black-capped vireos begin to depart from the breeding grounds in late August and September, with the young birds leaving first, followed by the adult females and then the adult males (Graber 1961, Marshall et al. 1985). In the spring, they arrive on the breeding grounds about a week after the average date of the last frost (Graber 1961), which is usually from mid-March to mid-April in Texas and approximately 10 days later in Oklahoma (Campbell 1995, Grzybowski 1995). Males typically arrive about a week or two before females and first-year males to select their territories (Graber 1961, Campbell 1995).

2.4 Nesting and Reproduction

Nesting begins shortly after the females arrive on the breeding grounds (Graber 1961). Males sing to attract mates and defend territories, which usually range in size from 1 or 2 hectares (ha; mean=1.5; Graber 1961) to 10 ha (mean=3.6 ha; Tazik 1991b). Pairs form after a brief courtship (less than 1 to 2 days). Pairs remain socially monogamous throughout the breeding season and select nesting sites together (Grzybowski 1995). It takes 2 to 9 days for females to construct the cup-shaped nests, which are suspended in the forks of shrubs in dense underbrush from 0.2 to 3.0 m (usually 0.5 to 2.0 m) above the ground (Campbell 1995, Grzybowski 1995).

The first egg is usually laid 2 days after nest completion; additional eggs are laid on each subsequent day (Graber 1961). The first nesting attempt usually results in three to four eggs, while later clutches may only contain two to three eggs (Campbell 1995). Incubation takes 14 to 17 days, with both males and females sharing incubation duties. Likewise, both males and females share the responsibility of feeding the chicks, which leave the nest 10 to 12 days after hatching (Campbell 1995).

2.5 Food Habits and Foraging Behavior

Black-capped vireos are opportunistic gleaners of insects (Graber 1961). Their spring and summer diet consists primarily of insect larvae, most of which are of the Order Lepidoptera (Graber 1961, Grzybowski 1995). The stomach contents from eight BCVIs captured range-wide during the breeding season was composed of Arthropods (94.1 percent) and seeds (5.9 percent), with major items including Lepidoptera adults (16.2 percent) and larvae (13.2 percent), Coleoptera (30.9 percent), Homoptera (10.3 percent), and Arachnida (Araneida; 7.4 percent) (Graber 1957, Graber 1961). The fall and winter diet appears to include a wider array of insect matter, as well as vegetable matter (primarily seeds, but possibly fruits as well), although data on this subject are very limited (Graber 1961, Powell personal observation). These data only supply limited information upon which to base management.

Both males and females forage in woody vegetation at all levels and seem to prefer deciduous substrates (especially oaks) (Graber 1961, Grzybowski 1995). Foraging behavior typically involves gleaning from leaves, twigs and small branches, as well as from the trunks of trees (Grzybowski 1995).

2.6 Survivorship and Mortality

Estimates of adult annual survivorship are variable. Based on returns of color-banded birds at Kerr Wildlife Management Area (WMA), the annual survivorship of adult males was estimated at 0.55 to 0.75 (Grzybowski 1991). Estimates of annual survival rates for adult males at Dolan Falls, Texas was 0.68 (*n*=63), while at Fort Hood, Texas it was 0.40 (*n*=884) (Alldredge et al. 2003). Population viability analysis (PVA) models for BCVI have used values of 0.57 for annual adult survival rates (USFWS 1996, Parysow and Tazik 2002). The above estimates were all derived from return rates, and should therefore be considered as minimum survival rates.

Adult female survivorship is not well established, but is likely to be lower than for males because sex ratios favor males (Grzybowski 1995). Juvenile survivorship also is not well established, but it has been suggested by Grzybowski (1995) to be higher than that of adults. Data of Alldredge et al. (2003) suggested hatch year survival rates of 0.17 (*n*=822), but these results may be due to high natal dispersal, which is a common trait of neotropical migrants (Villard et al 1995). Population viability analysis (PVA) models for BCVI have used values of 0.43 for juvenile survival rates (USFWS 1996, Parysow and Tazik 2002).

The most common predators of free-flying BCVIs are snakes and accipiters, although little data are available on this (Grzybowski 1995). Nests are frequently lost to predation. Of 225 eggs at sites in Oklahoma and Texas, 31 (14 percent) were believed lost to predators (Graber 1961). At Fort Hood (where cowbird removal has reduced nest loss from parasitism and subsequent nest abandonment), depredation was the largest cause of nest failure in 2004, accounting for 82 percent of the unsuccessful nests (*n*=166) and 44 percent of all nests (*n*=312) (Cimprich 2004). At Fort Hood, a nest-monitoring study from 1998 to 2001 found that snakes and fire ants (*Solenopsis* spp.) were the leading predators, accounting for 38 percent and 31 percent, respectively, of all depredated nests (*n*=48) (Stake and Cimprich 2003). Other nest predators in the Fort Hood study included avian predators (19 percent of depredated nests) and mammalian predators (11 percent). The fact that predation appears to increase when cowbird parasitism is decreased through removal programs suggests that predation by snakes and fire ants might limit some populations when cowbird parasitism is reduced.

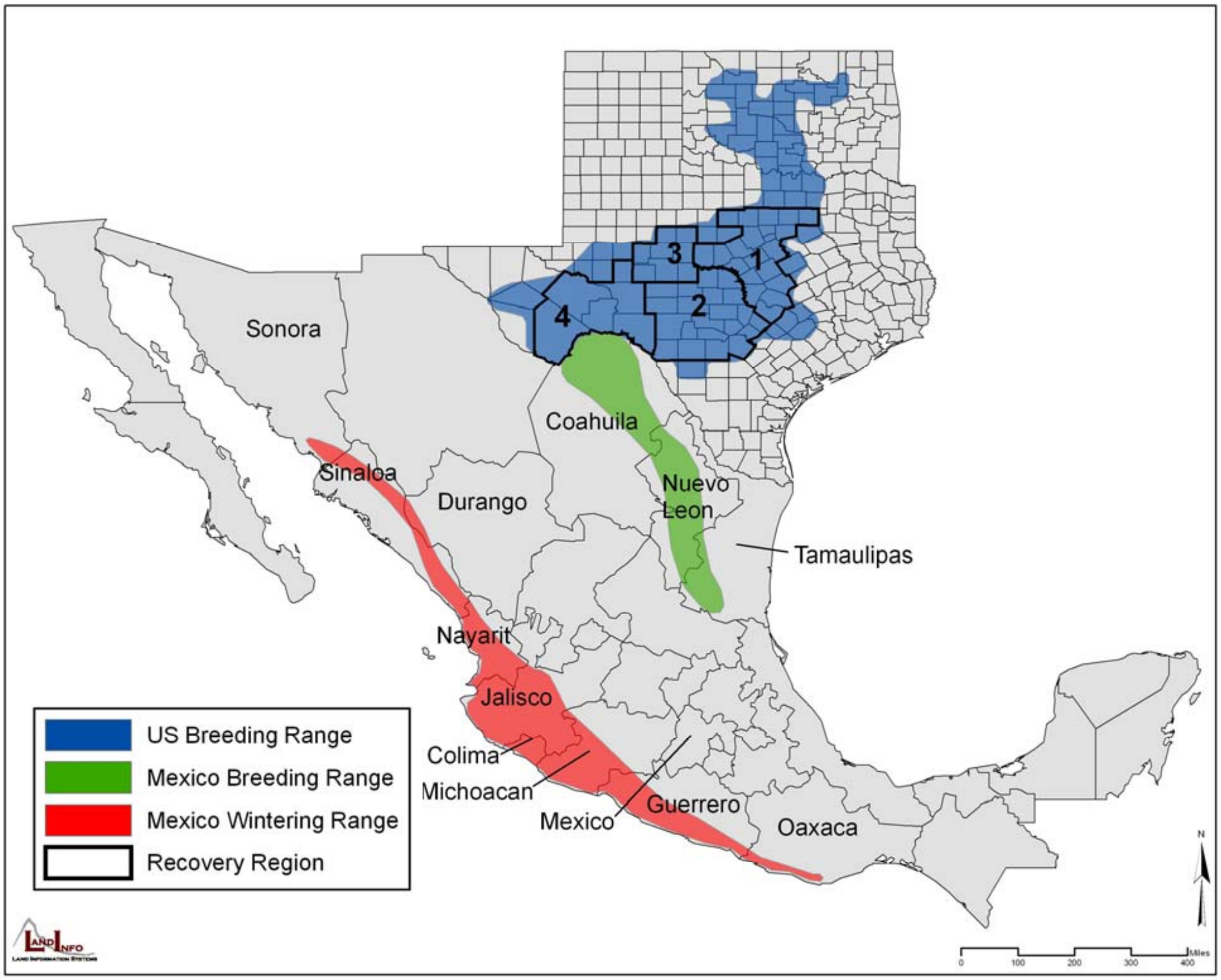

Figure 2.1. Currently known breeding and wintering ranges for the Black-capped Vireo with recovery regions as suggested for revision by the Population and Habitat Viability Assessment Report (USFWS 1996. Ranges are generalized for all known locations since time of listing. Note:Black outlines in the Texas range of the species represent recovery units.

3.0 Habitat Characteristics and Availability

3.1 Introduction

Here we discuss general characteristics of BCVI breeding habitat, nest site characteristics, and factors influencing habitat suitability, including the role of fire. Following that are estimates of the amount of habitat suitable for BCVIs in Texas and Oklahoma and an overview of known BCVI habitat relationships on the breeding and wintering grounds in Mexico. More information is available for breeding habitat than for wintering grounds.

3.2 Limitations

Ideally, the characteristics and availability of habitat should be considered at various scales: the landscape scale, the patch scale, and nest location. The monitoring of habitat suitability at the landscape scale would provide a metric for assessing the conservation status of the species. However, landscape-scale habitat information for the BCVI is severely limited. While there is much more information at the habitat patch and nest location scales, its utility is largely confined to site-specific management implications and it is not of much direct use in determining the status of the species.

3.3 Habitat Availability at the Landscape Scale

Estimates of the amount of suitable habitat at the landscape scale are generally made with the aid of remotely sensed data and data-intensive GIS analyses. The use of habitat modeling and remote sensing to construct habitat suitability models for BCVIs has been limited, partly because of the difficulty of distinguishing canopy-to-ground foliage cover, which is necessary for identifying suitable BCVI habitats. Recently, Light Detection and Ranging (LIDAR) was used at Fort Hood to describe and locate potential BCVI habitat patches based on size, shape, and vertical structure of vegetation (Leyva et al. 2004). Overall accuracy in classifying habitat (BCVI habitat and non-habitat) in this preliminary study was only 69% (n=199). Although this methodology is limited by expense and availability, its use may hold promise for future work.

The only wide-ranging estimates of suitable habitat for the species come from a recent USFWS Biological Opinion for brush management in Texas (USFWS 2004). The assessment relied heavily upon roadside surveys of 53 Texas counties conducted between July 1996 and August 1998 (Maresh et al. 1999, Maresh and Rowell 2000). In each of these counties (except Dallas County), two 30-mile transects were surveyed for BCVIs and estimates were made of the potential suitable habitat within the survey transects. The estimates of potential habitat within each county were then made by extrapolating the estimates from roadside surveys with USGS topographic maps. One exception to this was Dallas County, where no roadside surveys were conducted. Instead, potential habitat was estimated from an assessment of USGS topographic maps of areas of known occurrence within the county.

In three other counties (Montague, Brewster and Pecos), no roadside habitat segments were recorded (Maresh et al. 1999, Maresh and Rowell 2000), so potential habitat was estimated from an examination of topographic maps and recent site visits (USFWS 2004). Table 3.1 presents the habitat assessments from the Biological Opinion. It includes the estimated approximate land area by county, the area of potential BCVI habitat, and the proportion of total county land area potentially suitable as BCVI habitat.

According to the habitat assessments in Table 3.1, the 53 counties inventoried contained approximately 1.45 million acres of potential suitable habitat. This is equivalent to about 3.3 percent of the total land area considered. The estimate was made to support decisions concerning the amounts of potential habitat that might be manipulated by brush management during any one year. It should be mentioned, however, that the survey routes were chosen specifically to include areas of known or "most likely" BCVI occurrence, thus limiting the statistical rigor of the study and likely resulting in overestimates of occupied and potential suitable habitat. Furthermore, this estimate did not consider variation in habitat quality or variance for determining statistical confidence, and it is not comparable to any data collected in previous years. So, while this assessment was informative for the process of forming a Biological Opinion for the incidental take associated with brush management, it is of limited value in comparing current available habitat against the available habitat at time of listing. Also, due to the lack of statistical reliability or the random selection of survey routes, these estimates should be interpreted with caution. We found no estimates of suitable BCVI habitat available for either Oklahoma or Mexico.

3.4 Patch-level Habitat Characteristics

U.S. range. In Texas and Oklahoma, suitable BCVI habitat is characterized by a patchy distribution of low, scrubby growth made up mostly of deciduous woody shrubs and trees of irregular height (Graber 1961). When compared with adjacent habitats, the habitats in BCVI territories have a higher density of deciduous vegetation less than 2 m in height (Grzybowski et al. 1994). In an analysis of habitat across Texas and Oklahoma, deciduous cover around BCVI nests was typically 30 to 45 percent across the range, while total woody cover, including junipers (*Juniperus* spp.), was 36 to 55 percent (Grzybowski et al. 1994). Similarly, Juarez (2004) found average canopy cover by low-growing (less than 1.5 m) shrubs to be 18.6 percent at sites occupied by singing males during the breeding season, which was more than double that found at sites not known to be occupied.

Where there is low-growing, deciduous cover, BCVIs are more likely to occupy areas with sparser cover by *Juniperus* spp. (Grzybowski et al. 1994, Juarez 2004). For example, on private ranch land in Coryell and Hamilton Counties in Texas, singing males were found on sites with an average juniper cover of 9.3 percent (Ashe juniper, *J. ashei*, less than 3 m high), while sites with a cover of 19.6 percent were unoccupied (Juarez 2004).

Recent work conducted at Fort Hood suggests that habitat may be a limiting factor for BCVI (Noa 2005). Black-capped vireo abundance and age structure were compared between two habitat types – shrubland habitat and scattered patches of shrubby vegetation centered on one or several large trees (resulting from armored vehicle traffic) – over a 2-year period. The latter had a lower abundance of BCVI (*n*=63) than did the shrubland habitats (*n*=115) and a higher percentage of second-year males (49% vs.32%), suggesting that young BCVI may use lower quality habitats (Noa 2005). Grzybowski et al. (1994) also reported areas of suboptimal BCVI habitat that had higher ratios of second-year males, and it is not uncommon that younger males should occupy habitat that is less than optimal (Holmes et al. 1996, Petit and Petit 1996).

Mexican breeding range. Black-capped vireo populations in northern and central Coahuila have been described as occupying a mountainous zone with scrub-oak vegetation (Marshall et al. 1985, Grzybowski 1995). Throughout this region, distinct altitude-dependant vegetation belts occur (Miller 1955, Benson and Benson 1990). Graber (1961) described the habitat in Sierra Padilla, Coahuila as similar to that described by Lesueur (1945) for isolated limestone Sierras in northeastern Chihuahua, where the lowest oaks (*Quercus* spp.) appear at

5,600 feet, junipers grow at 5,800 feet, and a few large pines (*Pinus* spp.) grow on isolated ridges. As Graber (1961) described it, the habitat in Sierra Madera in Coahuila was similar to that at Sierra Padilla, where pine forests were more prevalent at the higher slopes, and similar to the descriptions of the Sierra del Carmen by Miller (1955). Black-capped vireos were found only on dry, limestone hillsides with thick mats of vegetation 3 to 5 feet high (Graber 1961).

Benson and Benson (1990) described the lowland habitat as desert shrub that extended from the base of the mountains up to the mouths of the canyons. Above this was habitat described as "montane low forest" (Muller 1947); it was dominated by live and deciduous oaks, as well as pinyon pine (*P. monophylla*), juniper, walnut (*Juglans* spp.) and elm (*Ulmus* spp.). Benson and Benson (1990) described the elevations above 1,300 m as pine-oak woodlands (primarily Ponderosa pine; *P. ponderosa*) with dense shinnery oak (*Q. havardii*). Above 2,000 m, mesas dominated by conifers were typical. Howell and Webb (1995) described BCVI habitat in Mexico as arid to semiarid scrub, especially with oaks, and they noted that the birds commonly nest at low to mid-levels in brush or scrubby trees.

Much of the vegetation suitable for BCVIs across the Mexican breeding sites in Coahuila, Nuevo Leon and Tamaulipas states can be characterized as either Tamaulipan thornscrub or submontane pine-oak chaparral (Farquhar and Gonzalez 2005). Tamaulipan thornscrub is a xeric habitat typically found below 1,000 m where the vegetation is patchy and low-growing (less than 3 m) as in large areas of west Texas (e.g., Big Bend National Park, Dolan Falls Ranch, and Devils River State Natural Area). The persistence of BCVI habitat in Tamaulipan thornscrub habitat type does not appear to depend on fire. The submontane pine-oak chaparral is found at higher elevations and is generally associated with foothills and the lower slopes of the Sierra Madre Oriental (western slopes in Nuevo Leon and Tamaulipas). The persistence of BCVI habitat in the submontane pine-oak chaparral, (consisting of low-growing oaks, sumacs [*Rhus* spp.], junipers and sotol [*Dasylirion wheeleri*]) may depend on fire to retard secondary succession (Farquhar and Gonzalez 2005). Interspersed among these areas are rocky slopes with shallow soils that are unable to support trees with deep roots; fire is probably not necessary to maintain the habitat in these areas (Farquhar and Gonzalez 2005).

Mexican wintering range. The winter range of the BCVI has received little attention, so there is only limited information about it. Graber (1957, 1961) qualitatively assessed wintering habitat requirements, determining that they are complex and have a wider range of vegetation types than do the breeding grounds. Based on her observations (which were restricted to sites in Sinaloa and Nayarit states), birds chose both arid scrub 0.75 to 3.0 m high (southern Sinaloa) and mesic, luxurious, secondary growth with a richness of plant species (coastal Nayarit). The latter plant community was suspected to have resulted from widespread clearing; it appeared to be particularly favored by the BCVI. Howell and Webb (1995) described wintering BCVI habitat as either arid to semiarid scrub (especially where there are oaks) or humid, brushy, secondary growth and forest edge.

During research in the winters of 2002-2003 and 2003-2004, BCVIs (n=56) in Sinaloa, Durango, Nayarit, Jalisco and Colima states selected habitat with significantly less canopy cover, denser shrubs and steeper slopes than random habitat points (Powell, unpublished data). This research confirmed the general assessments by Graber (1961) and Howell and Webb (1995) that BCVIs selected both mesic secondary growth and xeric scrub, although they used a variety of other habitat types as well, including shade coffee plantations, thorn forest, riparian forest, pine-oak forest and deciduous forest. Black-capped vireos were also found at a variety of altitudes from sea level to 1,462 m (4,798 feet), with a mean altitude of 585 ± 101 m (n=56) (Powell, unpublished data).

3.5 Nest Site Characteristics

Black-capped vireos construct their nests relatively near the ground, with most nests (90 percent) occurring 0.4 to 1.25 m above ground level (Grzybowski 1986). Low-growing branches of several species of oaks (*Quercus* spp.) provide the majority of known nesting substrates (Graber 1957, Tazik et al. 1989, Grzybowski et al. 1994).

Within habitat patches, BCVI nest sites tend to be in deciduous vegetation in areas with no more than 69 percent woody cover, considerable edge density (transitions among 2 or more patch types), and heavy foliage cover below 2 m (Bailey 2005). According to Grzybowski et al. (1994), the woody canopy cover immediately adjacent to BCVI nests is 35 to 55 percent across the species range. Most of the cover is deciduous (39.7 percent deciduous cover ± 13.81) rather than juniper (7.6 percent juniper cover ± 8.66). While juniper is occasionally used for nest locations, it is generally underused relative to availability in Texas and Oklahoma (Grzybowski

1986, Tazik and Cornelius 1989, Tazik et al. 1989, Grzybowski 1995, Bailey 2005)[1]. In breeding habitats at Fort Hood, Bailey (2005) found that BCVIs were almost three times (283 percent) more likely to nest in deciduous cover than in juniper.

Blackjack oak (*Q. marilandica*), shin oak (*Q. sinuata*), Spanish oak (*Q. texana*), plateau live oak (*Q. mohriana*) and Vasey oak (*Q. pungens* var. *vaseyana*) are the most frequently used species at nesting sites in Texas and Oklahoma (Graber 1957, Tazik et al. 1989, Grzybowski et al. 1994). Other common species in Texas and Oklahoma that compose the deciduous cover in BCVI habitat include sumac, Texas persimmon (*Diospyros texana*), roughleaf dogwood (*Cornus drummondi*) and redbud (*Cercis canadensis*) (Grzybowski 1995). Other species common to BCVI habitat include Texas ash (*Fraxinus texensis*) and Mexican buckeye (*Ungnadia speciosa*). At sites in northern Mexico, common species include oaks (*Q. grisea* and *Q. laceyi* in Coahuila, *Q. invaginata* and *Q. fusiformis* in Nuevo Leon) and sumac (*R. virens*) (Farquhar and Gonzalez 2005).

3.6 Factors Influencing Habitat Suitability

Suitable habitat for the species results from the combined effects of drought, periodic fire, and grazing pressures interacting with site characteristics such as landform, topography and dominant vegetation type. Depending on climate and other physical factors, the proper conditions for breeding habitat can be relatively short-lived. Fire, and in some cases moderate browsing by wildlife and livestock, can maintain suitable successional stages for the development of breeding habitats (Ratzlaff 1987). As a consequence, BCVIs are often found in areas with recent histories of fire, and the highest BCVI concentrations typically occur in areas recovering from a hot fire (Graber 1957, Marshall et al. 1985, Grzybowski et al. 1994). Under the proper burning conditions, fires can kill or retard invading junipers and favor the regrowth of fire-adapted oak and sumac species, thus providing the areas of dense, low foliage required by BCVIs (USFWS 1991, Campbell 1995, Grzybowski 1995).

Where there is moist soil, as is commonly found in the eastern two-thirds of the breeding range, BCVI habitat changes through succession into closed-canopy hardwood forest (Grzybowski et al. 1984). Some BCVI territories, however, are located on steep slopes where the

[1] We found no quantified data on nest-site characteristics in Mexico.

shallow soils slow succession and the microclimate perpetuates the clumping of vegetation suitable for BCVI habitat (Graber 1961). In general, the habitats used by BCVIs in southwestern Texas and northeastern Mexico are less influenced by succession than the areas in the northern and eastern portions of the range (Farquhar and Gonzalez 2005). Some areas of Mexico (i.e., Rancho La Escondida, Coahuila) do contain deep-soiled, shrubby oak BCVI habitat adjacent to fire-dependent pine forest. Although these habitat areas are affected by the fires, it is not thought that managing them with fire would be necessary to maintain BCVI habitat (Farquhar and Gonzalez 2005).

Marshall et al. (1985) also noted that in some areas (e.g., Kerr County, Texas) browsing by white-tailed deer can actually maintain a low-growth form of preferred nest substrates such as shinnery oak. However, if white-tailed deer populations exceed an areas' "carrying capacity," the resultant overbrowsing can diminish habitat suitability for BCVIs.

Experimental work by Ward and Schlossberg (2004) at Fort Hood, produced evidence that BCVIs are attracted to specific sites by recorded vireo vocalizations. Their results suggest that BCVIs may use vocalizations as a cue in identifying areas suitable as breeding habitats, thus implying that artificial stimuli may be used as a conservation tool for the species.

Influence of fire. The absence of fire on many rangelands and woodlands has led to the degradation of much potential BCVI habitat by allowing successional advancement and the encroachment of junipers. In the Edwards Plateau of Texas, the absence of fire has contributed to the encroachment of Ashe juniper onto open woodlands (Smeins and Merrill 1988). Recurring rangeland fires were a primary influence in the development of an oak-dominated plant community throughout much of the species range; the suppression of fire contributes to juniper invasion and dominance (Gehlbach 1988). Therefore, fire is important in creating and maintaining BCVI habitat across much of the eastern and northern portions of the species' breeding range (Graber 1961, Shaw et al. 1989, Benson and Benson 1990, USFWS 1991).

Several studies have addressed the effects of fire on BCVI populations and have attempted to estimate the time interval at which BCVI occupancy or re-occupancy occurs. Black-capped vireos fully recolonized burned areas the second year post-burn at Wichita Mountains Wildlife Refuge (WR) (Grzybowski 1989, Grzybowski 1990a), and early results from Fort Hood, Texas suggested a similar interval (Tazik et al. 1993). Modeling efforts at Fort Hood yielded a prediction that 72 percent of a burned area would be suitable for BCVI occupancy 3 years after a burn (Koloszar and Horne 2000). Results from a large fire at Fort Hood indicated that BCVIs were still increasing in abundance until at least 7 years after the fire (Cimprich 2002). A more recent study at Kerr WMA found that 53.8 percent of winter prescribed burns resulted in increased BCVI use within the same year as the burn, and 92.1 percent of the burns coincided with greater BCVI use within 2 years post fire (Dufault 2004). While cowbird control, deer management, and grazing management may have combined to influence habitat use, Dufault (2004) estimated that 81 percent of the increased use 1 year following a burn could be directly attributed to fire. At 2 and 3 years post-burn, these figures were 78 and 67 percent, respectively. Overall, as noted by Dufault (2004), surveys from Kerr WMA documented an increase in singing males from 27 to 445 during the period 1986 to 2003[2]. This increase was attributed to the prominent influence of prescribed fire combined with brush management, grazing management, white-tailed deer population control, and cowbird removal.

In addition to controlled studies, some wildfires also have provided opportunities for monitoring post-burn occupancy and re-occupancy. The most notable of these opportunities was at Fort Hood, where crown fires burned 4,015 ha (9,917 acres) in February 1996, including 508 ha (1,255 acres) of BCVI habitat (Goering 1998, Hayden et al. 1999). Since then, BCVI abundance has increased on the burned areas while remaining relatively constant on unburned areas of the base (Cimprich 2002). Black-capped vireo abundance increased dramatically between 3 and 4 years after the fire. At 6 years post-burn, there were twice as many point-count detections of BCVIs on burned areas as on unburned areas (Cimprich 2002). Furthermore, BCVIs were detected at a greater percentage of survey points in the burned areas than elsewhere (88 percent vs. 66 percent).

A variety of burn intervals have been suggested for maintaining BCVI habitat, including 4 to 7 years (Campbell 1995), 4 to 10 years (Beardmore et al. 1996), and 25 years (Tazik et al. 1993). Long-term data from Fort Hood and Kerr WMA suggest that the residual influence of fire in creating suitable BCVI habitat may last as long as 20 to 30 years (Tazik et al. 1993, Dufault 2004). However, taking into account the variability in climate and other physical factors across the species range, the actual post-burn use by BCVIs on any one site is likely to be influenced by the season in which the fire occurred, the burning conditions, and the weather patterns after the fire.

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[2] As of 2005, there were 358 known singing males on Kerr WMA.

Table 3.1. Approximate land area, by Texas county, within each black-capped vireo recovery region; estimated acreage of potential black-capped vireo habitat; and percent of county acreage suitable for BCVI habitat. Table adapted from USFWS (2004), based on roadside survey data from Maresh et al. (1999) and Maresh and Rowell (2000). See text for description of limitations of these data.

Recovery Region/County	County land area (acres)	Potential suitable habitat	
		(acres)	(%)
Region 1			
Bell	611,325	11,004	1.80%
Bosque	632,814	7,594	1.20%
Brown	603,915	36,235	6.00%
Burnet	637,260	11,683	1.80%
Coleman	806,208	20,155	2.50%
Comanche	599,963	10,999	1.80%
Coryell	672,828	4,486	0.70%
Dallas	580,549	900 [1]	0.20%
Erath	695,058	15,060	2.20%
Hamilton	534,508	9,799	1.80%
Hood	269,724	3,147	1.20%
Johnson	466,583	0	0.00%
Lampasas	455,468	4,555	1.00%
Mills	478,686	1,596	0.30%
Montague	590,662	100 [1]	0.20%
Palo Pinto	609,596	11,176	1.80%
Parker	577,980	963	0.20%
Somervell	119,795	1,198	1.00%
Stephens	572,299	7,631	1.30%
Travis	632,814	6,328	1.00%
Williamson	718,276	9,577	1.30%
Region 1 Total	**11,866,311**	**173,186**	**1.47%**
Region 2			
Bandera	506,597	7,599	1.50%
Bexar	797,563	47,854	6.00%
Blanco	454,974	2,275	0.50%
Comal	359,138	3,591	1.00%
Edwards	1,356,030	70,062	5.20%
Gillespie	678,756	58,826	8.70%
Hays	433,732	23,855	5.50%
Kendall	423,852	4,945	1.20%
Kerr	707,655	53,074	7.50%
Kimble	800,033	36,001	4.50%
Kinney	872,157	62,505	7.20%
Llano	597,987	1,993	0.30%
Mason	596,258	35,775	6.00%
McCulloch	684,190	62,717	9.20%
Medina	849,433	62,292	7.30%
Menard	582,920	30,118	5.20%
Real	447,811	31,347	7.00%
San Saba	725,686	6,047	0.80%

Recovery Region/County	County land area (acres)	Potential suitable habitat	
		(acres)	(%)
Schleicher	838,318	1,397	0.20%
Sutton	929,955	46,498	5.00%
Uvalde	995,657	29,870	3.00%
Region 2 Total	**14,638,702**	**678,641**	**4.60%**
Region 3			
Coke	575,016	25,876	4.50%
Concho	634,296	10,572	1.70%
Irion	672,581	0	0.00%
Nolan	583,414	37,922	6.50%
Runnels	672,087	8,961	1.30%
Sterling	590,577	11,812	2.00%
Taylor	585,637	9,761	1.70%
Tom Green	973,674	17,851	1.80%
Region 3 Total	5,287,282	**122,755**	**2.30%**
Region 4			
Brewster	3,961,633	1100 [1]	0.03%
Crockett	1,795,937	125,716	7.00%
Pecos	3,047,486	750 [1]	0.00%
Terrell	1,508,182	2,514	0.20%
Val Verde	2,028,117	344,780	17.00%
Region 4 Total	12,341,355	**473,010**	**3.85%**
TOTAL	**44,133,650**	**1,450,442**	**3.29%**

[1] Habitat area determined from site visits and examination of USGS 1:24,000 topographic maps (Maresh in USFWS 2004).

4.0 Population Status

4.1 Introduction

In this section is an accounting of the known population of BCVI. Ideally, such an assessment would be used to compare against previous range-wide reviews to yield conclusions concerning trends within recovery regions[3] and across the range at large. However, with the notable exception of four relatively well-surveyed areas, there are little data upon which to draw firm conclusions concerning the overall population. We do draw some conclusions concerning the changes in the *known* population of the species; and inasmuch as a large proportion of this known population is concentrated on a few sites, we draw some conclusions concerning the trends on those areas.

The occurrence and abundance data available are primarily for the U.S. breeding range of the species. We do, however, include some recent information on the bird's breeding range in Mexico.

4.2 Approach

The approach we have taken here is to assemble the most recent information available across the BCVI's present distribution. For this, we collected all available federal aid reports from the U.S. Fish and Wildlife Service. We consulted all published and available unpublished records for the species. We sought additional recent data by corresponding with state wildlife biologists, consultants and land managers throughout the species range. To compare current known populations with previous known populations, we draw heavily on information assembled for the Population and Habitat Viability Assessment Report (USFWS 1996) and on the status assessments used in preparing the original listing proposal (Marshall et al. 1985, Grzybowski 1985a).

[3] Here we use the most recent recovery regions (or "recovery units") as described in the black-capped vireo population and habitat viability assessment report (USFWS 1996), and these are slightly different from those described in the 1991 recovery plan for the species (USFWS 1991). The 1996 assessment described recovery regions limited to the species' breeding range in Texas, so we additionally refer to the breeding ranges in Oklahoma and Mexico as regions. These are also referred to as Recovery region 1- "North-central Texas", Recovery region 2- "Edwards Plateau", Recovery region 3- "Concho Valley", and Recovery region 4- "Southwest and Trans-Pecos" (USFWS 2004).

With few exceptions, these data are collected and expressed as direct counts of male birds observed during the breeding season, although some workers expressed occurrence as "pairs" or "territories." For the purpose of the present work, we treat males, pairs and territories as equivalent measures of a breeding unit. Because of inconsistent protocol in species surveys over the years, we used only direct count information where available. Where it appears that a worker estimated a "range" of individual males for an area, we have taken the conservative approach and used only the lowest number reported.

4.3 Known Breeding Populations

At the time of listing, the total known population of BCVIs across the bird's breeding range was approximately 350 adult birds, including about 191 breeding pairs (Marshall et al. 1985). These numbers comprised 45 to 50 adults, representing about 12 breeding pairs, from four counties in Oklahoma; 280 adults, representing 168 breeding pairs, from 33 sites across 21 counties in Texas; and 24 adults, representing 19 breeding pairs, in Coahuila, Mexico. These counts were based on a combination of records assembled for an earlier status review (Marshall et al. 1985), including surveys in Oklahoma by Grzybowski (1985), and are essentially the figures cited in the proposal that the species be listed as Endangered (Shull 1986). While the BCVI was once considered common in Comanche County, Kansas (Goss 1891) and the original listing included Kansas as part of the historic range (Ratzlaff 1987), there have been no known occurrences of BCVI in Kansas since at least 1956 (Tordoff 1956, Graber 1961).

In 1995, participants in a workshop sponsored by the U.S. Fish and Wildlife Service gathered the known recorded observations of BCVIs throughout the species' U.S. breeding range from 1990 to 1995. The resulting county-by-county records represent the minimum breeding population known for an area. This effort yielded a total count of 1,803 males–1,636 males from 40 counties in Texas and 170 males from three counties in Oklahoma (USFWS 1996).

For the present status assessment, we gathered a similar dataset of observations recorded from 1996 to 2005, where we used only the most recent data from any one site (i.e., records represent the most recent set of observations, but are not cumulative among years). This dataset is similar in quality to that of the 1996 U.S. Fish and Wildlife Service dataset. For the period 1996 to 2005, the total count of breeding males was 6,269–with 3,515 from 38 counties in Texas, 2,495 from three counties in Oklahoma, and 259 from three states in Mexico (Table 4.1, Fig. 4.1, and Appendix A).[4] When compared to the known occurrences of 1990-1995, BCVIs are now known to occur in nine Texas counties where the species was either not yet confirmed (six counties), was thought to be extirpated (Dallas County), or was not previously known (Callahan and Montague Counties). Likewise, no recent occurrences had been recorded in nine counties where BCVIs had been found during the 1990-1995 period. Of the 33 counties where the BCVI occurred in both time periods, the counts were higher in 19 counties, lower in 10 counties and unchanged in four counties. It is most likely that inconsistent survey efforts throughout much of the species range accounts for inconsistent county occurrence records among the 2 most recent time periods reported here. However, it is noteworthy that most of the counties occupied prior to listing, but from which the species has not been documented since listing, are on the edge of the geographic range (Fig. 4.1). In fact, in the northern-most portion of the breeding range, the species is currently known in only 4 of the 24 counties from which it was previously known.

The species' breeding range in Mexico has been only sparsely surveyed. At present, the entire inventory of 259 males from three states in Mexico can be attributed to some limited survey efforts during the past 3 years (Table 4.1, Appendix A). While the counts are relatively low, the population densities indicated by surveys in Mexico are relatively high and appear to hold promise for revealing major population centers for the species. For example, Benson and Benson (1990) documented 28 singing males at four sites in the Sierra del Carmen mountain range and estimated a breeding population of 6,301 ± 3,162 pairs (P<0.1) for the region, based on an extrapolation of their density estimates (1.43 pairs per km^2). This estimate was significantly higher than the 48 to 131 pairs estimated by Marshall et al. (1985). Scott and Garton (1991) called into question the methodology used in the original population estimate for northern Mexico, and Benson and Benson (1991) subsequently revised their techniques and produced a new estimated population size using a distance algorithm (Burnham et al. 1980). Upon reanalysis, Benson and Benson (1991) determined BCVI densities of 1.65 singing males per km^2

[4] A similar comparison was recently prepared by Maresh (2005), and we used that document and many of the same sources, to assemble the records in Appendix A, resulting in the summary of Table 4.1. We updated several of the records and added the results of surveys conducted on private lands in Texas. Another substantial difference in the final figures is the result of some extrapolated population numbers used by Maresh (2005). Our approach was to use (as much as we could tell) only known and documented occurrences.

for northern Mexico, which they extrapolated to a minimum of 3,395 singing males (7,286 ± 3,891).

McKinney (1998) corroborated high density estimates in northern Coahuila, finding 26 singing males in a 4-ha area and another 20 singing males in a 6-ha area. McKinney's results suggest a population density in this part of Mexico much greater than that known within the Texas and Oklahoma breeding ranges, where males typically defend breeding territories of 1 or 2 ha (mean=1.5 ha; Graber 1961) to 10 ha (mean=3.6 ha; Tazik 1991) in size. However these figures were based on a small number of sites. In northern Coahuila, Farquhar and Gonzalez (2005) estimated breeding densities of 3.29 singing males per ha (± 0.37), which is three to six times as large as the typical densities found in Texas and Oklahoma.

4.4 Abundance Patterns

At the time of listing, it was thought that the largest concentrations of BCVIs were in the immediate vicinity of Austin, Texas (Shull 1986, Ratzlaff 1987). This was predicated on the work of J. T. Marshall and R. B. Clapp, who found 33 pairs of BCVIs at Travis County's 227-acre (~100-ha) Wild Basin Wilderness Preserve, and on the approximately 20 males documented by C. Sexton and others in areas just west of Austin (Marshall et al. 1985). Other significant concentrations known at the time of listing included 34 pairs at Kerr WMA in Kerr County, Texas and 15 to 17 males and 3 females at Wichita Mountains WR in Comanche County, Oklahoma.

While the known breeding population today is at least 30 times greater than what was documented at the time of listing, these count data do not clearly establish that the overall population itself has increased by such a margin. Most of the known occurrences of BCVIs are concentrated on a small number of properties. In fact, about 75 percent of the known breeding population is found on four properties–Fort Hood Military Reservation (TX), Kerr WMA (TX), Wichita Mountains WR (OK), and Fort Sill Military Reservation (OK)–two of which (the Oklahoma properties) are adjacent. The other 25 percent of known occurrences are from at least 52 other properties distributed throughout the species' range. Many of these occurrences are on private lands, which account for more than 80 percent of the land within the species' geographic range. Where private lands are accessible, and have been included in systematic surveys, the species is often found. For example, on private lands in Texas, Magness (2003) documented 11 males on seven sites in Bandera and Real Counties and Juarez (2004) documented male BCVIs at 26 sites on private lands in Coryell and Hamilton Counties. Surveys on private lands in other counties also have yielded BCVI occurrences (Appendix A). Despite the increased survey efforts since 1995, most of the BCVI breeding range in the U.S. is on private lands that are as yet unsurveyed.

From 1995 to the present, the known breeding population at three of the four major population centers increased substantially (see Appendix A). At Wichita Mountains WR and Fort Sill (combined), the number of territorial males documented increased from 150 to 2,474; at Fort Hood, the count increased from an estimated 300 to 1,847 in 2003[5]. However, in Kerr County, Texas (Kerr WMA and other private lands), the known population decreased from 602 in 1995 to 436 in 2005.

Researchers at Fort Sill and Wichita Mountains WR have reliably documented population expansions since listing (Grzybowski 2005). Results of systematic surveys of fixed areas at Fort Hood have demonstrated substantial increases in numbers of territorial males since 1987 (Kostecke et al. 2005). At Kerr WMA, intensive habitat management has contributed to an increase in known territorial males from 27 in 1986 to 445 in 2003 (e.g., Dufault 2004).

While it remains unclear as to whether the species has increased or decreased in abundance over the time period represented by these surveys, it appears likely that the species has increased in abundance at Kerr WMA, Wichita Mountains WR, Fort Sill and Fort Hood.

4.5 Population Genetics

For declining and isolated populations, maintenance of genetic variation is a serious concern because fragmented populations often lose their genetic diversity over time. Genetic variation is important in providing flexibility in response to changing environments (Allendorf and Leary 1986, Hedrick and Miller 1993) and depletion of genetic variation within a population is common in small populations due to random drift and founder events (Wright 1931, Allendorf 1983, Lande and Barrowclough 1987). At particularly low population levels, genetic loss may

[5] The most recent surveys at Fort Hood suggest a population in the range of 4,834 to 8,261 (95% Confidence Interval) males (Cimprich 2005) – these figures were based on density estimates derived from distance sampling methods in representative habitats. We used the more conservative numbers for Appendix A based on direct observations rather than the extrapolated estimates.

be accelerated through inbreeding (Gilpin and Soule 1986). Fragmentation of once-continuous habitat can result in a loss of genetic variation and an increase in population differentiation (Stangel et al. 1992), leading many species to experience population declines.

The BCVI Recovery Plan (USFWS 1991) recognized concerns about genetics as an important element of population viability analysis (Gilpin and Soule 1986, USFWS 1996). Such concern might be warranted considering the large distances that separate many of the known populations (i.e., Oklahoma and Mexico) from the Texas populations. In fact, the distances between some BCVI populations are greater than those observed among some subspecies of vireos (Avise et al. 1982, Johnson et al. 1988, Johnson 1995). Large geographic distances between BCVI populations may be a concern because there is no evidence to suggest that dispersal is occurring between such isolated populations. Most (96%) adult male (>1 year old) BCVI return to breed on the same territory as the previous year (Grzybowski 1995). Many females and yearling males disperse to new sites both within and between seasons, but the longest known movement was 10 km (Grzybowski 1995). This suggests that dispersal over very large distances between populations is most likely rare, although Grzybowksi (1995) suggested that juvenile dispersal may be considerably underestimated.

Recent efforts to characterize heterozygosity and population structuring in the BCVI found surprising variability, considering the apparent limited dispersal between isolated populations, within four geographically isolated populations (Wichita Mountains WR, Fort Hood Military Reservation, Kerr Wildlife Management Area, and Kickapoo Caverns State Natural Area) in Texas and Oklahoma (n= 72) (Fazio 1994, Fazio et al. 2004). Within-population heterozygosity was high (0.058) relative to other species within Vireonidae (0.023-0.056, Johnson et al. 1988) and comparable to the mean for birds (0.068, Ward et al. 1992). The highest heterozygosity was within the Wichita Mountains population (0.067), which is surprising considering its relative isolation and historically small size. Generally, for subpopulations that remain small over periods of 50 or more generations, substantial loss of heterozygosity is predicted (Allendorf 1986, Lacy 1987), but that does not appear to be case in this situation.

It has been suggested that the relatively high levels of heterozygosity and the BCVI association with successional habitats may suggest source-sink population dynamics and a metapopulation structure (Hanski and Gilpin 1991), with extinctions and recolonizations occurring in satellite groups within the Wichita Mountains (e.g., Fort Sill and Wichita Mountains WR) (Fazio et al. 2004).

There was significant differentiation between BCVI populations (mean θ=0.17; bootstrap 95% confidence interval 0.004-0.35), as one would expect for disjunct populations, but gene flow between populations appeared sufficient to maintain substantial within-group variation, perhaps due to dispersal by juveniles (Fazio et al. 2004). The authors found that patterns of gene flow suggested a long-term pattern of limited gene flow, at levels less than those observed for other migratory species (Rockwell and Barrowclough 1987). They concluded, nevertheless, that gene flow was sufficient among populations to overcome the effects of genetic drift (Slatkin 1985). It is unclear what patterns of gene flow exist within and among BCVI populations in southwestern Texas or in northern Mexico, as no genetics studies have been conducted at this time on those populations.

Greater genetic similarity was found between the Kickapoo Caverns and Kerr populations and between the Wichita Mountains and Fort Hood populations (Fazio et al. 2004). The authors suggested that if Wichita Mountains is acting as a sink, then it is likely that colonists may have come from populations at Fort Hood.

Table 4.1. Number of known black-capped vireos, based on the most recent surveys, within each of the recovery regions and in other areas of known occurrence. See Appendix A for detailed occurrence records.

Region	Known breeding population (males)
Texas Recovery region 1	2,110
Texas Recovery region 2	1,018
Texas Recovery region 3	149
Texas Recovery region 4	236
Texas (other)	2
Oklahoma	2,495
Mexico	259
Total	6,269

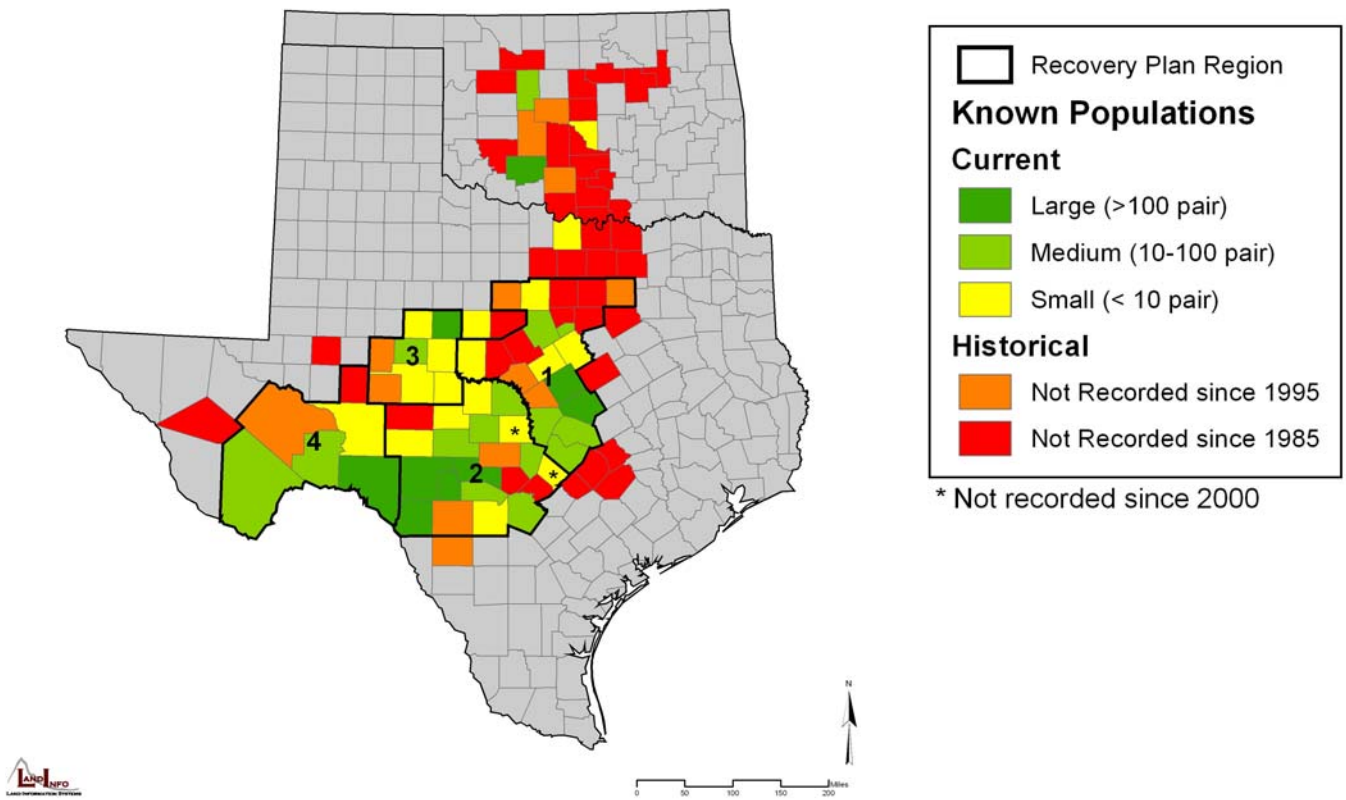

Figure 4.1. Current relative population sizes for known occurrences of black-capped vireos throughout the contiguous U.S. breeding range of the species, including areas where the species has been known to occur but has not been documented in the past 10 and 20 years, respectively. Relative population sizes by county are based on figures available in Appendix A. Note: the species breeding range in 3 states of Mexico are not included in this figure due to limited data from those states.

5.0 Analysis of Threats

5.1 Introduction

At time of listing, the major threats to the BCVI were identified as habitat loss through land use conversion, vegetation succession, grazing and browsing by domestic and wild herbivores, and brood parasitism by brown-headed cowbirds (Ratzlaff 1987). Using the resources identified by our review team and review panel, we have collected and reviewed the available information concerning these threats and attempted to address the ways they have changed since listing. In many cases, we depend on summary analyses of secondary data that provide an indirect assessment of the threat.

5.2 Habitat Conversion and Land Use Change

Habitat loss (through conversion, fragmentation and land use change) was a threat factor considered in the listing of the BCVI. At the time of listing, much of the concern focused on impending urban development in the greater Austin, Texas area (Shull 1986), where a large portion of the known population of the species was found.

Because there are no direct measures of the amounts and distribution of suitable habitat for the species, it is not possible to conduct a direct trend analysis for this threat factor. Other available data do not clearly indicate the rates of habitat loss from land use conversion. However, data on land use change and land ownership size distribution may be helpful in understanding some of the trends that might affect the species.

5.2.1 Land use

The proposed current U.S. breeding range of BCVI spreads across 98 counties in Texas and Oklahoma. This area comprises 68.8 million acres, about 80 percent of which was classified as farm and ranchland in 2002 (Table 5.1, USDA Agricultural Statistics Service). In the statistical accounting of the Agricultural Census, essentially all suitable habitat for BCVIs is likely classified as “rangeland.” According to the 2002 Agricultural Census, approximately 33.9 million acres of the U.S. breeding range was classified as rangeland (Table 5.1). In the Oklahoma portion of the breeding range, the area counted as farm and ranchland and that portion considered rangeland have remained relatively stable since 1992–in fact, the statistics suggest a slight increase in both over this period. In contrast, across the Texas portion of the breeding range, comparisons of the 1992 and 2002 Agricultural Census figures show a net loss of approximately 2.3 million acres of farm and ranchland and a net loss of 3.2 million acres of rangeland. This amounts to a 4.9 percent loss of farm and ranchland and an 8.6 percent loss of rangeland. This suggests that rangeland was lost not only because it was converted to uses other than farming and ranching, but also because it was converted to farm and ranchland (such as cropland or non-native pastures). This trend has reduced the overall area that would otherwise have been available for the development of suitable habitat across portions of the species' range in Texas. However, the amount of suitable breeding habitat actually lost to land use conversion is unknown.

5.2.2 Ownership fragmentation

As was the case with land use conversion, the trends in ownership fragmentation across the species' range in Oklahoma were quite different than those in Texas. In Texas, large ownerships (more than 2,000 acres) declined from 31.2 million acres in 1992 to 28.4 million acres in 2002–a net loss of 9.1 percent. In Oklahoma, where smaller ownerships were already prevalent across the region, there was actually an increase in larger ownerships (from 2.9 million acres to 3.3 million acres) over the same period (2002 USDA Census of Agriculture).

The total number of farm and ranch ownerships of less than 500 acres increased dramatically across the species' range in both states during the 1992-2002 period. In Texas, a 40 percent increase in such ownerships resulted in a net gain of 19,571 new farms and ranches. In Oklahoma, a 39 percent increase resulted in 6,026 new ownerships. Oklahoma's gain in the number of smaller farms and ranches was the product of fragmented mid-size ownerships (500 to 2,000 acres).

Although the relationship between ownership size distribution and wildlife habitat fragmentation is not entirely known, there is some evidence that the fragmentation of large farm and ranch ownerships (more than 2,000 acres) into smaller parcels may change land use and habitat patterns unfavorably for many species of wildlife (Wilkins et al. 2003, Kjelland et al. 2006). However, there are no studies directly implicating ownership fragmentation or its outcome as a conservation threat to BCVIs. While habitat loss from land use conversion can legitimately be considered a direct threat, the continued fragmentation of large land parcels might be considered an indirect threat simply because of the consequences associated with an increase in small ownerships. While the fragmentation and loss of larger ownerships might pose a challenge for maintaining large, intact areas of suitable habitat, new management styles on smaller ownerships may create suitable habitat for BCVIs. Many ranches in Texas have traditionally been managed for wildlife conservation, and BCVIs are now known to occur on several ranches. Some newer landowners also seem interested in management systems that could result in the development of suitable habitats for BCVIs (Sanders 2005).

Table 5.1 Area in farm and ranchland, and rangeland area, by state and BCVI recovery region, 2002 and change since 1992.

State[1]	Recovery region	Farm and ranchland			Rangeland		
		2002	Change since 1992		2002	Change since 1992	
		Area (acres)	Area (acres)	Percent	Area (acres)	Area (acres)	Percent
Texas	1. North-central Texas	8,801,998	-208,221	-2.3	5,147,140	-385,632	-7.0
	2. Edwards Plateau	12,142,910	-458,496	-3.6	9,934,658	-590,079	-5.6
	3. Concho Valley	4,641,999	-582,747	-11.2	3,408,370	-674,325	-16.5
	4. Southwest and Trans-Pecos	9,937,848	-1,176,238	-10.6	9,728,496	-1,217,865	-11.1
	Not in recovery region	9,720,610	106,116	1.1	5,691,449	-302,873	-5.1
Texas total		45,245,365	-2,319,586	-4.9	33,910,113	-3,170,774	-8.6
Oklahoma total		9,673,720	359,915	3.9	4,628,535	198,803	4.5
TOTAL		54,919,085	-1,959,671	-3.4	38,538,648	-2,971,971	-7.2

[1] Includes only those counties in the proposed current U.S. breeding range of the black-capped vireo.

5.3 Vegetation Change

"Vegetational succession" was listed as a major threat to the BCVI in the original listing document for the species (Ratzlaff 1987). In general terms, this vegetational succession is better described as an increase in the canopy cover and stature of woody vegetation. Black-capped vireos breed in shrubland and scrub habitat that, in many parts of the species' range, is considered mid- to early successional. Habitats within the BCVI range have changed substantially in the past century. Perhaps the most apparent change is the increased abundance of woody plants (Fuhlendorf and Smeins 1997). Increased stature and cover by woody vegetation often results in loss of breeding habitat suitability (USFWS 1991, Grzybowski 1995).

Here, we describe the threat posed by woody plant encroachment to BCVI habitat across a major portion of the species' breeding range in Texas and Oklahoma. We discuss various factors that contribute to such vegetational changes. Finally, to establish an index for determining the influence of vegetational changes on the BCVI, we examine abundance trends for a group of birds that prefer increased shrub and tree cover and discuss the implications of these findings.

5.3.1 Invasive woody plants

The increase in shrub and tree cover across arid and semi-arid rangelands in Texas and Oklahoma is well documented (Bogusch 1952, McPherson et al. 1988, Smeins and Merrill 1988, Archer 1990, McPherson and Wright 1990, Scanlan and Archer 1991, Snook 1985). Much of the increase can be attributed to the expansion of junipers (*Juniperus* spp.) beyond their historic range (Foster 1917, Tharp 1926, Fowler and Dunlap 1986, Ansley et al. 1995, Engle et al. 1995, Thurow and Thurow 1997, Thurow et al. 1997, Ueckert 1997). This encroachment by junipers corresponds with a period of more intensive livestock grazing and the suppression of fire (Archer 1994, Fuhlendorf et al. 1996, Smeins et al. 1997).

The Natural Resource Conservation Service's (NRCS) Texas State Technical Committee recognized that Ashe and redberry juniper (*J. smallii*) and (in some cases) honey mesquite (*Prosopis glandulosa*) had the potential to reduce the quality of BCVI habitats (USFWS 2004). According to some generalized mapping efforts, Ashe juniper is distributed across a minimum of approximately 18 million acres (Fig. 5.1), while redberry juniper (Fig. 5.2) and honey mesquite

(Fig. 5.3) are distributed across 10 and 58 million acres, respectively (USFWS 2004). All three of these species are native but considered invasive.

Ashe juniper is found mostly in the Edwards Plateau, and it is the invasive species with the most effect on BCVI habitats in the eastern two-thirds of the species' U.S. breeding range. Ashe juniper is most common in the eastern and southern portions of the Edwards Plateau, while redberry juniper is found in the northern and western portions (Lyons et al. 1998). The distribution of these two juniper species overlaps along the western margin of the BCVI's breeding range, and in some of those areas redberry juniper is the primary invasive species.

In the absence of fire, grazing or similar disturbance, junipers can out-compete native grasses and change the structural characteristics of native rangelands (Arend 1950, Archer 1994, Ansley et al. 1995). In the higher rainfall areas of the eastern Edwards Plateau and across parts of the Rolling Plains, invading juniper can develop into dense stands that are generally unsuitable for BCVIs (Keddy-Hector 1992). In the drier portions of the western Edwards Plateau, however, many areas have remained relatively free of juniper and, where there are other preferred brush species, BCVIs remain unaffected by juniper invasion (Keddy-Hector 1992).

Fire can help control both Ashe and redberry juniper. Ashe juniper does not sprout after disturbance and is easily killed by fire if the entire shrub or tree is consumed (Fonteyn et al. 1988), while redberry juniper does re-sprout from the roots. Thus, suppressing fire contributes to invasion by these species (Fuhlendorf et al. 1996, U.S. Fish and Wildlife Service 1996, Lyons et al. 1998). Overgrazing combined with extended drought is also a factor in juniper invasion (Lyons et al. 1998, McPherson et al. 1988). Both redberry and Ashe juniper are phreatophytes, meaning that they can develop deep root systems and exist on water from a permanent ground supply or the water table. This allows them to out-compete other woody species during times of drought.

Honey mesquite has also increased on much of the south Texas brushlands, the Rolling Plains and other semi-arid rangelands (USFWS 2004), making these areas less suitable for many grassland bird species (Magness 2003). Honey mesquite is native to parts of Texas and has increased in abundance and density within its historic range, rather than expanding its geographic range (Tharp 1926, Bogusch 1952, Johnston 1963). Honey mesquite may affect BCVI habitat in some portions of the breeding range, but it has not received (nor deserved) as much attention as juniper.

In Oklahoma, eastern redcedar (*J. virginiana*) is widespread and has degraded BCVI habitat across much of its range (Graber 1957, Penfound 1968, Hayden and Tazik 1991, Greenman 1995), with the possible exception of the most southwestern and panhandle counties (Crockett 1985). The acreage of eastern redcedar in Oklahoma was estimated to have increased by 141 percent between 1950 and 1985, to a total of 3.54 million acres (Snook 1985).

As is the case with juniper in Texas, the suppression of fire in Oklahoma is a primary contributor to invasion by eastern redcedar (U.S. Fish and Wildlife Service 1996). Without fire, eastern redcedar invades aggressively (Arend 1950, Blan 1970, Blewett 1986, Stritzke and Bidwell 1990); after burns, there are far fewer of the plants (Penfound 1969, Rollins 1985, Greenman 1995). Much of the BCVI's former range in west-central Oklahoma is now substantially covered in eastern redcedar, as are large areas of north-central and central Texas (Grzybowski 1995). Modelling studies have estimated that at the current rate of expansion in Oklahoma, juniper species will overrun substantial areas of remnant grassland over the next 10 years (Coppedge et al. 2004).

5.3.2 Influence of fire

Fire can help maintain suitable successional stages of vegetation for the development of breeding habitats (Ratzlaff 1987). As a consequence, BCVIs are often found in areas where fires have recently occurred, and the highest BCVI concentrations typically occur in areas recovering from hot fires (Graber 1957, Marshall et al. 1985, Grzybowski et al. 1994). With the proper burning conditions, fires can kill or retard invading junipers and favor the regrowth of fire-adapted oak and sumac species. This produces areas of dense foliage at the low level required by BCVIs (USFWS 1991, Campbell 1995, Grzybowski 1995).

Throughout much of the species' U.S. range, the appropriate successional stages for nesting habitat were historically maintained by fire. Therefore, fire suppression is considered to be an indirect cause of habitat loss (Grzybowski 1995, Gehlbach 1988, Smeins and Merrill 1988). Fire suppression, in combination with heavy grazing and browsing, can transform a mixed-oak savanna into oak woodland with dense under-story and mid-story juniper (Fonteyn et al. 1988), making it unsuitable as nesting habitat for BCVIs (Marshall et al. 1985). Although this dynamic is important in the eastern portion of the species' U.S. breeding range, there are portions of the breeding range in southwestern Texas and in Mexico where disturbance by fire is substantially less important in maintaining suitable habitat structure (Farquhar and Gonzalez 2005).

Several studies have addressed the beneficial effects of fire on BCVI habitat and populations. Black-capped vireos fully recolonized burned areas by the second year following a burn at Wichita Mountains WR (Grzybowski 1989, Grzybowski 1990a); results from Fort Hood, Texas suggested a similar interval (Tazik et al. 1993). A more recent study at Kerr WMA found that 53.8 percent of winter-season prescribed burns resulted in increased BCVI numbers within the same year as the burn, and that 92.1 percent of the burns produced larger numbers of BCVIs within 2 years of the burn (Dufault 2004).

Some wildfires have also provided opportunities for monitoring post-burn re-occupancy. One example occurred at Fort Hood, where crown fires burned 4,015 ha (9,917 acres) in February 1996, including 508 ha (1,255 acres) of BCVI habitat (Goering 1998, Hayden et al. 1999). On areas that were burned, BCVI numbers have increased with time, while remaining relatively constant on unburned areas of the base (Cimprich 2002). The unequivocal and substantial effect of fire on BCVI breeding habitat cannot be ignored. The social, legal and political constraints to using prescribed burning as a management tool are, in fact, a concern for the species.

5.3.3 Trends in woodland birds as an index of vegetation change.

Birds that depend on grassland and savanna habitats appear to be declining more than any other North American avian group (Askins 1993, Peterjohn and Sauer 1999). Across the southern Great Plains, the invasion of woody plants has been implicated as a significant factor in this trend (Brennan and Kuvlesky 2005). A general increase in woodland habitats could result in a region-wide shift in breeding bird assemblages with a greater representation by those species that prefer wooded habitats. While the BCVI is not a grassland obligate per se, its preference for short-stature shrubland and scrub means that a general increase in woodland habitats would likely result in loss of suitable breeding habitat. To gain an index for such a change within the specific U.S. breeding range of the BCVI, we analyzed trends for bird species known to commonly use shrubland and woodland habitats. The species selected were the white-eyed vireo (*V. griseus*), blue-gray gnatcatcher (*Polioptila caerulea*), Bell's vireo (*V. bellii*), painted bunting

(*Passerina ciris)*, and yellow-breasted chat (*Icteria virens*)[6]. These species characteristically inhabit denser stands of scrub and thickets than do BCVIs (Ehrlich et al. 1988).

While these species commonly use habitat that is also used by BCVI, they also use habitats with woody vegetation developed beyond the point of suitability for BCVI breeding. For instance, white-eyed vireos tend to select habitats in large woodland patches (Rodewald and Vitz 2005) and with dense shrubs (Annand and Thompson 1997). At study sites in Hamilton and Coryell Counties, Texas, the sites occupied by white-eyed vireos had significantly ($P \leq 0.05$) more woody vegetation than unoccupied sites (Juarez 2004). In Bandera, Real, Kerr, Uvalde and Medina Counties, Texas, sites occupied by white-eyed vireos also had significantly ($P<0.05$) more juniper cover, at both the local and landscape scales, than unoccupied sites (Magness 2003). In the same counties, sites occupied by blue-gray gnatcatchers also had significantly ($P<0.05$) more juniper cover at the landscape scale than unoccupied sites (Magness 2003). Other research in juniper-dominated landscapes has shown that breeding blue-gray gnatcatchers select habitats with the most shrub cover (Pavlacky and Anderson 2001). Bell's vireos prefer habitat with dense shrub layers (Goldwasser 1981, Franzreb 1989b, Brown 1993). At sites across the Concho Valley (in Reagan, Tom Green, Irion and Schleicher Counties, Texas), habitat occupied by painted buntings had significantly ($P<0.05$) more juniper and mesquite cover than unoccupied sites (Magness 2003). In Oklahoma, painted buntings were generally more abundant where there was more closed forest than open country (Brennan and Schnell 2005), and it has been predicted that painted buntings will increase in abundance in Oklahoma with continued juniper encroachment (Coppedge et al. 2004). Yellow-breasted chats are often more abundant, and are more likely to nest, in shrubby patches that are conspicuously large and dense (Annand and Thompson 1997, Burhans and Thompson 1999, Woodward et al. 2001, Rodewald and Vitz 2005).

We used data from the USGS North American Breeding Bird Survey (BBS). The BBS data is useful for examining geographic patterns of abundance and population change over the breeding range of a species or suite of species (Sauer and Droege 1992, Maurer and Villard

[6] Species were chosen in consultation with the review panel to represent species known to use habitats of greater woodland cover than that generally used by BCVIs.

1994, James et al. 1996).[7] There are currently 217 BBS routes in Texas and 70 routes in Oklahoma (Fig. 5.4)[8]. We confined analysis to only those routes within the recent breeding range of BCVIs in Texas and Oklahoma (Fig 5.4) and used only the best quality data available (i.e., "Type 1," as designated by the U.S. Geological Survey Patuxent Wildlife Research Center). We also followed route selection criteria, as described by James et al. (1996), considering the data only from those routes that maintained a fairly consistent level of operation, and omitting routes that were run sporadically, were discontinued, or were run consistently only recently. Thus, for displaying trends, we selected routes only if they 1) had been surveyed eight or more times and 2) had been surveyed at least once in each of the four periods 1966-1975, 1976-1987, 1988-1994 and 1995-2004. We also used paired t-tests to make comparisons between periods (James et al. 1986).[9] Thus, the division of data into these specific periods was intended to provide a primary comparison between the 10-year period prior to BCVI listing and the most recent 10-year period for which data is available. For use in these paired comparisons, we only considered routes that were in operation for at least 5 years during any of the periods being compared.

While the overall population trends for these five species are variable (Figs. 5.5 to 5.9), they do tend to have a single common feature – all five species appear to have increased in relative abundance in the 10-year period ending in 2004. For the white-eyed vireo (Fig. 5.5), the average observations per route for the 10-year period ending 2004 was approximately 4-fold higher than that for any other prior period (P<0.01). For the blue-gray gnatcatcher (Fig 5.6), relative abundance increased in the 10-year period ending 2004 when compared to both 10-year periods before to the 1987 listing of black-capped vireos (P<0.05). For the yellow-breasted chat, while mean observations per route remained relatively low, the 10-year average for the period ending 2004 was higher than that of the prior seven years (1988-1995, P<0.10) but was

[7] BBS data are collected by observers along pre-defined 40-km routes. Observers stop every 0.8 km to record all birds seen or heard during a 3-minute period. Not all routes are regularly surveyed, and these data often have gaps because of poor weather, improper timing of survey, etc. Nevertheless, for the purposes of examining trends across space and time, BBS data can be useful.

[8] There are no data for these species in the breeding range of the BCVI in Mexico.

[9] The data represent number of observations per route for each species during each year that a route was surveyed. For statistical comparisons, these observations were square-root transformed to stabilize variance per James et al. (1986).

statistically indifferent from that observed in previous periods. For Bell's vireo (Fig. 5.8) and painted buntings (Fig. 5.9), the pattern suggests a decrease during the seven-years immediately following the BCVI's listing ($P<0.05$), followed by an increase in relative abundance during the final 10-year period ($P<0.05$).

It is also notable that cowbird abundance is known to decrease significantly with increasing forest cover and increase with increasing edge density (meters per hectare) (Donovan et al. 2000, Thompson et al. 2000). Magness (2003) found, at the local and landscape scales, that sites brown-headed cowbirds occupied had significantly ($P<0.05$) less juniper cover than unoccupied sites in Bandera, Real, Kerr, Uvalde and Medina Counties, Texas. Similarly, Juarez (2004) found that the sites cowbirds occupied had significantly ($P\leq0.01$) less woody vegetation and significantly ($P\leq0.01$) less juniper cover than unoccupied sites in Hamilton and Coryell Counties, Texas. The declining number of cowbirds across the BCVI range (see Section 5.5 on Brood Parasitism) further suggests that vegetation changes may be influencing avifauna at a regional scale – and the implications for BCVI might be confounded by the impacts.

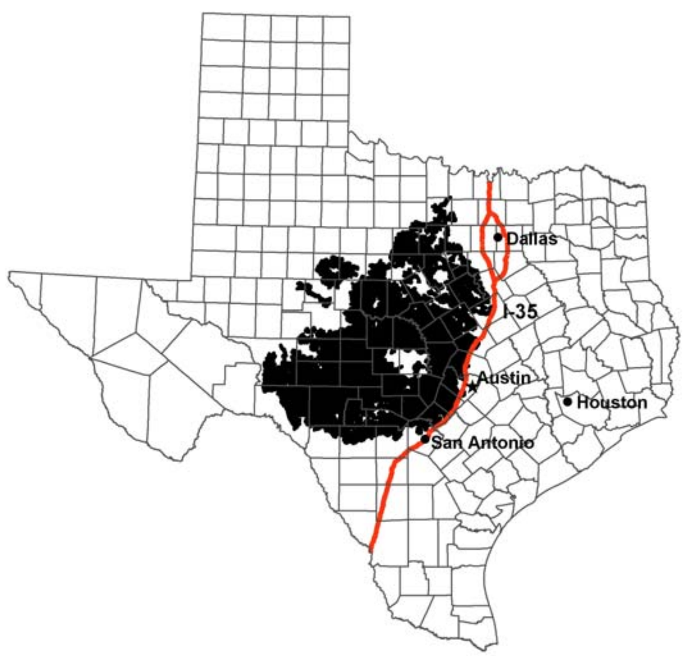

Figure 5.1. Distribution of Ashe juniper in Texas.

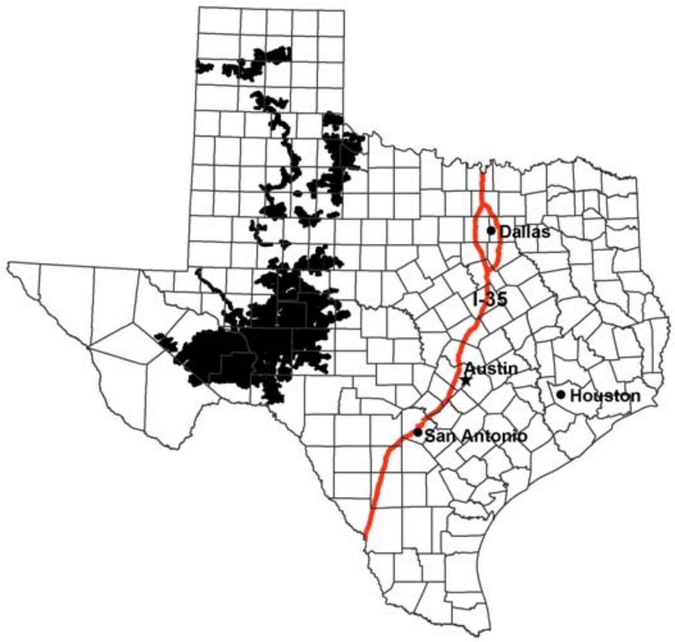

Figure 5.2. Distribution of redberry juniper in Texas.

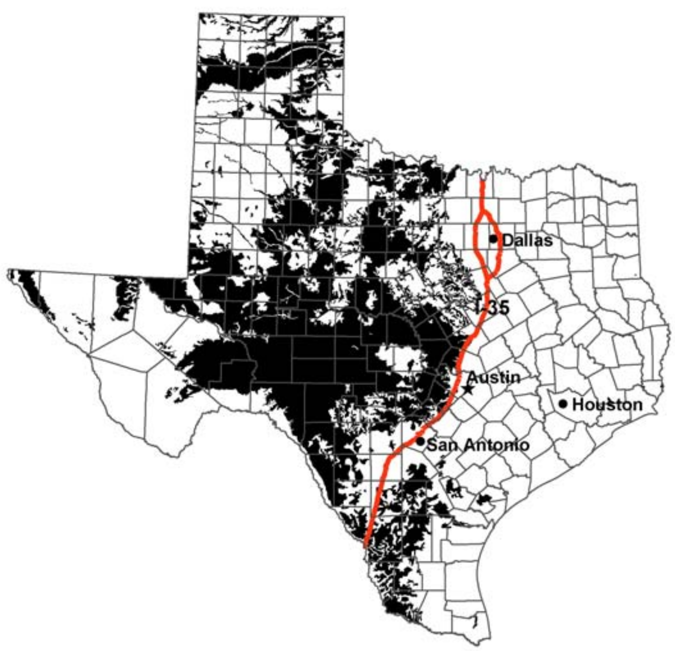

Figure 5.3. Distribution of honey mesquite in Texas.

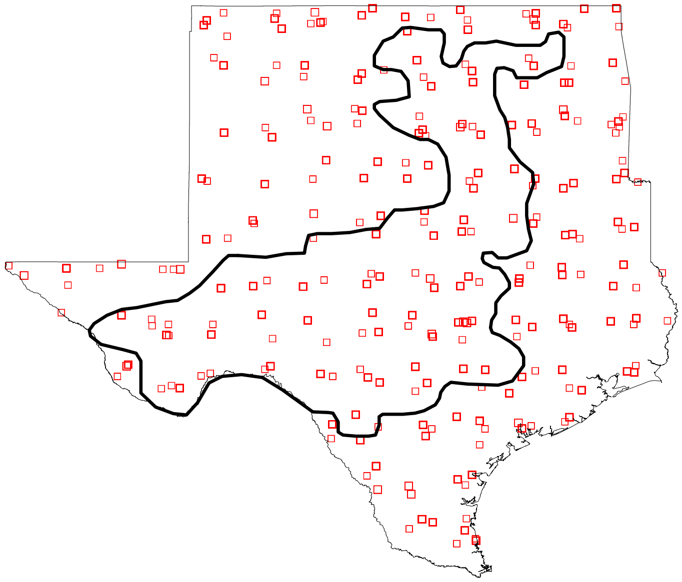

Figure 5.4. Approximate center-points for 287 Breeding Bird Survey routes across Texas and Oklahoma. The thicker black line represents the current estimated U.S. breeding range of black-capped vireos.

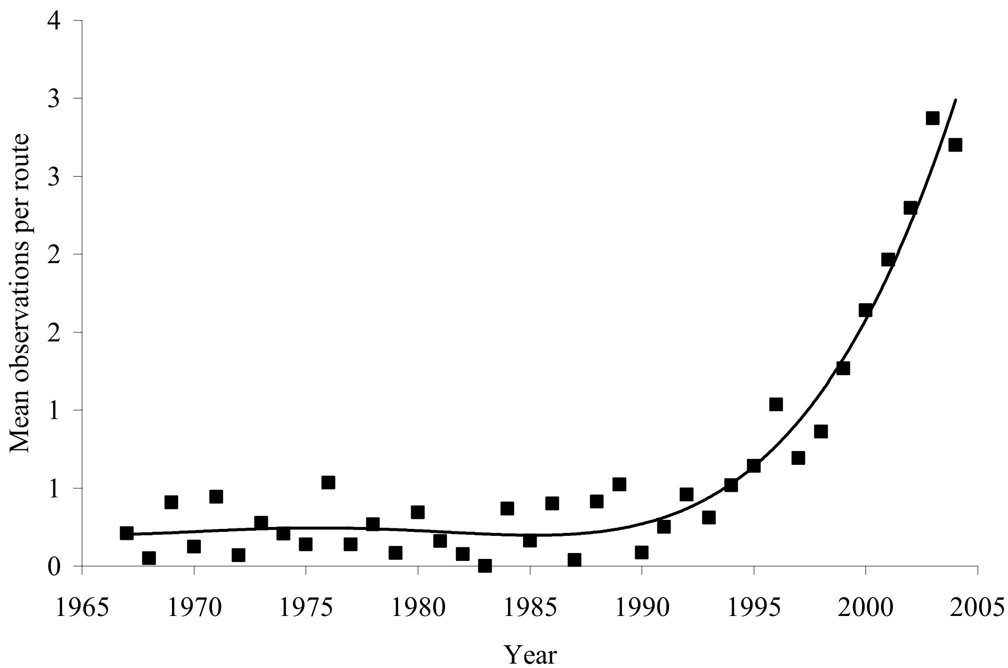

Figure 5.5. Relative abundance for the white-eyed vireo in the breeding range of the black-capped vireo in Texas and Oklahoma, 1967-2004. Data Source: Sauer et al. (2005).

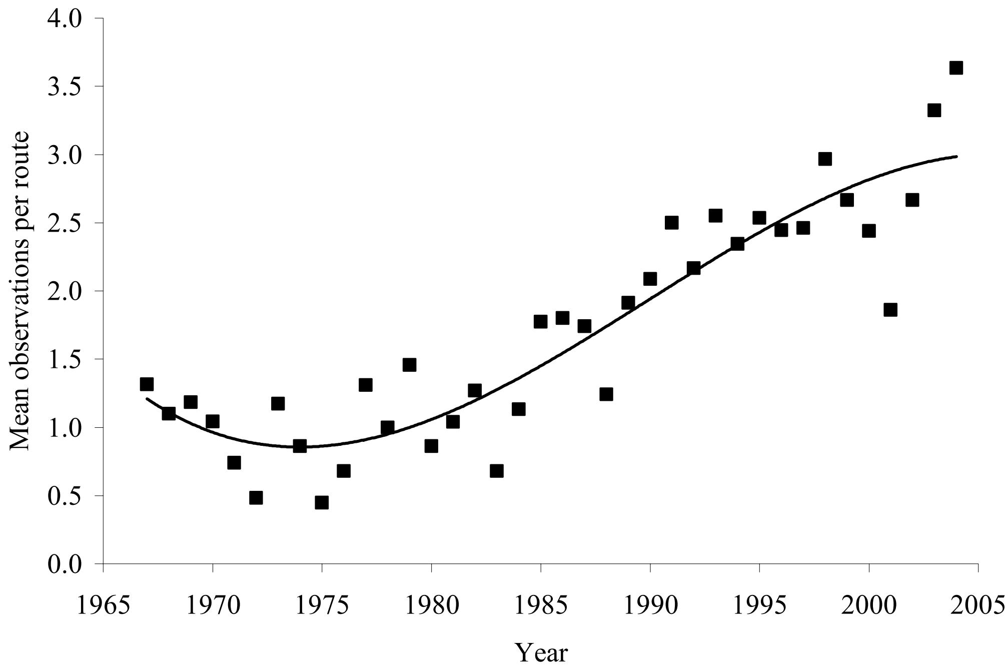

Figure 5.6. Relative abundance for the blue-gray gnatcatcher in the breeding range of the black-capped vireo in Texas and Oklahoma, 1967-2004. Data Source: Sauer et al. (2005).

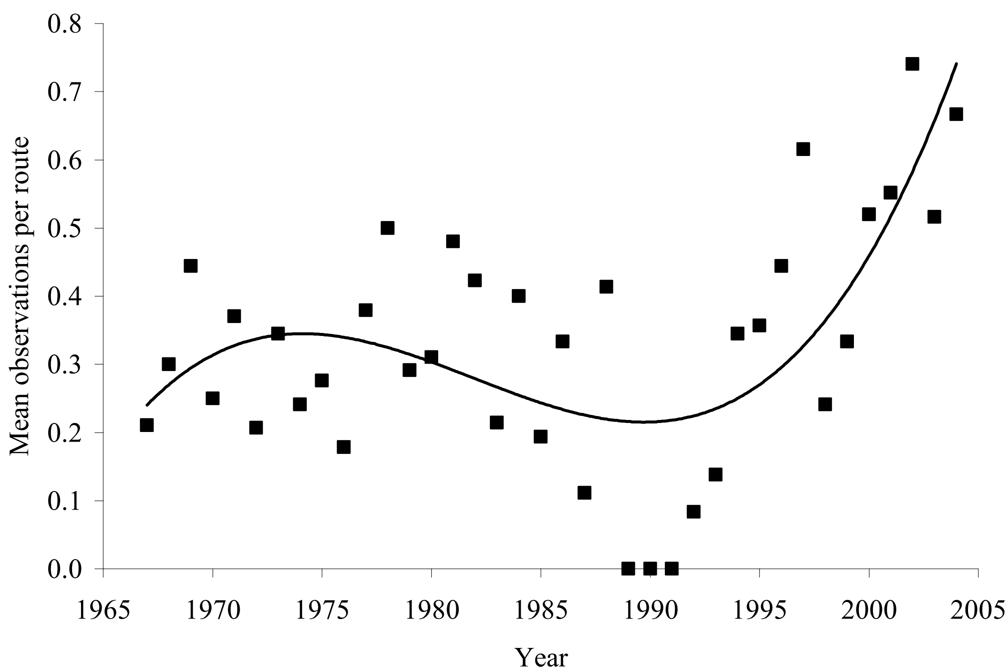

Figure 5.7. Relative abundance for the yellow-breasted chat in the breeding range of the black-capped vireo in Texas and Oklahoma, 1967-2004. Data Source: Sauer et al. (2005).

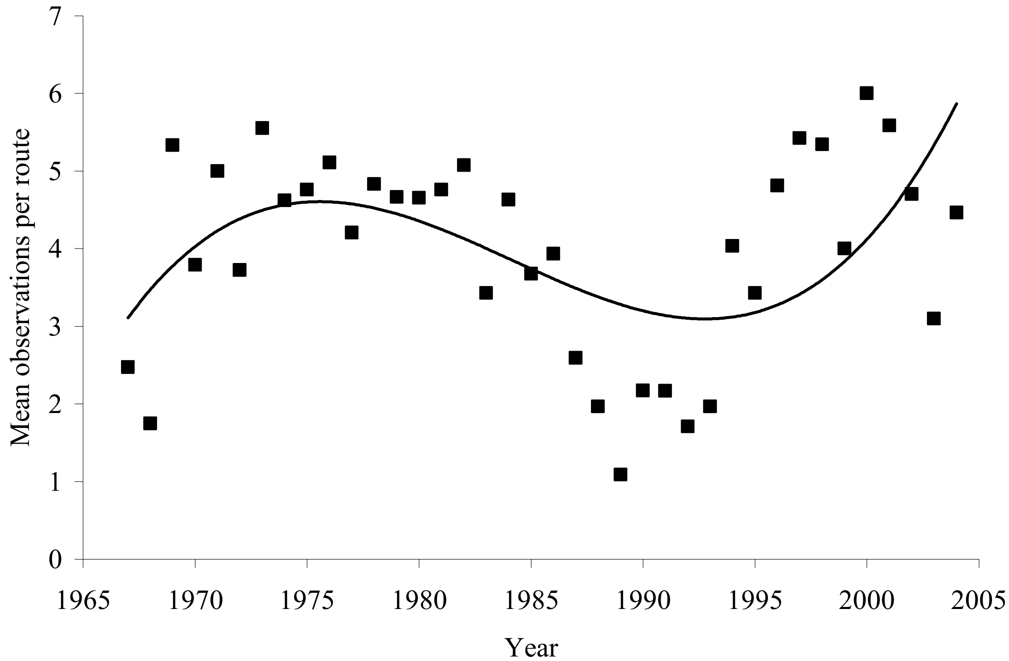

Figure 5.8. Relative abundance for Bell's vireo in the breeding range of the black-capped vireo in Texas and Oklahoma, 1967-2004. Data Source: Sauer et al. (2005).

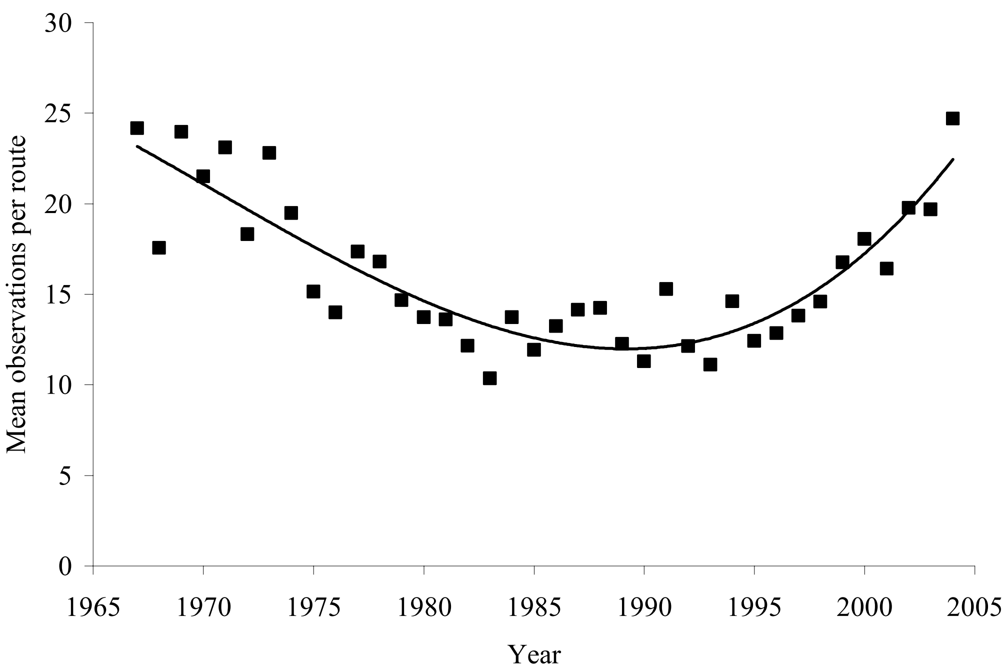

Figure 5.9. Relative abundance for the painted bunting in the breeding range of the black-capped vireo in Texas and Oklahoma, 1967-2004. Data Source: Sauer et al. (2005).

5.4 Grazing and Browsing

The grazing of cattle, sheep, goats and other herbivores was said to be one of the primary threats to the BCVI in the original listing of the species as endangered (Ratzlaff 1987). Overgrazing, particularly by browsers, typically removes vegetation at the heights needed by BCVIs (Grzybowski 1995). Before the listing it was determined that intensive grazing, primarily by goats and sheep in many areas of the Edwards Plateau of Texas, had reduced the habitat available to BCVIs (Grzybowski 1995). The association between brown-headed cowbirds and concentrations of cattle (Lowther 1993, Ortega 1998) may have compounded the threat of grazing to BCVIs.

Here, we provide an overview of the threat of overgrazing to BCVIs across their breeding range. We present background information on the effects of grazing on vegetation communities and passerine birds, discuss known effects on BCVIs in particular, then examine trends in cattle and goat densities, as well as deer numbers, across the range of the BCVI and discuss the implications of these findings.

5.4.1 Grazing on native rangelands

Grazing by domestic livestock is the principal economic use of native rangelands in the western United States (Platts 1991, Lauenroth et al. 1994). Throughout the BCVI's breeding range in Texas, Oklahoma and northern Mexico, more than 80 percent of the native rangeland is privately owned and is managed primarily as grazingland.

Drought, fire and grazing are the major ecological forces that have historically maintained this area of the southern Great Plains (Sauer 1950, Stebbins 1981, Anderson 1982). Many grassland systems are vulnerable to invasions by woody plants, and climate alone cannot sustain them as grasslands (Sauer 1950). Historically, wildfires retarded or reversed invasions by trees or shrubs, and the grazing of bison and other hooved ungulates also maintained the disturbance pattern that created the habitats upon which grassland birds ultimately depended (Askins 2000, Brennan and Kuvlesky 2005).

While fire once may have been the most important ecological factor in maintaining the grasslands, (Gibson and Hulbert 1987), the introduction of domestic livestock and the development of the ranching enterprise have increased the importance of grazing in determining the nature of these grasslands (Saab et al. 1995).

The pressures of high stocking rates in confined pastures can degrade rangeland habitat over time (Brennan and Kuvlesky 2005). Overgrazing can create conditions that not only preclude fire but facilitate the dispersal and establishment of woody invaders (Risser et al. 1981, Bock and Bock 1987, Humphrey 1987, Steinauer and Bragg 1987, Bock and Bock 1988, Archer 1989). Habitat degradation can be particularly severe where native grazers were historically scarce or absent (e.g., Mack and Thompson 1982, Milchunas et al. 1988, Schlesinger et al. 1990). However, when the grazing of domestic livestock is well-managed, it can be used to improve rangeland habitat for wildlife by simulating historic grazing pressures and patterns (Severson and Urness 1994).

5.4.2 Effect of grazing on grassland birds

Saab et al. (1995) made a comprehensive review of the literature on the effects of grazing on grassland birds. Of 68 species of neotropical migrants in western habitats, 46 percent decreased in abundance with cattle grazing, 29 percent increased, and 25 percent showed no clear response (Saab et al. 1995). A study of 61 riparian bird species in Arizona showed that 53 percent decreased in abundance with cattle grazing, 8 percent increased, and 39 percent showed no clear response (Krueper et al. 2003). In another review, 63 percent of riparian bird species were found to be less abundant in grazed locations, while none were less abundant in ungrazed locations (Tewksbury et al. 2002). While more species respond negatively to grazing than respond positively, there is some variability in the responses, so an analysis of the effect of grazing on neotropical migratory birds must be both habitat-specific and species-specific, and based on field data (Saab et al. 1995).

Rather than responding directly to the presence of livestock, grassland birds usually respond to the effect of grazing and browsing on vegetation (Bock and Webb 1984). Livestock trample plants, may remove some plants entirely, and can cause soil compaction, all of which can change vegetation structure, plant species composition, and vegetation density (Branson 1985, Holechek et al. 1989, Vavra et al. 1994). It is to these structural and floristic alterations that some breeding birds are known to positively or negatively respond (Saab et al. 1995). Birds are affected by habitat structure, floristics and vegetation volume (Willson 1974, James and Wamer 1982, Cody 1985, Mills et al. 1991). Vegetation structure, in particular, is critical to habitat selection and to the productivity of bird species in the grasslands of the central United States (Johnson and Schwartz 1993, McCoy et al. 2001).

Scott et al. (2003) showed that long-term grazing was correlated with a less complex habitat structure and, as a result, with less diverse and abundant populations of 17 bird species in a riparian area in Montana. Long-term overgrazing by livestock can alter vegetation succession by simplifying vegetation structure and composition (Knopf and Cannon 1982, Kauffman and Krueger 1984, Taylor 1986, Schultz and Leininger 1990). This is important because the structural complexity and volume of habitat can influence avian abundance and composition (MacArthur et al. 1962, Willson 1974, James and Wamer 1982, Cody 1985, Mills et al. 1991). Other studies also have demonstrated the negative correlation of grazing pressure with avian abundance and diversity (Kirsch et al. 1978, Taylor 1986, Bock et al. 1993, Ammon and Stacey 1997, Dobkin et al. 1998, Belanger and Picard 1999).

The reduced vegetation density that results from overgrazing has been correlated with increased predation rates on breeding birds (Wray and Whitmore 1979, Johnson and Temple 1990, Clark and Nudds 1991, Riley et al. 1992). Vegetation density is an important predictor of nest predation rates in birds (Bowman and Harris 1980, Martin and Roper 1988), and grazing itself has been associated with higher nest predation rates (Ammon and Stacey 1997).

Grazing is also thought to promote parasitism by brown-headed cowbirds, because the presence of livestock influences cowbird distribution (Lowther 1993, Ortega 1998, Goguen and Mathews 1999, Mayfield 1965; also, see Section 5.5 on Brood Parasitism). Cowbirds are associated with livestock primarily because grazing creates foraging areas for cowbirds (Friedmann 1929, Mayfield, Morris and Thompson 1998). A study of plumbeous vireos (*V. plumbeus*) in New Mexico found that cowbird abundance, brood parasitism of vireo nests (n=182), and nests lost to parasitism declined significantly with distance from livestock grazing, regardless of host density or habitat type (Goguen and Mathews 2000).

Overgrazing by cattle can lead to woody plant encroachment into grasslands because it reduces the amount of fuel available for fires (Brown and Archer 1989, Engle et al. 1995) and because cattle effectively disperse the seeds of invasive plants such as juniper (Brown and Archer 1987, Brown and Carter 1998; see Section 5.3 on Vegetation Change).

Grassland birds are decreasing in number more than any other North American avian group (Askins 1993), which is thought to be due to the loss and degradation of grassland habitats

(Knopf 1994, Herkert 1995, Peterjohn and Sauer 1999, Vickery et al. 1999), as well as to fragmentation of habitat patches (Johnson and Igl 2001, Herkert et al. 2003; see Section 5.2 on Habitat Conversion and Land Use Change). While the relative importance of grazing, versus other factors, in the decline of grassland birds is not entirely clear (Clark and Nudds 1991, Knopf 1994), overgrazing practices have been implicated as a primary threat (Saab et al. 1995), as has the invasion of woody plants that often results from overgrazing (Brennan and Kuvlesky 2005).

5.4.3 Overgrazing as a threat to black-capped vireos

There is little quantitative information on the relationships between BCVI populations and a) grazing, b) grazing intensity, and c) types of grazers. But there are comments in the literature suggesting that long-term, intensive grazing is associated with reduced BCVI populations.

Direct effects of grazing and browsing. Black-capped vireos typically construct nests 0.5 to 2.0 m off the ground (range 0.2 to 3.0 m, median 1.0 m) in shrubs or brush mottes where woody vegetation grows close to ground level (Grzybowski 1986, Campbell 1995, Grzybowski 1995). Overbrowsing by goats and white-tailed deer (*Odocoileus virginianus*) removes the low vegetation BCVIs need for nesting (Marshall et al. 1985, Rust and Tazik 1990, Grzybowski 1995), and there is evidence that species that prefer nest sites within 2.5 m of the ground are less abundant when habitat is overbrowsed (Tewksbury et al. 2002).

Early reports suggested that overbrowsing by goats, free-ranging exotic ungulates and white-tailed deer had reduced the habitat available for BCVIs (Graber 1961, Webster 1962). Marshall et al. (1985) stated that one of the major threats to the BCVI was "grazing by sheep, goats, and other exotic herbivores over vast areas of the Edwards Plateau and westward." Grzybowski (1995) stated that "many areas of the Edwards Plateau are seriously overgrazed by goats and sheep, which remove much potential habitat for use by black-capped vireos." In the Black-capped Vireo Population and Habitat Viability Assessment Report (USFWS 1996), it was also stated that overbrowsing by sheep, goats and native and exotic wildlife has led to loss of BCVI habitat.

In the Edwards Plateau, goats were specifically implicated in the loss of BCVI breeding habitats. At the time of listing, the Edwards Plateau was the "Angora goat capital of the world," and according to Marshall et al (1985), there was clear evidence of heavy grazing, trampling and browsing across that region. In a report from Camp Bullis in Bexar and Comal Counties, Shaw et al. (1989) suggested that cattle grazing had little impact on BCVIs, aside from attracting cowbirds, but that grazing by goats was detrimental because they browsed the low hardwood foliage BCVIs use for nesting.

Research at Kerr WMA shows that like white-tailed deer, exotic ungulates prefer green forbs and browse when available (Traweek and Welch 1992). Unlike white-tailed deer, however, many exotic ungulates can shift their diets to grasses when forbs and browse are unavailable, which allows them to compete with domestic goats and, to a lesser extent, with sheep and cattle (Traweek and Welch 1992). As a result, exotic ungulates are likely to have an effect on BCVI habitat similar to that of goats in areas where exotics are increasing and goat numbers are on the decline. When confined within high fences, many exotic species, including axis deer (*Cervus axis*), sika deer (*Cervus nippon)* and blackbuck (*Antilopa cervicapra),* can out-compete white-tailed deer (Traweek and Welch 1992).

While overgrazing and overbrowsing are clearly implicated as a major cause of the loss of BCVI habitat, there is evidence to suggest that the effects are reversible once the overuse ends. For example, at Dobbs Mountain Ranch in Edwards County (in the southwestern Edwards Plateau), Maresh (2004) reported that a history of heavy use by livestock, especially goats, had seriously harmed BCVI habitat. As compared to areas left ungrazed, the overgrazed habitat differed in both structure and composition (Maresh 2003, Maresh 2005a). In areas not subjected to overuse, stands of low-growing shrubs developed substantial foliage in the 0 to 2 m height range, and all known BCVI nests were in these areas before grazing pressure was relieved in the other areas (Maresh 2004). After livestock were removed, the overgrazed sites recovered, there was more vegetation in the 0 to 2 m height range as the browse line diminished, and ground cover increased as grass, forbs and woody species began to re-establish themselves (Maresh 2005a). As a result, the number of breeding BCVI territories in these formerly grazed areas increased from one to seven over a 4-year period (Maresh 2004). Likewise, Sparkman (1996) described habitat that was once grazed heavily by cattle, goats and sheep; once livestock were removed and the area was under less intense browsing pressure by deer, the regrowth of shrubs made it suitable as BCVI breeding habitat.

Indirect effects of grazing and browsing. Overgrazing can cause changes in the vegetation community that indirectly influence the suitability of habitats for use by BCVIs.

Overgrazing may reduce grass cover to the point that prescribed burning is no longer possible and woody cover can develop to the point where habitat is no longer suitable for BCVI (USFWS 1996). In some situations, overgrazing may allow grasslands historically dominated by native warm-season grasses such as little bluestem (*Schizachyrium scoparium*) and indiangrass (*Sorghastrum nutans*) to be overtaken by cool-season grasses such as Texas winter grass (*Stipa leucotrichia*) and prairie dropseed (*Sporobolus asper*). This reduces the fine fuel needed to carry a fire (Tazik et al. 1990).

Another indirect effect is that the presence of cattle may encourage use by brown-headed cowbirds. Research at Fort Hood in Coryell and Bell Counties, Texas suggests a relationship between cattle grazing intensity and cowbird parasitism on BCVI nests (Koloszar and Horne 2000, Kostecke et al. 2003). The number of cattle grazing in one area (9,622 ha) of the base was reduced by 86 percent (from 752 animal units in 1995-1996 to 103 animal units in 1997-1998) while cowbird trapping was being curtailed, to monitor changes in cowbird-BCVI dynamics. After the reduction in stocking rates, cowbirds shifted their foraging to sites where more cattle were present, so that the reported cowbird parasitism rates were 13 times lower than before the number of cattle was reduced. But despite the lower parasitism rates, reducing the cattle stocking rate shifted only the female cowbirds' feeding areas, not their breeding areas. Cowbirds are known to regularly commute up to 7 to 15 km daily (Rothstein et al. 1984, Thompson 1994, Gates and Evans 1998, Curson et al. 2000). Cowbirds appear to be largely regulated by the density and locations of feeding areas (Chace et al. 2005).

The Fort Hood study further suggested that manipulating cattle grazing would be effective only if carried out on a large scale and in the absence of alternative foraging sites for cowbirds (Kostecke et al. 2003). Even with the removal of cattle from certain areas of Fort Hood, there are still ample foraging sites for cowbirds outside the base, considering the rapid urban sprawl in the Texas hill country (Kostecke et al. 2005, Ortega et al. 2005). Nevertheless, there is evidence to suggest that forcing cowbirds to commute longer distances between breeding and foraging sites may reduce parasitism by lowering the fecundity of individual cowbirds (Chace et al. 2005). Cowbirds that commute long distances produce fewer eggs than cowbirds that commute shorter distances and are, therefore, less threatening to BCVIs (Curson and Mathews 2003).

A study at Camp Bullis in Bexar and Comal Counties in central Texas found little parasitism on BCVI nests and suggested that this was because the cattle stocking rate was low, the cattle were free-ranging, and there was no supplemental feeding program that would lure large numbers of cowbirds (Rust and Tazik 1990). However, cowbird parasitism on BCVIs can be relatively high even when there are few or no cattle. For example, at Fort Sill, Oklahoma, where there are no cattle, cowbird parasitism on BCVI nests (before cowbird trapping) was 40 to 50 percent. At nearby Wichita Mountains WR, where cattle and buffalo are present in relatively low numbers, BCVIs were parasitized by cowbirds at rates of 60 to 70 percent (Tazik 1991a).

Some grazing may be compatible with the development and conservation of BCVI habitat as it helps maintain the habitat in an early successional stage. For example, when cattle were removed from some areas of Hill Country State Natural Area in Bandera and Medina Counties, Texas, Sparkman (1996) observed that the resulting successional advancement appeared to contribute to some habitats becoming unsuitable for BCVIs. Grazing by cattle and browsing by white-tailed deer are typically less destructive to BCVI habitat than is grazing by goats and other non-native animals (Guilfoyle 2002).

5.4.4 Trends in livestock numbers

Inasmuch as the effect of overgrazing and overbrowsing by domestic livestock was considered to be a major threat to the species at the time of listing, it is necessary to assess the overall change in livestock numbers since that time to determine whether this threat has increased or decreased. We compared goat and cattle numbers from the USDA Census of Agriculture in 1987 (the year of listing) to the same numbers in 2002, the most recent year for which county-level data are available (2002).

Trends in goat numbers[10] Over the entire Texas and Oklahoma range of the BCVI, there was a 19.1 percent decrease in goat numbers between 1987 and 2002 (Table 5.2). There is a dramatic difference, however, between the two states. Texas had a 22.6 percent decrease in goat numbers, while Oklahoma had a 277.2 percent increase in goat numbers during the same time

[10] Unless otherwise noted, the livestock inventories cited here are from the county-level statistics of the USDA Census of Agriculture for the respective years analyzed. These agricultural statistics are available in 5-year intervals. Tables 5.2 and 5.3 present data from 1982 through 2002, but for analytical purposes, we compared only data between the years 1987 and 2002 which were consistent with an overall trend.

span. Nevertheless, goat densities in Oklahoma remain relatively small (one goat per 120 acres) compared to those in Texas (one goat per 35 acres) in the most recent survey (2002). Goat density in Oklahoma was 8.3 goats per 1,000 acres of rangeland compared to 28.7 goats per 1,000 acres in Texas (Table 5.2).

Other regional differences in goat densities can be seen in Figure 5.10 and are described numerically in Table 5.2. In 1987, the Edwards Plateau region had the highest densities of goats (74.3 per 1,000 acres), followed by the North-central Texas region (47.5), the Southwest and Trans-Pecos region (38.7), the Concho Valley (20.9), and the counties of Oklahoma (2.2). In 2002, the Edwards Plateau still had the highest goat densities (48.7), followed by North-central Texas (41.2), the Concho Valley (27.3), the Southwest and Trans-Pecos region (16.1), and Oklahoma (8.3).

The changing patterns of goat densities across the range of the BCVI can be seen in two additional figures. Figure 5.11 depicts the numerical change in goat densities at the county and recovery region levels. Between 1987 and 2002, two regions had net increases in absolute goat densities: the Concho Valley (6.4 goats per 1,000 acres) and the counties of Oklahoma (6.1 goats per 1,000 acres). The remaining regions all saw net decreases in goat densities during this period. The largest decline was in the Edwards Plateau (a decrease of 25.6 goats per 1,000 acres), followed by the Southwest and Trans-Pecos region (-22.6), and North-central Texas (-6.3).

Figure 5.12 depicts the percent change in goat densities at the county and recovery region levels. The counties of Oklahoma had a very large increase in goat densities between 1987 and 2002 (277 percent), while the Concho Valley also had an increase (30.6 percent). The largest decline in goat densities during this time was in the Southwest and Trans-Pecos region (58.4 percent decrease), followed by the Edwards Plateau (34.5 percent decrease), and North-central Texas (13.3 percent decrease).

Most Texas counties had decreasing goat densities between 1987 and 2002, although many counties along the eastern and northern portions of the BCVI's range had stable or increasing goat densities. The largest declines in goat densities have generally been in counties that once had the highest goat densities. All of the counties that had the highest densities in 1987 (Hamilton, Mills, Edwards, Mason, Menard, Kimble, Sutton, Gillespie, Kendall and Uvalde) had moderate to significant declines in goat densities. In fact, seven of the eight counties with the largest numerical decreases in goat numbers between 1987 and 2002 were also counties with the highest densities in 1987.

Trends in cattle numbers. Over the Texas and Oklahoma range of the BCVI, cattle numbers decreased 2.8 percent from 1987 to 2002 (Table 5.3). Despite this slight decrease in cattle numbers overall, significant regional differences can be seen in Figure 5.13 and are described numerically in Table 5.3.

At the state level, Texas had a 9.6 percent decrease in cattle numbers, while Oklahoma had a 12.5 percent increase in cattle numbers. In 1987, the counties of Oklahoma had the highest densities of cattle (323.8 per 1,000 acres), followed by North-central Texas (221.6), the Concho Valley (117.5), the Edwards Plateau (80.0), and the Southwest and Trans-Pecos region (11.9). In 2002, the counties of Oklahoma still had the highest densities of cattle (364.3), followed by North-central Texas (225.7), the Edwards Plateau (74.7), the Concho Valley (63.9), and the Southwest and Trans-Pecos region (8.9).

In both 1987 and 2002, most of the counties with high densities of cattle were located in the eastern and northern portions of the BCVI's Texas range, as well as in most of its Oklahoma range (which, coincidentally, are the areas with the highest cowbird densities and reported parasitism rates). The highest cattle densities (more than 400 cattle per 1,000 acres of rangeland) in Oklahoma were in Blaine, Caddo and Canadian Counties in 1987. These are also the most important counties in Oklahoma for BCVIs. In 2002, cattle densities remained high in these counties as well as in Major, Tulsa and Cleveland Counties. Most of the central and western portion of the BCVI's Texas range had low cattle densities in both 1987 and 2002.

The changing patterns of cattle densities across the range of the BCVI can be seen in two additional figures. Figure 5.14 depicts the numerical change in cattle densities at the county and recovery region levels. Between 1987 and 2002, two regions had net increases in absolute cattle densities–the counties of Oklahoma (40.5 cattle per 1,000 acres) and North-central Texas (4.1). The remaining regions all saw net decreases in cattle densities during this time interval. The most significant decline was in the Concho Valley (a decrease of 53.6 cattle per 1,000 acres), followed by the Edwards Plateau (-5.3), and the Southwest and Trans-Pecos region (-3.0).

Figure 5.14 depicts the percent change in cattle densities at the county and recovery region levels. The counties of Oklahoma had the highest increase in cattle densities between 1987 and 2002 (12.5 percent), while North-central Texas also had a slight increase (1.9 percent).

The largest decline in cattle densities during this time was in the Concho Valley (45.6 percent decrease), while there were also declines in the Southwest and Trans-Pecos region (-25.2 percent) and the Edwards Plateau (-6.6 percent).

Most of the Oklahoma counties and the northern Texas counties had increasing cattle numbers, while most of the central and western portions of the BCVI's range had slightly to moderately (5 to 25 percent) decreasing numbers. In general, the largest decreases in cattle densities occurred in the western portions of the BCVI's Texas range, while the largest increases occurred in the northeastern portion of the BCVI's Texas range, along the southern edge of the range, and in Oklahoma.

5.4.5 Trends in deer numbers

In addition to sheep and goats, "other exotic herbivores" were listed as a major threat to BCVI habitat at the time of listing because these animals remove vegetative cover near ground level that is necessary for BCVI nesting (Ratzlaff 1987). These other herbivores include exotics such as axis deer, blackbuck deer, nilgai antelope (*Boselaphus tragocamelus*), aoudad sheep (*Ammotragus lervia*), fallow deer (*C. dama*) and sika deer. White-tailed deer also remove low vegetation when they browse (Marshall et al. 1985, Rust and Tazik 1990, Grzybowski 1995). As much as is possible, it is beneficial to assess the overall change in white-tailed deer and exotic herbivore numbers since listing.

The number of white-tailed deer in Texas peaked in 1986 at about 4.2 million, but population management and subsequent state regulations resulted in population declines in many areas (Lockwood 2005). Populations in the Edwards Plateau region, however, have remained high and the 2004 population estimate of 1,979,194 deer was the highest on record for the region (Lockwood 2005). In fact, while the Edwards Plateau ecoregion comprised only 28.6 percent of the deer habitat in the state, it harbored 50.5 percent of the state's deer population in 2004. This density of deer results in an average of one deer per 12.07 acres (82.88 deer per 1,000 acres) in the Edwards Plateau of Texas (Lockwood 2005), which exceeds the region's estimated carrying capacity (Harmel and Litton 1981). Statewide, average white-tailed deer density is one deer per 21.3 acres (46.9 deer per 1,000 acres) (Lockwood 2005). The heaviest densities of white-tailed deer in the Edwards Plateau occur in the eastern and central portions of the ecoregion (e.g., Burnet, Travis, Blanco, Hays, Kendall, Comal, Mason, Llano, Gillespie, Edwards, Sutton and Schleicher Counties) (Lockwood 2005).

The Edwards Plateau ecoregion has also traditionally harbored the largest populations of exotic herbivores in the state (Traweek and Welch 1992, Traweek 1995). In the most recent survey of exotics in Texas, approximately 58 percent were found in the Edwards Plateau (Traweek 1995). In the same survey, 62 percent of all confined exotics and 50 percent of all wild exotics were located in the Edwards Plateau (with the highest totals found in Kerr, Real, Edwards, Bandera, Sutton and Medina Counties) (Traweek 1995).

Of the six most abundant species of exotics, all but nilgai showed increasing populations compared to previous surveys (surveys conducted in 1963, 1974, 1979, 1984, 1988 and 1994). In the most recent survey of exotics in Texas (1994), there were 195,483 exotic animals in the state, 77,218 of which were free-ranging (Traweek 1995). Axis deer accounted for 24.7 percent of all confined exotics and 29.3 percent of all free-ranging animals, and had increased in number by 32.9 percent since the 1988 survey (Traweek and Welch 1992). Blackbuck accounted for 21.8 percent of all confined exotics in 1994 and 5.9 percent of all free-ranging exotics, and had increased 43.1 percent in numbers since 1988. Nilgai represented 36.9 percent of the free-ranging exotics (the highest percentage), but very few were confined (0.2 percent of total). Most free-ranging nilgai (97 percent) occur on large ranches in south Texas (Kenedy and Willacy Counties, both outside the range of BCVI), and their numbers have declined 22 percent since the 1988 survey. Between 1988 and 1994, Aoudad populations increased 16 percent, fallow deer increased 42 percent, and Sika deer increased 4 percent (Traweek 1995).

Table 5.2. Number of goats per 1,000 acres of rangeland by county and recovery region within the breeding range of the black-capped vireo.

County	1982	1987	1992	1997	2002	Total change*	% Change**
Oklahoma Counties							
Beaver	0.2	0.3	0.1	0.0	0.3	0.0	13.4
Major	0.1	0.1	2.6	0.2	0.5	0.4	410.1
Tulsa	2.0	1.7	5.3	4.0	19.1	17.5	1058.3
Payne	0.6	2.3	11.6	3.2	11.8	9.5	413.5
Creek	1.2	2.7	2.2	6.2	14.5	11.8	438.7
Blaine	0.0	0.1	0.2	0.2	0.7	0.6	415.3
Dewey	0.0	2.1	0.5	0.4	0.8	-1.3	-62.1
Canadian	0.3	0.8	0.6	1.4	4.4	3.6	454.2
Oklahoma	1.2	0.0	2.5	12.9	27.1	27.1	
Caddo	0.3	8.2	0.0	0.2	0.6	-7.6	-92.5
Cleveland	1.8	13.5	8.2	7.0	28.2	14.7	108.6
Comanche	0.4	0.8	2.0	1.6	2.0	1.2	141.2
Murray	0.4	0.2	0.1	0.4	18.5	18.3	9432.4
Stephens	0.3	1.8	7.0	3.5	6.3	4.4	241.1
Logan	0.8	6.0	6.7	7.8	13.5	7.5	125.2
Kiowa	0.0	2.0	0.0	1.3	0.6	-1.4	-71.2
Garvin	0.3	0.0	1.4	4.0	5.1	5.1	0.0
Grady	0.4	0.9	17.5	1.5	4.0	3.1	332.4
McClain	0.4	2.7	2.1	1.6	3.4	0.7	26.4
Carter	0.5	2.8	0.9	2.3	4.6	1.7	61.5
Jefferson	0.0	0.0	0.3	3.4	7.5	7.5	0.0
Marshall	0.1	1.2	0.8	3.4	6.6	5.4	465.5
Love	0.0	0.9	0.4	2.2	10.3	9.4	885.4
Oklahoma Total	0.5	2.2	3.2	3.0	8.3	6.1	**277.2%**
Recovery region 1: North-central Texas							
Palo Pinto	14.4	7.5	5.7	9.4	9.0	1.5	20.4
Parker	2.1	5.9	20.4	18.8	25.4	19.5	328.0
Coryell	50.2	75.0	73.9	45.6	60.6	-14.4	-19.2
Dallas	10.2	12.9	9.3	28.4	35.7	22.9	178.1
Erath	9.2	19.9	22.1	18.3	32.2	12.3	62.0
Somervell	7.2	33.2	37.5	8.1	25.8	-7.4	-22.3
Comanche	38.3	31.7	43.2	30.0	21.5	-10.1	-32.0
Burnet	49.8	48.1	39.0	39.5	39.5	-8.6	-17.9
Lampasas	37.6	67.9	64.6	65.7	55.6	-12.3	-18.1
Bell	13.7	29.8	26.5	45.0	54.9	25.1	84.3
Brown	54.1	31.5	36.2	30.0	44.7	13.2	41.9
Mills	216.9	324.5	248.0	166.3	170.9	-153.6	-47.3
Williamson	63.0	57.1	43.6	52.3	61.5	4.3	7.6
Travis	12.4	11.0	16.7	10.1	27.8	16.8	152.5
Johnson	2.8	5.0	8.4	14.8	27.3	22.3	441.5

County	1982	1987	1992	1997	2002	Total change*	% Change**
Hood	2.7	4.4	7.6	22.3	31.6	27.2	613.7
Stephens	2.5	5.4	13.9	11.3	8.3	2.9	53.0
Bosque	22.3	49.3	33.1	8.6	20.1	-29.2	-59.2
Hamilton	72.0	121.3	102.6	62.6	49.9	-71.4	-58.9
Coleman	4.1	8.8	9.1	18.8	21.6	12.9	146.5
Region 1 Total	34.3	47.5	43.1	35.3	41.2	-6.3	**-13.3%**
Recovery region 2: Edwards Plateau							
Bandera	38.9	39.7	39.5	42.1	41.0	1.3	3.3
Bexar	4.1	3.4	8.8	16.0	40.1	36.7	1080.6
Medina	1.9	5.7	8.1	9.0	9.3	3.6	63.5
Uvalde	110.0	144.7	173.9	86.1	38.7	-106.0	-73.3
Kinney	52.5	77.1	99.5	71.6	46.2	-30.9	-40.1
Schleicher	41.4	58.0	50.6	43.6	53.6	-4.4	-7.6
Sutton	79.8	100.3	147.9	84.3	69.2	-31.1	-31.0
Blanco	35.7	33.4	76.7	36.3	41.0	7.6	22.8
Hays	24.4	26.6	23.2	45.3	51.4	24.8	93.0
Edwards	134.4	160.9	172.1	105.3	90.7	-70.2	-43.6
Comal	41.4	25.7	40.0	56.2	63.1	37.5	146.0
Gillespie	103.6	124.0	94.2	71.3	73.9	-50.1	-40.4
Kendall	93.6	104.5	95.0	73.9	71.9	-32.7	-31.2
Real	72.2	75.4	89.7	66.9	30.6	-44.8	-59.4
Kerr	42.0	44.1	82.5	41.9	42.5	-1.6	-3.6
Mason	83.3	168.4	90.9	31.4	41.7	-126.7	-75.2
Llano	13.2	19.3	5.6	8.7	10.4	-8.9	-46.3
Kimble	104.7	109.2	97.9	69.2	69.3	-39.9	-36.5
McCulloch	33.3	52.4	42.2	32.6	58.0	5.5	10.6
San Saba	34.5	77.2	30.2	10.9	20.6	-56.6	-73.3
Menard	63.9	110.4	156.2	61.8	60.2	-50.2	-45.5
Region 2 Total	57.6	74.3	77.4	50.7	48.7	-25.6	**-34.5%**
Recovery region 3: Concho Valley							
Coke	10.7	19.3	33.0	24.9	26.9	7.6	39.4
Runnels	4.5	13.1	16.8	26.5	32.5	19.3	147.2
Concho	39.3	54.5	64.2	38.8	66.8	12.3	22.6
Irion	4.1	22.3	20.6	19.9	18.2	-4.1	-18.6
Nolan	7.3	15.8	10.2	2.7	7.2	-8.6	-54.4
Sterling	1.6	6.5	7.8	7.2	5.4	-1.2	-17.7
Tom Green	40.1	31.7	40.5	40.9	52.8	21.1	66.4
Taylor	7.7	4.0	32.6	7.5	8.6	4.6	114.3
Region 3 Total	14.4	20.9	28.2	21.1	27.3	6.4	**30.6%**
Recovery region 4: Southwest and Trans-Pecos							
Brewster	6.0	0.0	0.5	0.4	1.0	1.0	
Terrell	73.8	53.2	42.9	29.7	15.7	-37.5	-70.5

County	1982	1987	1992	1997	2002	Total change*	% Change**
Val Verde	80.8	82.5	90.4	64.2	32.5	-49.9	-60.6
Crockett	27.1	44.0	48.3	29.7	24.5	-19.4	-44.2
Pecos	5.9	14.0	11.8	9.0	6.8	-7.2	-51.2
Region 4 Total	38.7	38.7	38.8	26.6	16.1	-22.6	**-58.4%**
Other Texas Counties							
McLennan	1.6	3.9	3.9	10.9	18.0	14.1	363.2
Reagan	3.2	3.5	2.6	1.4	5.2	1.7	49.2
Lee	0.7	0.6	3.2	4.5	7.9	7.2	1120.6
Bastrop	2.0	2.0	4.8	10.0	13.5	11.5	573.7
Fayette	0.4	0.8	1.1	5.3	5.7	4.9	579.4
Caldwell	1.4	9.5	21.7	22.6	16.7	7.2	75.9
Cameron	3.7	2.7	13.0	9.0	20.3	17.6	653.4
Midland	1.4	3.5	4.6	3.2	10.0	6.5	187.8
Montague	0.5	3.9	1.3	1.7	8.0	4.1	103.8
Grayson	0.9	4.5	6.8	4.9	9.8	5.3	116.0
Cooke	0.7	0.4	3.7	3.5	11.1	10.7	2930.9
Tarrant	4.1	4.7	7.3	23.2	10.6	5.9	125.3
Ellis	2.5	5.0	3.2	10.2	14.8	9.7	192.6
Eastland	12.8	7.8	24.6	19.4	18.1	10.3	132.7
Callahan	2.5	2.2	5.3	7.6	9.0	6.8	306.0
Jeff Davis	0.0	0.0	0.0	0.0	0.1	0.1	0.0
Stephens	0.3	1.8	7.0	3.5	6.3	4.4	241.1
Logan	0.8	6.0	6.7	7.8	13.5	7.5	125.2
Kiowa	0.0	2.0	0.0	1.3	0.6	-1.4	-71.2
Garvin	0.3	0.0	1.4	4.0	5.1	5.1	0.0
Zavala	0.0	31.9	23.0	4.8	11.7	-20.2	-63.4
Other Total	1.9	4.6	6.9	7.6	10.3	5.7	**123.9%**
Texas Totals	29.4	37.2	38.9	28.2	28.7	-42.4	**-22.6%**
TX & OK Totals	29.9	39.4	42.0	31.2	37.0	-36.4	**-19.1%**

* Total change measures the numerical change (positive or negative) in goat density from 1987 (when the BCVI was listed as endangered) to 2002.

** Percent change measures the percentage change (positive or negative) in goat density from 1987 to 2002. It is calculated by subtracting the goat density in 1987 from the goat density in 2002, dividing that value by the 1987 goat density, then multiplying by 100.

Table 5.3. Number of cattle per 1,000 acres of rangeland by county and recovery region within the breeding range of the black-capped vireo.

County	1982	1987	1992	1997	2002	Total change*	% Change**
Oklahoma Counties							
Beaver	144.3	158.7	156.4	193.1	154.3	-4.4	-2.8
Major	255.9	280.0	344.0	356.0	424.0	144.0	51.4
Tulsa	483.7	390.1	322.4	469.7	597.6	207.5	53.2
Payne	329.9	288.0	328.8	337.4	336.1	48.1	16.7
Creek	253.2	224.4	234.3	287.5	273.6	49.2	21.9
Blaine	350.3	489.7	456.2	442.2	446.2	-43.5	-8.9
Dewey	144.2	167.2	172.8	169.7	174.1	6.9	4.1
Canadian	556.8	562.1	608.4	600.1	586.8	24.7	4.4
Oklahoma	314.0	361.6	286.9	367.2	351.5	-10.1	-2.8
Caddo	468.5	448.0	446.7	499.6	491.6	43.6	9.7
Cleveland	539.2	395.1	444.8	486.2	447.4	52.3	13.2
Comanche	283.9	292.1	275.3	294.4	324.8	32.7	11.2
Murray	253.8	245.5	192.1	256.0	266.9	21.3	8.7
Stephens	318.9	290.1	278.4	328.9	358.7	68.6	23.7
Logan	333.6	393.6	404.0	371.6	455.7	62.2	15.8
Kiowa	257.1	317.8	284.6	356.9	310.7	-7.1	-2.2
Garvin	343.4	314.3	305.1	303.8	302.1	-12.2	-3.9
Grady	407.2	402.8	417.7	441.7	441.9	39.1	0.8
McClain	417.7	374.2	371.1	434.6	397.6	23.4	0.2
Carter	235.7	239.7	248.9	287.6	266.2	26.5	0.7
Jefferson	279.8	274.8	230.4	293.7	352.1	77.3	2.7
Marshall	227.6	179.8	203.6	201.1	265.8	86.0	3.0
Love	369.4	358.2	296.0	291.7	353.1	-5.1	2.6
Oklahoma Total	329.0	323.8	317.8	350.9	364.3	40.5	**12.5%**
Recovery region 1: North-central Texas							
Palo Pinto	115.6	116.7	103.8	130.1	125.3	8.6	7.4
Parker	333.5	271.1	311.8	331.4	283.2	12.1	4.5
Coryell	135.3	119.7	132.3	160.1	255.8	136.1	113.7
Dallas	323.2	322.9	295.1	280.9	277.5	-45.4	-14.0
Erath	322.1	398.8	478.0	575.6	541.8	143.0	35.8
Somervell	256.6	197.9	273.8	197.4	126.3	-71.7	-36.2
Comanche	363.2	304.7	362.2	450.4	410.3	105.6	34.7
Burnet	114.1	106.9	108.8	116.8	102.5	-4.4	-4.1
Lampasas	153.3	110.3	122.3	118.8	119.8	9.5	8.6
Bell	347.2	345.3	350.9	298.7	269.2	-76.0	-22.0
Brown	188.9	143.6	171.4	191.3	169.1	25.4	17.7
Mills	154.9	131.4	124.8	153.5	120.9	-10.6	-8.0
Williamson	408.6	340.2	311.3	331.2	278.2	-62.0	-18.2
Travis	184.2	233.8	188.3	118.2	194.4	-39.5	-16.9
Johnson	416.1	507.0	560.7	600.3	396.9	-110.1	-21.7
Hood	202.3	210.6	226.3	262.1	270.2	59.7	28.3

County	1982	1987	1992	1997	2002	Total change*	% Change**
Stephens	87.2	93.3	88.7	94.8	78.5	-14.8	-15.9
Bosque	181.9	157.3	171.3	163.5	166.1	8.7	5.6
Hamilton	201.4	218.1	212.7	240.0	228.0	9.9	4.6
Coleman	126.3	102.2	113.0	123.2	100.4	-1.8	-1.7
Region 1 Total	230.8	221.6	235.4	246.9	225.7	4.1	**1.9%**
Recovery region 2: Edwards Plateau							
Bandera	73.2	60.5	56.9	48.5	44.0	-16.5	-27.3
Bexar	224.3	202.1	255.8	259.9	219.9	17.8	8.8
Medina	179.1	186.5	194.8	146.8	143.9	-42.6	-22.9
Uvalde	73.3	73.2	92.9	89.8	81.2	8.0	11.0
Kinney	30.1	37.0	34.9	23.2	18.9	-18.1	-48.9
Schleicher	43.0	37.9	39.8	33.2	23.8	-14.1	-37.3
Sutton	29.5	26.1	27.4	24.4	15.3	-10.9	-41.6
Blanco	92.2	78.9	81.8	82.9	69.7	-9.2	-11.7
Hays	180.9	121.6	84.4	136.5	139.6	18.1	14.9
Edwards	22.7	20.4	21.2	16.1	18.5	-1.9	-9.1
Comal	138.9	114.6	104.8	117.0	115.8	1.2	1.1
Gillespie	126.0	107.3	99.3	99.9	97.8	-9.5	-8.9
Kendall	93.4	79.5	76.6	71.6	54.6	-24.9	-31.3
Real	44.3	28.0	26.4	24.4	20.4	-7.6	-27.0
Kerr	52.4	48.4	52.9	46.2	45.0	-3.4	-7.0
Mason	108.8	99.3	90.9	99.2	125.8	26.5	26.7
Llano	101.4	99.2	97.8	90.6	86.6	-12.6	-12.7
Kimble	42.6	29.6	32.7	31.4	29.2	-0.4	-1.5
McCulloch	86.9	78.2	87.5	88.1	82.0	3.8	4.8
San Saba	100.9	102.9	103.6	115.2	108.3	5.4	5.2
Menard	50.9	47.6	48.5	44.7	27.8	-19.8	-41.7
Region 2 Total	90.2	80.0	81.5	80.5	74.7	-5.3	**-6.6%**
Recovery region 3: Concho Valley							
Coke	67.6	50.2	47.3	45.4	25.6	-24.5	-48.9
Runnels	156.6	206.4	154.4	144.0	124.3	-82.1	-39.8
Concho	61.0	58.0	54.6	57.9	43.7	-14.4	-24.7
Irion	27.6	25.4	26.0	27.8	16.0	-9.4	-37.1
Nolan	131.6	99.2	98.7	119.3	43.5	-55.8	-56.2
Sterling	25.3	21.1	24.5	22.8	14.5	-6.6	-31.4
Tom Green	74.3	84.1	80.9	80.8	90.2	6.1	7.3
Taylor	293.8	396.0	274.4	285.0	153.7	-242.3	-61.2
Region 3 Total	104.7	117.5	95.1	97.9	63.9	-53.6	**-45.6%**
Recovery region 4: Southwest and Trans-Pecos							
Brewster	19.3	16.2	18.3	16.7	7.9	-8.3	-51.3
Terrell	10.3	4.3	6.6	9.1	5.2	0.9	20.2
Val Verde	8.3	7.4	7.0	11.6	9.3	1.9	25.6

County	1982	1987	1992	1997	2002	Total change*	% Change**
Crockett	16.5	13.7	15.2	13.4	9.5	-4.2	-30.5
Pecos	17.9	17.7	18.4	15.6	12.4	-5.3	-30.1
Region 4 Total	14.5	11.9	13.1	13.3	8.9	-3.0	**-25.2%**
Other Texas Counties							
McLennan	451.9	510.4	462.0	554.9	486.8	-23.6	-4.6
Reagan	17.9	19.6	19.6	19.3	9.7	-9.9	-50.5
Lee	540.6	565.1	624.2	622.4	507.0	-58.1	-10.3
Bastrop	454.1	425.7	455.3	517.2	462.7	37.0	8.7
Fayette	573.1	608.7	557.6	595.2	502.9	-105.8	-17.4
Caldwell	431.5	409.1	364.7	369.8	328.1	-80.9	-19.8
Cameron	314.6	200.2	221.6	240.0	252.0	51.8	25.9
Midland	35.7	33.5	36.3	31.2	24.9	-8.7	-25.9
Montague	252.5	275.4	246.0	295.5	317.6	42.2	15.3
Grayson	444.3	423.1	456.7	460.2	385.9	-37.2	-8.8
Cooke	328.6	283.6	354.4	408.9	410.3	126.6	44.7
Ellis	385.4	403.8	405.6	385.1	322.6	-81.2	-20.1
Eastland	193.6	219.9	184.5	250.6	257.1	37.2	16.9
Callahan	110.8	145.3	138.7	177.9	137.2	-8.1	-5.5
Tarrant	311.5	273.1	296.1	255.6	225.3	-47.8	-17.5
Jeff Davis	23.0	26.2	24.4	23.5	15.9	-10.3	-39.4
Zavala	95.2	101.6	70.6	83.6	94.8	-6.8	-6.7
Jack	119.3	126.0	129.9	139.5	120.4	-5.6	5.2
Wise	383.0	387.9	363.7	432.8	340.1	-47.8	5.1
Denton	349.6	250.6	341.2	407.2	319.2	68.6	4.3
Collin	594.7	524.4	568.9	649.7	434.7	-89.7	8.8
Other Total	305.3	295.9	301.0	329.5	283.6	-12.3	**-4.2%**
Texas Totals	149.1	145.4	145.2	153.6	131.4	-70.0	**-9.6%**
TX & OK Totals	478.1	469.2	463.0	504.5	495.6	-29.6	**-2.8%**

* Total change measures the numerical change (positive or negative) in cattle density from 1987 (when the BCVI was listed as endangered) to 2002.

** Percent change measures the percentage change (positive or negative) in cattle density from 1987 to 2002. It is calculated by subtracting the cattle density in 1987 from the cattle density in 2002, dividing that value by the 1987 cattle density, then multiplying by 100.

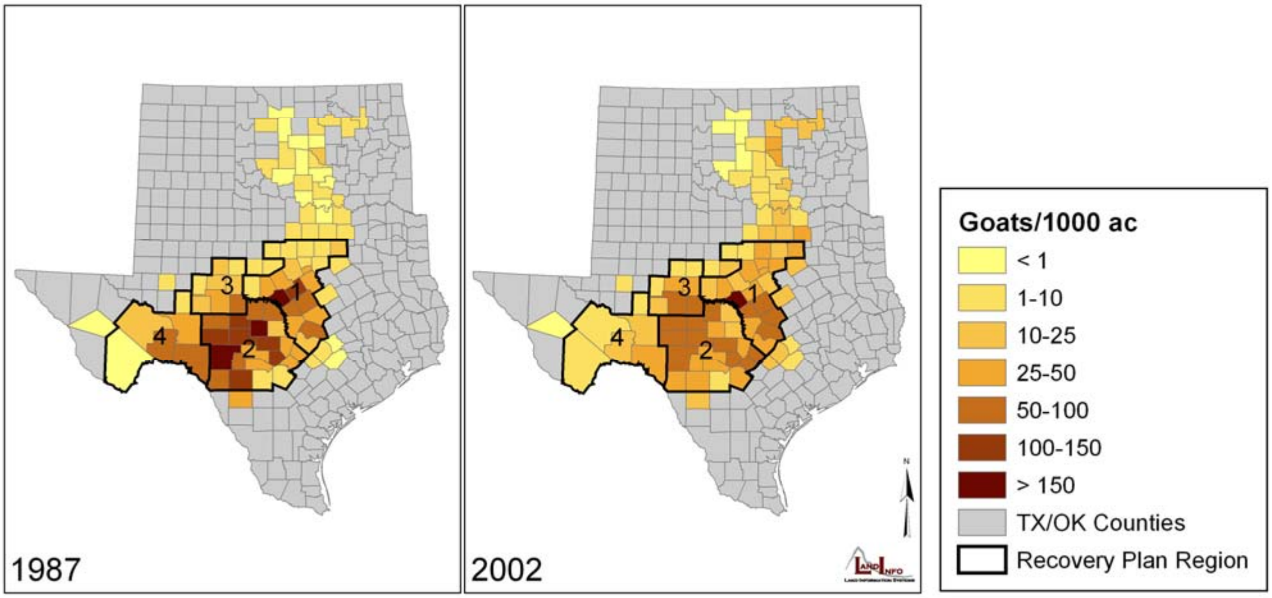

Figure 5.10. Goat densities within the range of the black-capped vireo in Texas and Oklahoma. Goat densities are depicted for both states in 1987 and 2002, as represented by the left and right maps, respectively.

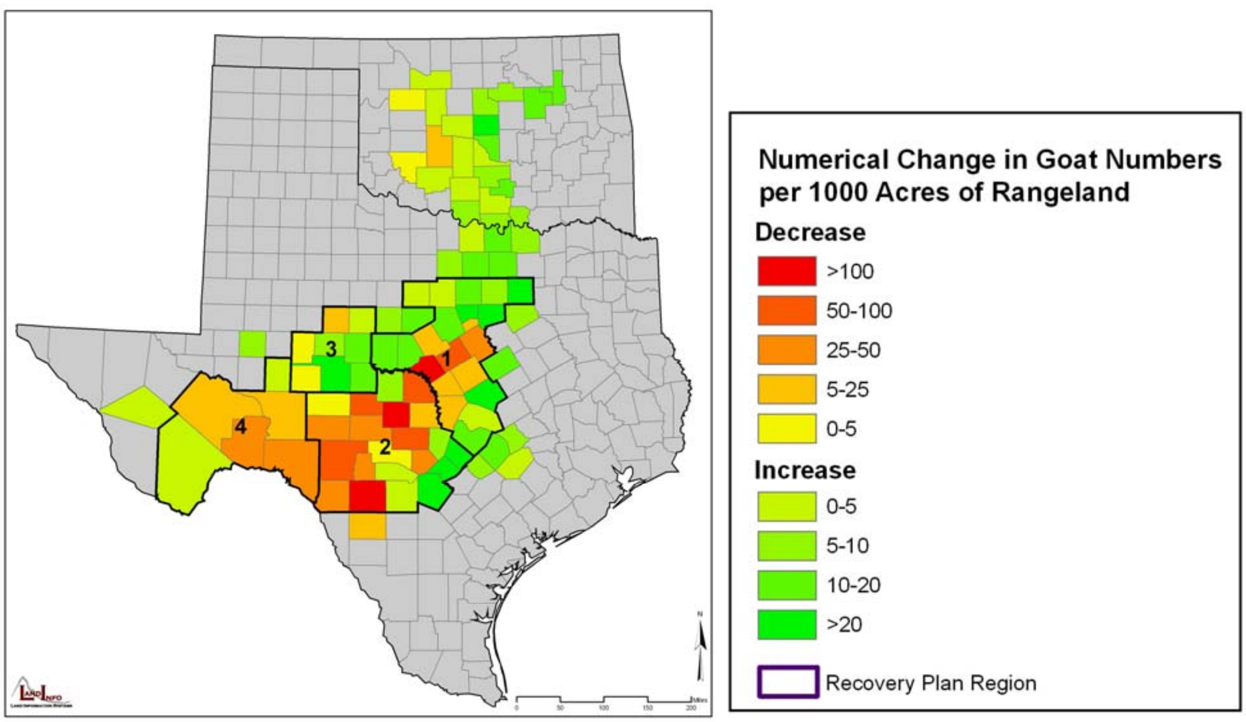

Figure 5.11. Numerical change in goat densities from 1987 to 2002 across the range of the black-capped vireo.

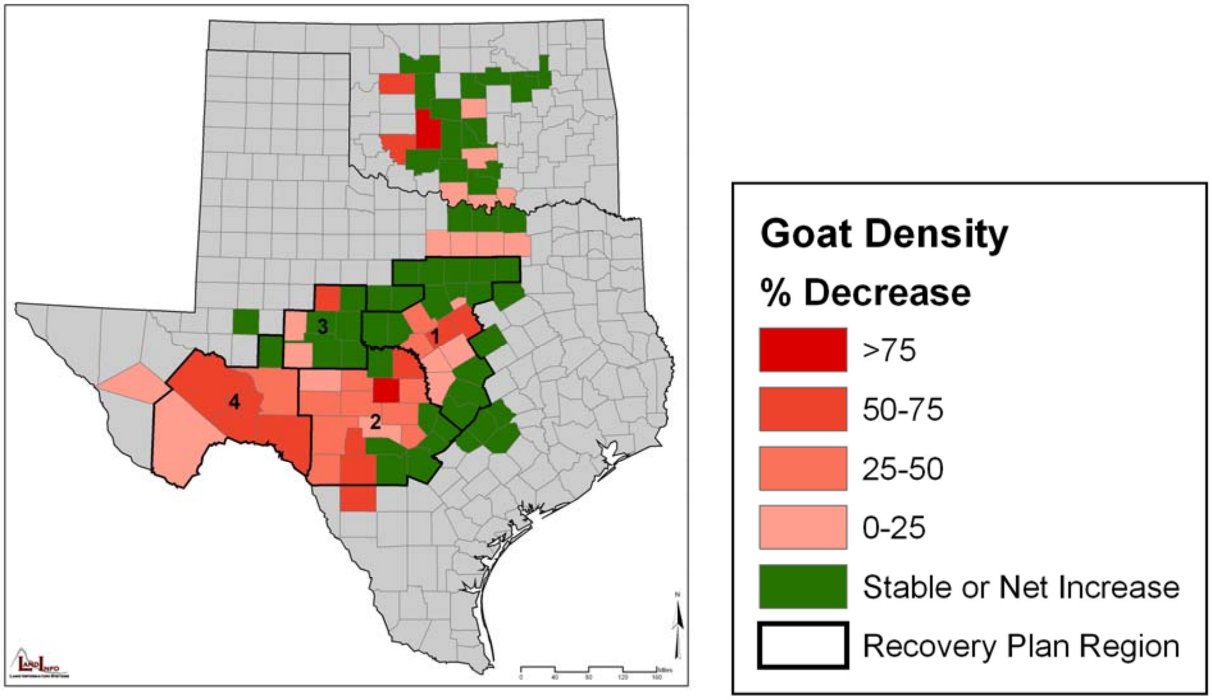

Figure 5.12. Percent change in goat densities from 1987 to 2002 across the range of the black-capped vireo.

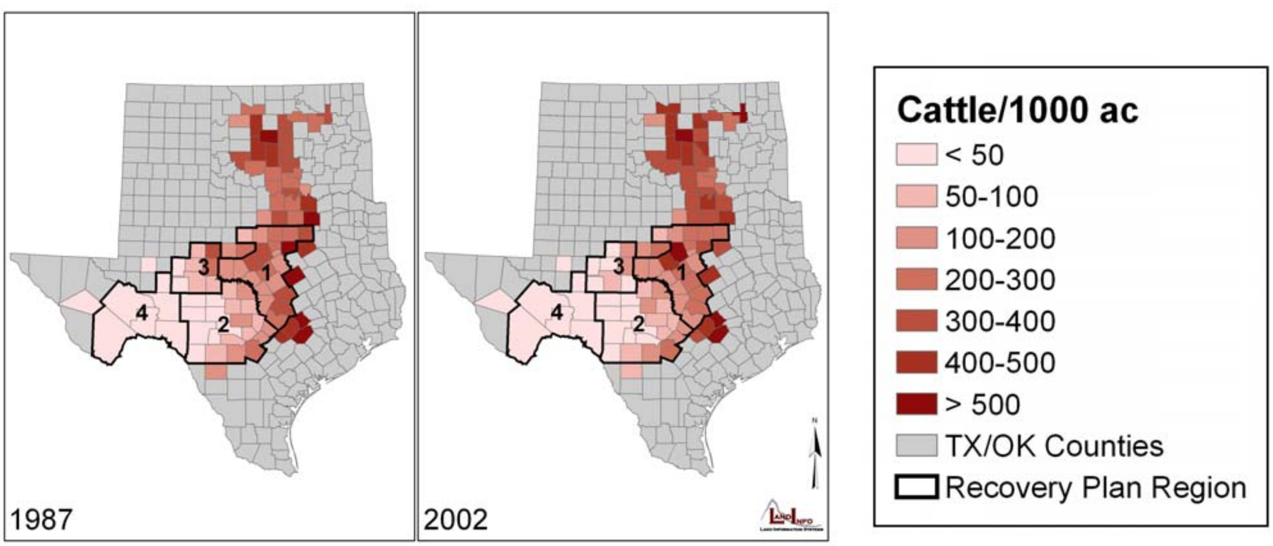

Figure 5.13. Cattle densities within the range of the black-capped vireo in Texas and Oklahoma. Cattle densities are depicted for both states in 1987 and 2002, as represented by the left and right maps, respectively.

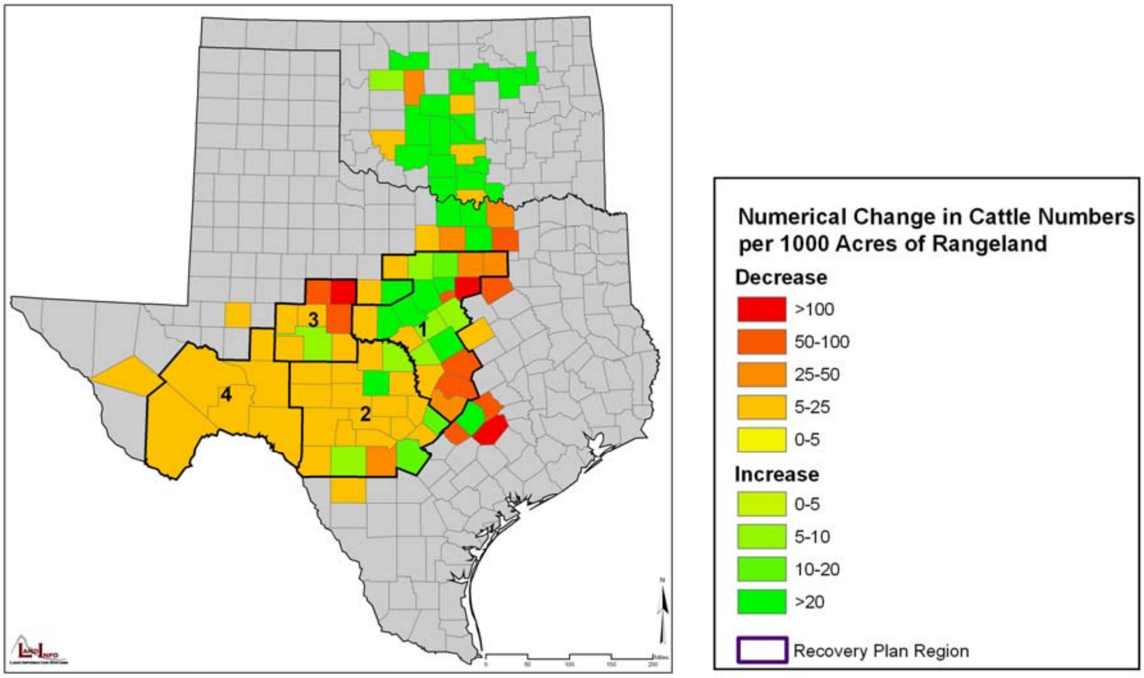

Figure 5.14. Numerical change in cattle densities from 1987 to 2002 across the range of the black-capped vireo.

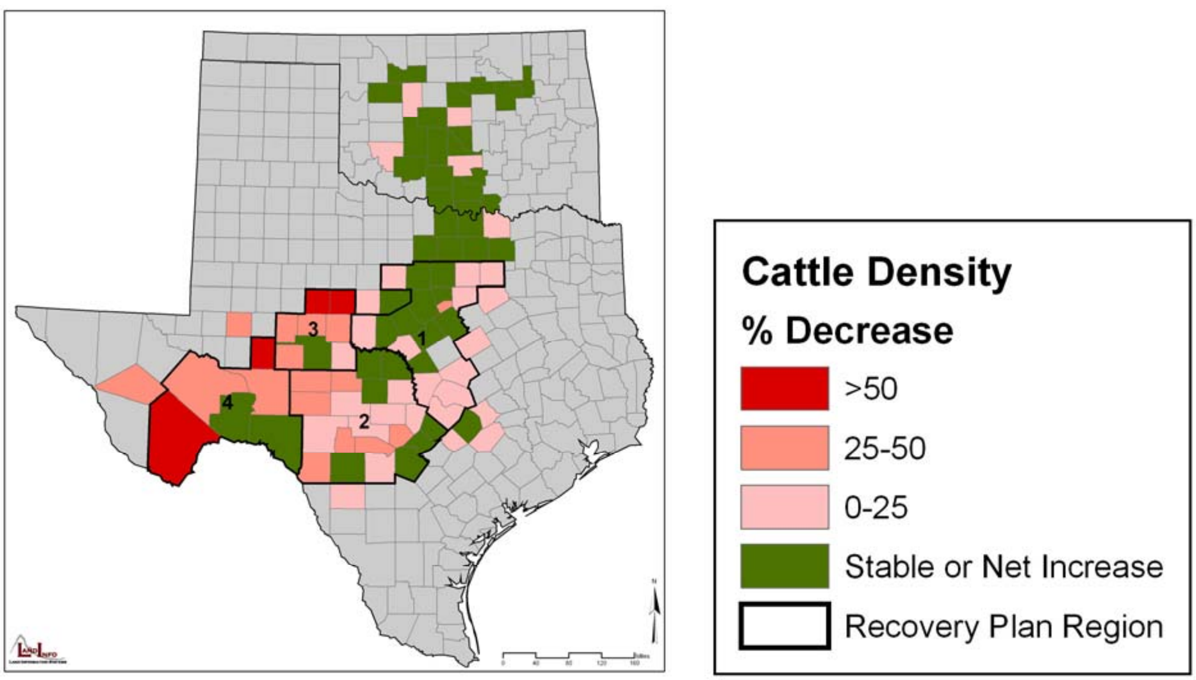

Figure 5.15. Percent change in cattle densities from 1987 to 2002 across the range of the black-capped vireo.

5.5 Brood Parasitism

It is generally accepted that brood parasitism by brown-headed cowbirds has contributed to the declines of several species of songbirds (Brittingham and Temple 1983, Robbins et al. 1989, Terborgh 1989, Robinson et al. 1995). At the time of its listing, the remaining known populations of BCVIs were thought to be seriously threatened by brown-headed cowbirds (Ratzlaff 1987). Brood parasitism rates were reported to be about 80 percent across several study sites in Texas and Oklahoma (Grzybowski 1986).

Here, we assess the changes since listing in the overall threat of cowbird parasitism on the range-wide population of BCVIs. We provide an overview of the most recent research on the ecology of brood parasitism, brown-headed cowbirds, and their effects on BCVIs. Because the biggest factor in the incidence of brood parasitism is cowbird abundance (McGeen 1972, Mayfield 1977, Brittingham and Temple 1983), we include an analysis of cowbird population trends within the range of BCVIs. Our goal is to determine whether the threats to the BCVI from cowbird parasitism have increased, decreased or remained unchanged since listing, and to describe the degree of change, if any.

5.5.1 Ecology of brood parasitism

Brood parasitism is a form of breeding biology, known to occur in birds and insects, whereby the parasites lay their eggs in the nests of host species. The host species cares for the eggs and rears the parasite's offspring (Davies et al. 1989). Some birds are facultative brood parasites, meaning that they sometimes care for their own young but also lay their eggs in the nests of other birds. Some birds are obligate brood parasites, in which case they never care for their own young. Worldwide, there are approximately 100 species of birds that are obligate brood parasites (Rothstein and Robinson 1998). Three of these species occur in North America– the brown-headed, bronzed (*M. aeneus*) and shiny cowbirds (*M. bonariensis*).

The brown-headed cowbird is the only cowbird that is widespread in the United States, breeding in all states except Hawaii (Lowther 1993). It also breeds in northern and central Mexico. Before the European colonization of North America, the brown-headed cowbird was found primarily in the Great Plains and Great Basin, where it associated with migratory buffalo (Rothstein 1994). Cowbird numbers began to increase dramatically in the eastern United States in the mid- to late 1700s (Mayfield 1965) and in the western states around 1900 (reviewed in

Rothstein 1994). This dramatic expansion east and west of its ancestral range occurred largely as a result of the widespread clearing of forests in the East, Sierra Nevada, Cascades and Pacific Northwest, and because of irrigation and agriculture in the Southwest (Rothstein 1994). These factors improved or created feeding and breeding habitat for cowbirds. It has also been suggested that the historic growth in cowbird numbers may be related to increased winter food supplies (Brittingham and Temple 1983, Robinson et al. 1993). Cowbirds generally prefer habitats that have been altered by humans (Lowther 1993) and are more likely to occur in areas with domestic livestock and where habitat fragmentation has increased the amount of edge (Ortega 1998). Cowbird abundance is known to decrease significantly with increasing forest cover and increase with increasing edge density (meters per hectare) (Donovan et al. 2000, Thompson et al. 2000). Furthermore, nest parasitism levels decrease with increasing forest cover (Hochachka et al. 1999, Thompson et al. 2000) and increase with increasing proportions of open land (grassland and agriculture) (Hejl and Young 1999, Stribley and Haufler 1999).

Some evidence suggests a significant correlation between cowbird and host abundance (Lowther and Johnston 1977, Robinson and Wilcove 1994, Thompson et al. 2000), while other research has not established such a correlation (Robinson et al. 2000). At Fort Hood, Texas, cowbird parasitism of BCVIs was greater where there were denser populations of these potential hosts (Barber 1993, Barber and Martin 1997). This relationship was driven by the density of northern cardinals (*Cardinalis cardinalis*), which were the most abundant bird, as cowbird parasitism of BCVIs was greatest where cardinal density was highest. The density of other co-existing species did not influence this relationship. This correlation suggests that conspicuous hosts, such as the cardinal, might attract cowbirds, which then increases the probability that cowbirds will parasitize any hosts with conspicuous nests or conspicuous behavior, both of which are traits of the BCVI (Barber and Martin 1997).

Cowbirds are unusual among passerines in that they use distinct types of habitat for foraging and breeding and establish separate home ranges for those activities (Chace et al. 2005). Cowbirds forage on the ground in open habitats, often using a variety of feeding sites in modified landscapes such as grazed grasslands, agricultural fields, lawns and livestock corrals (Friedmann 1929, Mayfield 1965, Ortega 1998). There is a particularly strong association between cowbird foraging habitat and the presence of livestock. In a radiotelemetry study in the Midwest, where many alternative foraging sites were available, cowbirds foraged with cattle in

57 percent of the observations (Thompson 1994). Likewise, 98 percent of the foraging observations of radio-tagged cowbirds in a New Mexico short-grass prairie landscape occurred with either pastured or corralled livestock (Goguen and Mathews 2001). Cowbirds commute daily between separate breeding and foraging sites, maintaining regular home ranges in each throughout the breeding season (Rothstein et al. 1984, Thompson 1994, Gates and Evans 1998, Goguen and Mathews 2001).

Several empirical studies have demonstrated that local cowbird abundance declines when the distance from feeding habitat to breeding habitat increases (Morse and Robinson 1999, Tewksbury et al. 1999, Young and Hutto 1999, Goguen and Mathews 2000, Chace et al. 2003). Multivariate models indicate that the distance from feeding sites appears to be one of the most important determinants of cowbird abundance (Tewksbury et al. 1999, Young and Hutto 1999, Goguen and Mathews 2000). However, cowbird abundance does not depend only on the distance to the nearest feeding site, but also on the number of feeding sites within commuting distance, especially in areas where cowbird abundance is low (Chace et al. 2005). For example, local cowbird abundance in Vermont was positively correlated to the number of livestock areas within 7 km, but not influenced by distance to the nearest livestock area (Coker and Capen 1995).

The historic range of the bronzed cowbird extended from the lower Rio Grande Valley of Texas south through Mexico and all of Central America (Sennett 1878, Ridgway 1902, Lowther 1995). Beginning in the early 20th Century, however, its range expanded (Kostecke et al. 2004), and the bronzed cowbird is now a resident in California, Arizona, New Mexico, Texas and Louisiana. Breeding Bird Survey data indicate increasing bronzed cowbird numbers in many of these areas (Sauer et al. 1996, Sauer et al. 2003). Populations in Texas and New Mexico continue to expand northward (Kostecke et al. 2004). In Texas, the current distribution of the species spans most of the southwestern portions of the state and continues northeast to the northern edges of the Edwards Plateau (Bell, Coryell, Eastland and Lampasas counties). Bronzed cowbirds are larger than brown-headed cowbirds and usually parasitize moderate to large passerines (Friedmann and Kiff 1985). They are not generally known to parasitize BCVI nests, although there is one such account on record (Kelly Bryan *in* USFWS 1991).

The shiny cowbird is a South American species that has colonized the West Indies in the past 100 years (Cruz et al. 1985) and has recently invaded Florida (Cruz et al. 1998). Shiny cowbirds have been reported in several other southeastern states from Texas and Oklahoma to the Carolinas, but in small numbers (Grzybowski and Fazio 1991, Post et al. 1993). Because of the restricted ranges of the bronzed and shiny cowbirds, and the fact that there have been few reports of parasitism on BCVI nests, we will focus only on brown-headed cowbirds from this point forward.

5.5.2 Relationship between cowbird abundance and parasitism rates

The threat to BCVIs that we address in this chapter is not cowbirds themselves, but rather, parasitism of BCVI nests by cowbirds. Unfortunately, there are no data on trends in parasitism of BCVIs, but there are data on trends in cowbird abundance (see Section 5.5.3). While cowbird abundance does relate to the threat of parasitism to host species such as the BCVI, the relationship is not linear. And there might be site-specific thresholds, above which parasitism rates do not vary with cowbird abundance.

It is often accepted that cowbird parasitism is directly related to cowbird density at the local scale (McGeen 1972, Mayfield 1977, Brittingham and Temple 1983), but the correlation is not always straightforward (Chace et al. 2005). For example, at forest sites in Illinois, Robinson et al. (2000) found that the percentage of host nests parasitized was not related to cowbird abundance, but the number of cowbird eggs per parasitized nest increased significantly with increasing cowbird abundance. Robinson et al. (2000) suggested that the cowbird-to-host ratio is a more useful index to levels of parasitism than is absolute cowbird abundance because it controls for host abundance. Nevertheless, they acknowledged that the cowbird-to-host ratio is not a good predictor of parasitism levels for all species, especially for the hosts preferred by cowbirds, which is likely the case for the BCVI. In a study of cowbird parasitism across several midwestern landscapes, Thompson et al. (2000) found that cowbird abundance and parasitism levels were positively correlated across study areas at the landscape scale; however, the relationship was not always linear, as habitat fragmentation and other landscape variables can influence parasitism rates, and both cowbird numbers and parasitism levels are often regulated at several spatial scales.

Despite the subtle ways in which this relationship can be influenced by other factors at the local scale, there does seem to be a clear relationship between regional cowbird abundance and the threat of parasitism. Therefore, an overall change in cowbird abundance over time suggests a corresponding change in the threat of parasitism to host species across the same geographic area. It remains unknown whether there is a threshold below which a decrease in cowbird abundance might benefit the host population.

5.5.3 Trends in brown-headed cowbird abundance

Breeding Bird Surveys have revealed an overall downward trend in brown-headed cowbird numbers in Texas since the surveys began (Fig. 5.16), and a less dramatic but also declining trend in Oklahoma (Fig. 5.17). Combining the data for both states, the overall declining trend can be seen (Fig. 5.18). The trend is consistent with overall patterns of cowbird abundance across North America: cowbird populations have been declining since the beginning of the BBS surveys in 1966 (Peterjohn et al. 2000, Wiedenfeld 2000, Sauer et al. 2003). In fact, BBS data indicate that cowbirds declined 1.2 percent per year in North America when averaged across the years 1966 to 2003 ($P<0.01$) (Sauer et al. 2004). During this period, there was a 39 percent decrease in the relative abundance of cowbirds on BBS routes. It should be noted, too, that most of these declines, including those in Texas and Oklahoma, started well before any cowbird control programs began (Rothstein and Peer 2005).

As analyzed by Sauer et al. (2005), the observations of brown-headed cowbirds at the state level trend significantly downward in both Texas and Oklahoma (Figs. 5.16 and 5.17). Likewise, the trend is downward when considering those routes that met our selection criteria for the BCVI's U.S. breeding range (Fig. 5.18, see section 5.3.3. for selection criteria and analytical methods). However, considering pair-wise comparisons at the state level within the BCVI's breeding range, there were clearly some differences between the states. In the Oklahoma range, the mean observations per route of 23.7 (SE=3.6) for the last 10 years (1995-2004) was essentially unchanged from the mean of 23.8 (SE=4.1) observed during the 10-year period before listing (1976-1987). In Texas, however, the mean observations of 15.1 (SE=2.2) over the last 10 years was less than the mean of 20.0 (SE=2.6) observations per route from the 10 years prior to listing ($P<0.05$). This translates to a 23.4 percent decline in the relative abundance of brown-headed cowbirds since listing.[11] During these same periods, the pattern of change in brown-headed cowbird abundance seems to roughly coincide with regional boundaries (Fig. 5.20). For

[11] The sample size available for these analyses was large enough to draw conclusions concerning trends at the state level; however, we were not able to reliably assess trends at the recovery region level.

example, relative abundance increased in the Southwest and Trans-Pecos region while apparently decreasing in the Edwards Plateau and Concho Valley regions. In North-central Texas, abundance tended to increase as part of the southern extension of some areas of increase in central Oklahoma. In summary, it appears that the overall abundance of brown-headed cowbirds has declined in major portions of the species' range in Texas and has remained stable in the species' range in Oklahoma.

Although speculative, one possible explanation for the decline is a general pattern of afforestation (Donovan et al. 2000, Thompson et al. 2000). For example, large decreases in cowbird numbers have occurred in southeastern Canada and the northeastern United States where significant reforestation has occurred in the last 100 years (Askins 1993).

While an examination of trends across the states of Texas and Oklahoma (Figs. 5.16-5.18) is revealing, it is also important to describe trends specific to those portions of the states that encompass the actual range of the BCVI. To accomplish this, we estimated annual counts of cowbirds within the BCVI's Texas range, using the same route selection procedure described above and based on methods of James et al. (1996). Of the 70 BBS routes within the Texas range of the BCVI, 31 met the overall selection criteria and are presented in Figure 5.19.[12] Sample sizes for routes that met the selection criteria in Oklahoma were inadequate so we were unable to present a similar figure for Oklahoma.

While overall cowbird numbers have decreased over time, there are some important changes in spatial variability that have occurred, likely in response to changing land use and other factors. Figure 5.20 displays the percent change in breeding season brown-headed cowbird abundance from the period 1976-1987 to the period 1995-2004. In addition to an overall decline in cowbird numbers in Texas and Oklahoma, there has also been a shift in abundance patterns within the two states since the decade immediately before listing (Fig. 5.20). The area of greatest change was in the central Edwards Plateau (depicted in dark green on Fig. 5.20), where cowbird abundance decreased dramatically.

Cowbird trends vary among the recovery regions. In Recovery region 1 (North-central TX, cowbird numbers have largely remained constant. In Recovery region 2 (Edwards Plateau), the overall pattern is a decline in population, although cowbird numbers have increased in some

[12] Individual cowbird counts were square-root transformed before computation of annual means, following James et al. (1996).

portions of this region, mainly along the southern border. Cowbird abundance in Recovery region 3 has generally declined. A large portion of Recovery region 4 (Southwest and Trans-Pecos) has shown slight, and sometimes moderate, increases in cowbird numbers.

In Oklahoma, cowbird numbers are generally increasing across the current and historic range of the BCVI. In the counties with current BCVI populations, cowbird numbers have shown moderate increases. Within much of the rest of the historic range, cowbird numbers have remained relatively stable.

The first Mexican record of brown-headed cowbird parasitism on a BCVI nest was reported recently at Rancho La Escondida in Coahuila state (Farquhar and Gonzalez 2005). No formal surveys of cowbirds were conducted at this site, but cowbirds appeared to be less abundant there than in central Texas (Farquhar and Gonzalez 2005). At sites surveyed for BCVIs in Nuevo Leon and Tamaulipas states, both brown-headed and bronzed cowbirds were rarely encountered (Farquhar and Gonzalez 2005). Livestock (e.g., cattle, sheep and goats) grazing in those states typically occurs at higher elevations than the BCVI breeding habitat, which might explain the relatively low abundance of cowbirds at BCVI breeding sites (Farquhar and Gonzalez 2005). However, research results on the impacts of cowbird parasitism in Mexico are limited.

5.5.4 Cowbird parasitism rates

The literature on cowbird parasitism frequently notes alarmingly high rates of parasitism on BCVI nests. It is worth noting, however, that such high rates are not necessarily representative of parasitism across the range of the BCVI or across time.

One example often cited is the case of brood parasitism at Fort Hood, which exceeded 90 percent before the cowbird trapping program began in 1988 (e.g., Tazik 1988, Tazik 1991b, Tazik and Cornelius 1993, Eckrich et al. 1999, Hayden et al. 2000). A parasitism rate of 90.9 percent (*n*=33) was found in 1987 and a rate of 90.8 percent (*n*=87) was found in 1988, for a combined rate of 90.8 percent (*n*=120) over the 2-year period. Data gathered elsewhere support the notion that natural parasitism rates on BCVI nests are high. Between 1983 and 1985, the overall parasitism rate on BCVI nests at three sites in Texas (*n*=33) and one in Oklahoma (*n*=3) was 86 percent (Grzybowski 1985a). Cowbird parasitism on BCVI nests at Kerr WMA in Texas fluctuated from 82 percent (*n*=33 nests) in 1986 to 66 percent (*n*=6) in 1987 and to 90 percent (*n*=10) in 1988 (Grzybowski 1991). A 1987 study of all known BCVI sites in Oklahoma found a parasitism rate of 85 percent (*n*=14) across four counties (Grzybowski 1987).

However, not all BCVI populations have faced such a high cowbird parasitism rate. For example, a study at Kickapoo Caverns State Park documented a nest parasitism rate of 24.7 percent (20 of 81 nests) in 1992 (Keddy-Hector 1992). At Devil's River State Natural Area, the parasitism rate was 48 percent without cowbird control, but BCVIs were still able to maintain 50 percent nesting success (*n*=93 territories) in 1990 (Bryan and Stuart 1990). Farquhar and Maresh (1996) noted that parasitism is generally lower in the southwest portion of the BCVI range. Between 2001 and 2004, at three sites in the western portion of the Texas range (Big Bend National Park in Brewster County, Chandler Independence Creek Preserve in Terrell County, and Dobbs Mountain Ranch in Edwards County), the overall parasitism rate of monitored BCVI nests (*n*=75) was 28 percent (Maresh 2005a). At Dolan Falls Preserve in Val Verde County, natural parasitism rates on BCVI nests were 32 percent (*n*=25 nests) in 2000 and 27 percent (*n*=30 nests) in 2001 (Farquhar, unpublished data).

In general, it appears that the highest rates of parasitism occur in the northern and eastern portions of the BCVI's breeding range. The highest reported parasitism rates have occurred in Oklahoma (85 percent; Grzybowski 1987) and in the northeastern part of the Texas range (more than 90 percent at Fort Hood; Tazik 1991b), while rates have been much lower at sites farther away from the ancestral cowbird range, such as at Kickapoo Caverns State Park (24.7 percent; Keddy-Hector 1992) or Devil's River State Natural Area (48 percent; Bryan and Stuart 1990), both of which are located in the southwestern Edwards Plateau of Texas. Others have suggested that parasitism rates on BCVI nests might be low in Mexico as well (Grzybowski 1995, Farquhar and Gonzalez 2005).

These results support the notion that cowbird abundance and parasitism frequency on most host species generally decline with distance from the historic (and current) center of cowbird abundance in the northern Great Plains (Hoover and Brittingham 1993, Smith and Myers-Smith 1998, Thompson et al. 2000). For example, wood thrush (*Hylocichla mustelina*) parasitism levels are typically more than 80 percent in Illinois (Hoover and Brittingham 1993, Robinson et al. 2000) but less than 25 percent in Maryland (Dowell et al. 2000, Petit and Petit 2000). Similarly, parasitism of grassland birds is generally higher in the northern Great Plains than in the Midwest (Davis and Sealy 2000, Koford et al. 2000). Therefore, at the continental scale, cowbird abundance is often a good predictor of parasitism levels (Chace et al. 2005).

Cowbird parasitism can be quite variable over time. Parasitism rates for southwestern willow flycatcher (*Empidonax trailii extimus*) nests at various sites in Arizona ranged from 8 percent to 21 percent between 1994 and 1996. Along the South Fork of the Kern River in California, parasitism rates fluctuated from 50 percent to 80 percent from 1989 to 1997; and in the Gila River Valley of New Mexico, they ranged from 14.7 percent to 27 percent between 1995 and 1997 (Whitfield and Sogge 1999). In another study of willow flycatchers across several study areas, parasitism rates varied from 10.9 percent to 40.7 percent over a 10-year period (Sedgwick and Iko 1999). Parasitism rates on least Bell's vireos (*V. bellii pusillus*) at the San Luis Rey River in California varied from a low of 19 percent to a high of 56 percent over a 9-year study period (Kus 1999). A study of the effect of cowbirds on plumbeous vireos in Colorado found parasitism rates that ranged from 38 percent to 66 percent over a 13-year period (Chace and Cruz 1999). In a 7-year study of warbling vireos (*V. gilvus*) in Colorado, parasitism rates fluctuated from 40 percent to 100 percent across the years (Ortega and Ortega 2003).

At Kerr WMA in Kerr County, Texas, the reported parasitism rates on BCVI nests fluctuated from 65 percent in 1985 (n=20) to 90 percent in 1988 (n=10) (Grzybowski 1991). Across several sites in Oklahoma, parasitism on BCVI nests decreased from 92 percent in 1986 (n=13) to 58 percent in 1987 (n=19), while for several sites in Texas, parasitism changed from 76 percent in 1986 (n=37) to 53 percent in 1987 (n=15) (Grzybowski 1988). Such variability in cowbird parasitism from year to year must be considered before making generalizations concerning the region-wide impact of parasitism.

Parasitism rates also can be highly variable across space within a breeding season (Robinson et al. 1995). For example, across sites in Arizona, mean annual parasitism rates for southwestern willow flycatchers ranged from 3 percent to 48 percent, and across sites in California, parasitism rates ranged from 29 percent to 66 percent (summarized in USFWS 2002). Populations within short distances of each other also can experience very different parasitism rates. Three sites at Malheur NWR in Oregon were all located in the same drainage, had similar types of vegetation, and were within 2 km of each other, but had mean parasitism rates that ranged from 15.4 percent (range of 11.1 to 87.1 percent) at one site to 18.8 percent (0.0 to 53.1 percent) at another to 41.5 percent (10.9 to 40.7 percent) at the third, over a 10-year period

(Sedgwick and Iko 1999). This level of variability further demonstrates the need to be cautious about extrapolating the results from one study across space and time.

The ecological costs of cowbird parasitism are not reflected entirely by measures of nest success. In their analysis of studies of cowbird parasitism, Lorenzana and Sealy (1999) noted that 95 percent of empirical studies defined the cost of parasitism in terms of the difference in the number of young fledged from parasitized vs. unparasitized nests (i.e., “percent parasitized”). This approach does not necessarily reflect the selection pressure that parasitized individuals face because sometimes they renest and can raise the same number of young as unparasitized individuals (Smith 1981, Roth et al. 1996). This approach is, therefore, of limited value as compared to actually quantifying the productivity of females over the entire breeding season with a measure such as seasonal fecundity (Pease and Grzybowski 1995, Lorenzana and Sealy 1999, Grzybowski and Pease 2000).

The effect of parasitism rates on BCVIs cannot be considered separately from predation and other factors influencing recruitment. It is important to understand the difference between the effects of parasitism on individual host nests vs. its effect on entire host populations. Although parasitism almost always reduces the reproductive success of parasitized nests, the host species often produce enough young to maintain stable populations (Rothstein 2004). Likewise, in some portions of the species range, predation rates (e.g., snakes and fire ants) appear to increase as cowbird parasitism is decreased. Because there are no available data on post-fledging survival for BCVIs, there remains some uncertainty as to whether predation on post-fledglings could likewise vary under varying parasitism rates.

5.5.5 Effects of cowbird parasitism on host populations

Brown-headed cowbirds are known to parasitize at least 220 bird species, 144 of which are known to raise cowbird young (Friedmann and Kiff 1985, Lowther 1993). Cowbirds are host generalists and can parasitize several co-occurring passerine species (Friedmann and Kiff 1985, Carter 1986, Wiley 1988). Because female cowbirds do not select only a single host species (Friedmann 1963, Fleischer 1985, Hahn et al. 1999), the decline of a particular host species will not produce a corresponding decline in cowbird populations (Rothstein 1975, Mayfield 1977, Grzybowski and Pease 1999). Thus, cowbirds are a relatively greater threat to host species that already have small populations because of other factors. As a result, cowbird parasitism has been deemed a primary threat for several endangered species or subspecies such as Kirtland's warbler (*Dendroica kirtlandii*) (Mayfield 1977), BCVI (Grzybowski et al. 1986, USFWS 1991), least Bell's vireo (Goldwasser et al. 1980, Franzreb 1989a), and southwestern willow flycatcher (Unitt 1987, Brown 1988), as well as for common species such as dickcissel (*Spiza americana*) (Fretwell 1977).

Brood parasitism is typically a proximate threat as opposed to an ultimate threat, with many other factors usually contributing to the overall threat to the species. In fact, the recovery plan for the BCVI recommends an integrated approach to managing land, habitat and grazing as a way of reducing the long-term effects of cowbird parasitism (USFWS 1991). Furthermore, brood parasitism generally affects seasonal fecundity (young raised per female per year) in passerine birds less than nest predation does (Grzybowski and Pease 2000).

When considering the results of 44 separate studies on 25 host species, the effect of cowbird parasitism on the success of individual nesting efforts becomes clear–significantly fewer young are fledged per nest (Lorenzana and Sealy 1999). What is not so obvious, however, is the overall effect parasitism has on the population parameters of the host species (Robinson et al. 1995). For example, in prairie warblers (*D. discolor*), Nolan (1978) found that while parasitized nests resulted in 74 percent fewer young, the overall effect on the population was only a 13 percent reduction in seasonal fecundity. They found that prairie warblers routinely abandon their parasitized nests and then renest. Similarly, Sedgwick and Knopf (1988) found that the effect of cowbird parasitism on the overall seasonal productivity of willow flycatchers was much less than one would expect from simply measuring the productivity of individual nests. While the success of parasitized nests was low (18.2 percent vs. 56.3 percent for unparasitized nests), the overall nest success for parasitized pairs was at least 54.5 percent because renesting is a successful strategy with lower parasitism rates than initial nests. Wiedenfeld (2000) examined large-scale patterns of abundance (BBS data) for cowbirds and eight species of wood warbler host species in the eastern United States and Canada and found no relationship between cowbird abundance and population changes in the host species.

In their response to brood parasitism, host species are typically classified as either egg "rejectors" (sometimes called "ejectors," Rothstein 1976, Scott 1977) or egg "acceptors." Rejectors (Rothstein 1975) remove cowbird eggs from their nests or simply abandon the parasitized nests altogether (e.g., Clark and Robertson 1981, Sealy 1992). Acceptors do not remove cowbird eggs from their nests or abandon them (Rothstein 1975). Grzybowski and Pease (1999) further divide acceptors into two categories: insensitive acceptors (species that raise cowbird young but are not detrimentally affected by this at the population level) and extinction-prone acceptors (species that are detrimentally affected by cowbird parasitism).

The cowbird incubation period is only 11 days, so cowbird nestlings usually hatch before the host's young and cause the death of some or all of the host's young (Rothstein 2004). Particularly hard hit are species with incubation periods longer than 10 to 12 days, such as the small vireos and the small flycatchers (Ehrlich et al. 1988, Briskie and Sealy 1987). The BCVI has an incubation period of 14 to 17 days (Graber 1961). Cowbird hatchlings out-compete the much smaller BCVI hatchlings, which soon die (Graber 1957, Grzybowski et al. 1986). Few parasitized BCVI nests are successful. Parasitized nests at Kerr WMA produced 0.2 fledglings per nest in 1986-1987 (Grzybowski 1995), and parasitized nests at Fort Hood (n=13) fledged 0.9 BCVIs per nest (Tazik 1991b). In fact, at Kerr WMA, where cowbird parasitism was reduced to 3% of observed nests, BCVI seasonal fecundity increased from 0.9-1.0 young/female/season to 3.78 (Grzybowski 1995). Graber (1961) observed no BCVI young fledged from parasitized nests at a site in Oklahoma, and 40 percent of all eggs laid were lost to cowbird activity. However, 60 percent of BCVI pairs were still able to fledge at least one young during the nesting season, be it from a first or second nesting attempt.

Some host species respond to parasitism by deserting their nests (Clark and Robertson 1981, Sealy 1992). Black-capped vireos desert parasitized nests at a much higher rate than unparasitized nests, and respond to nesting failure by renesting, even after successful broods, and by remating during an extended breeding season (Graber 1961, USFWS 1991, Tazik and Cornelius 1993, Hayden et al. 2000). At Fort Hood, 42 percent (42 of 101) of observed nests with one cowbird egg were abandoned in favor of a second nest (Tazik 1991b). In most populations studied in Oklahoma and Texas, only about 10 percent of females fledged two broods, although when cowbird parasitism levels were reduced to 3 percent of observed nests, 25 percent of females successfully fledged two BCVI broods in a season (Grzybowski 1995). At Fort Hood, very few BCVIs had more than two successful nesting attempts in a season (only four of 170 pairs in 2003 and nine of 202 pairs in 2004) (Cimprich 2003, Cimprich 2004).

Female cowbirds often remove a host egg from nests they parasitize (Ortega 1998). This has been observed at Fort Hood (Stake and Cavanagh 2001), where video monitoring also documented cowbirds removing BCVI nestlings from seven of 133 (5.3 percent) BCVI nests (Stake and Cavanagh 2001). In two of those cases the entire brood (four nestlings) was removed, and two nestlings were removed on four occasions. The same study at Fort Hood documented three instances of cowbirds ingesting or removing fecal sacs produced by host nestlings.

Cowbird parasitism has also been shown to skew the sex ratios of host offspring in song sparrow (*Melospiza melodia*) nests (Zanette et al. 2005). The presence of cowbird young increased competition within the nests; female fledglings were at a competitive disadvantage because of their smaller size and had high rates of mortality, reducing the proportion of female sparrows in the parasitized nests to half that of the unparasitized nests in the study. Parasitism can also alter adult sex ratios by increasing the mortality of nesting females, who must expend much more energy to tend parasitized nests (Robinson et al. 1995). In one study, the ratio of adult female BCVIs to adult males was significantly higher after cowbird control reduced parasitism levels to less than 30 percent, compared to the same population where parasitism had exceeded 80 percent before control (Grzybowski unpublished data). Females may also disperse from heavily parasitized areas. Over a 4-year period, it was found that the annual return rates for male BCVIs were constant, while female return rates were twice as high (89 percent vs. 45 percent) following a year with low parasitism rates (4 percent) as they were following a year with high parasitism rates (45 percent) (Grzybowski 1991).

A female cowbird can deposit 30 to 40 eggs (Ankney 1985, Robinson et al. 1995, Rothstein et al. 1986, Scott and Ankney 1983) into the nests of ten or more hosts per year (Grzybowski and Pease 1999). Most of these eggs have no effect on host productivity because they are placed in the nests of egg ejectors or are lost to predation (Rothstein 1977, Robinson et al. 1995). For example, at Dolan Falls Ranch Preserve, approximately 70% of parasitized BCVI nests in 2000-2001 (n=37) were subsequently depredated (Farquhar et al. 2005). A female cowbird normally lays two to eight eggs in nests of appropriate hosts (Hahn et al. 1999). According to DNA analyses, the potential mean annual reproductive capacity (i.e., fecundity) of female cowbirds is effectively 2.8 eggs (ranging from one to 13 with SD=2.7) (Alderson et al. 1999). A 6-year study of cowbirds in Manitoba, Canada found similar results, with a realized female fecundity (defined as eggs laid in host nests that could potentially fledge cowbird young) of only 2.3 ± 0.6 (n=59, range of one to 13) (Woolfenden et al. 2003).

5.5.6 Cowbird removal

Trapping effort. Since listing, there has been a substantial cowbird trapping effort by state and federal agencies and private landowner groups. Verifiable records of the last 5 years show that an average of 47,589 individuals are removed per year (most of them females) across the BCVI's range.[13]

The areas in Texas with the largest trapping efforts (more than 5,000 birds trapped) include Coryell (the location of Fort Hood), Burnet, Blanco, Bandera, Kerr, Kimble and McLennan Counties (Fig. 5.21). In Oklahoma, the only trapping effort occurs in Comanche County at Fort Sill and Wichita Mountains WR.

Since 2000, 228,660 cowbirds have been trapped in the state of Texas and 9,286 in Oklahoma. The largest effort has been in Coryell and Bell Counties, Texas, where a total of 66,726 cowbirds have been trapped since 2000. Of those, 53,495 were caught at Fort Hood (Summers et al. 2000, Summers and Sterling 2001, Summers and Norman 2002, Summers and Norman 2003, Summers and Norman 2004). Most of these cowbirds are likely migrants and only 25 percent are potential local breeders (Kostecke et al. 2005). It is possible that a large percentage of cowbirds trapped elsewhere are also not local breeders.

Regionally, the southern portions of Recovery region 1 (Travis, Williamson, Burnet, Lampasas, Coryell and Bell Counties) are areas where moderate to high levels of trapping are carried out. Less trapping occurs in other parts of the region.

In Recovery region 2, the most intensive trapping occurs in the center of the region (Kimble, Kerr and Bandera Counties) and in Blanco County. Moderate trapping generally occurs in the southwestern (Edwards, Kinney, Real and Uvalde Counties) and northeastern (San Saba, Mason and Llano Counties) portions and in Kendall County. There is little trapping elsewhere in the region.

There is also little cowbird trapping in Recovery region 3. Only 147 cowbirds have been trapped in Tom Green County during the last 5 years, and fewer than 100 in the other counties.

[13] This includes trapping programs operated by Fort Hood, Fort Sill in Oklahoma, Wichita Mountains WR in Oklahoma, and private landowners in Texas who are required to report their numbers to the Texas Parks and Wildlife Department (Linda Campbell, personal communication).

The same is true of Recovery region 4. In Val Verde County, a total of 2,237 cowbirds were trapped between 2000 and 2004. The other counties in the region have each trapped fewer than 100 cowbirds.

In Oklahoma, cowbird trapping has occurred only in Comanche County, where it has been intense. Between 2000 and 2004, 12,104 cowbirds were trapped at Wichita Mountains WR (personal communication, S. Waldstein) and 2,283 cowbirds were trapped at Fort Sill (personal communication, G. Wampler). There are no known cowbird removal programs in Mexico (Farquhar and Gonzalez 2005).

Influence of cowbird removal on cowbird abundance. At the regional and range-wide levels, there does not seem to be any clear association between cowbird trapping and cowbird abundance. In Comanche County, Oklahoma, cowbird trapping has been intense, yet the numbers of cowbirds are increasing moderately. Much of Recovery region 3 in Texas has seen dramatic decreases in cowbird numbers, but there is little trapping there. In Recovery region 4, where there also has been little trapping, cowbird abundance has remained relatively constant across the region. The areas of dramatic declines in cowbird numbers in Recovery region 2 include some counties with little or no trapping, some counties with moderate trapping, and only one county (Kimble) with intensive trapping. The other counties in this region where the trapping effort has been intense (Kerr, Bandera and Blanco) show moderate decreases in cowbird numbers. In Recovery region 1, the areas with intensive cowbird trapping (Burnet and Coryell Counties) have had only slight decreases in cowbird numbers, as have most of the counties with moderate levels of cowbird trapping. The only exceptions to this are in Somervell County and the western portion of Johnson County, where moderate levels of trapping coincide with slight increases in cowbird numbers.

Thus, it is unclear whether cowbird trapping has led to declines in cowbird numbers across the range of the BCVI. In fact, the area of the Edwards Plateau with the sharpest declines in cowbirds is composed almost entirely of counties with only low to moderate trapping efforts. The exception to this is in Kimble County and part of Kerr County, where cowbird trapping is intense and cowbird numbers are on the decline. One might suggest that trapping efforts in Kimble and Kerr Counties have been successful enough to affect the cowbird populations in adjacent and nearby counties. If this were the case, however, we would expect the same to be true of Coryell and Bell Counties, where the largest trapping program in the state (at Fort Hood) is based. This does not appear to be the case, however, because cowbird numbers in these and adjacent counties have largely remained constant. At Fort Hood, the number of cowbirds killed each year has not declined since the control program began (Eckrich et al. 1999, Summers and Norman 2004). While the evidence is overwhelming that cowbird trapping programs can reduce nest parasitism at the local level, there is little evidence that trapping has helped reduce cowbird numbers at a regional or range-wide level. These patterns are consistent with research on Kirtland's warblers (DeCapita 2000) and least Bell's vireos (Griffith and Griffith 2000), in which increased trapping success had little or no effect on cowbird numbers.

Influence of cowbird removal on parasitism rates. It has been suggested that parasitism is a concern when it affects more than 30 percent of a host population (Halterman et al. 1999). This level was set to indicate a significant impact because studies by Mayfield (1977) and Laymon (1987) showed that a 30 percent parasitism rate may make a host population unstable. However, the Mayfield paper also noted that ovenbirds (*Seiurus aurocapillus*) reproduced well despite 50 percent parasitism. Grzybowski and Pease (2000) demonstrated through modeling that the relationship between percent parasitism and seasonal reproductive success (seasonal fecundity) is complex, and that 30 percent of nests parasitized is probably too low to be a threshold of concern for most host species. They suggest that passerines can often tolerate parasitism exceeding 50 percent. Based on this information, and the fact that parasitism rates can be variable in space and time, Smith (1999) suggests that managers should consider implementing cowbird management programs only when parasitism rates in a local sample of 30 or more nests exceeds 50 percent over a time span of at least 2 consecutive years. Likewise, Tazik (1991b) suggested that a parasitism rate of 50 percent on BCVI nests at Fort Hood could serve as the upper limit for an acceptable rate that would allow the BCVI to maintain stable populations and still allow for incidental losses from military activities.

Intensive cowbird trapping has been associated with dramatic reductions in cowbird parasitism for many species. Parasitism rates of Kirtland's warbler nests dropped from 70 percent between 1966 and 1971 to only 6 percent from 1972 to 1977, after cowbird trapping (Bocetti 1994). Least Bell's vireos at Camp Pendleton, California suffered parasitism rates of about 50 percent in the early 1980s before cowbird trapping. The rate dropped to between 4 percent and 20 percent from 1983 to 1987 and to no more than 1 percent since 1988 (Griffith and Griffith 2000). Mean parasitism rates on southwestern willow flycatchers in California dropped from 63 percent (1989-1991) to 17 percent (1994-1997) following intensive cowbird control (Whitfield et al. 1999).

Brood parasitism of BCVI nests at Fort Hood, Texas exceeded 90 percent (e.g., Hayden et al. 2000) before the initiation of cowbird control in 1988. The control program at the base has coincided with reduced cowbird parasitism levels and increased nesting success for BCVIs (Eckrich et al. 1999, Kostecke et al. 2005). Similarly, cowbird trapping programs elsewhere in Texas and Oklahoma have dramatically decreased parasitism rates on BCVI nests at those sites.

The control program at Fort Hood was relatively ineffective until 1991 when biologists began to target pastures with large concentrations of cattle, adopted innovative trap designs, manipulated trap numbers, and began shooting female cowbirds (Eckrich et al. 1999). The switch to targeting pastures with large concentrations of cattle occurred because it was thought that the base contained too much host breeding habitat for trapping to be cost-effective. Between 1988 and 1990, parasitism rates at the base remained above 50 percent, but they fell to just 8.6 percent by 1997. The number of breeding male BCVIs increased from 85 (Tazik and Cornelius 1993) to 357 (Koloszar 1998) over the same 10-year span. Intensive cowbird trapping has continued since that time, and parasitism on BCVI nests has remained low, with overall mean annual rates ranging from 5.4 percent to 7.4 percent between 1999 and 2004 (Summers et al. 2000, Summers and Norman 2002, Summers and Norman 2003, Summers and Norman 2004). Overall, the parasitism rate has not exceeded 10 percent since 1997. The mean number of territorial male BCVIs has increased significantly, and nest success has had a strong negative correlation with parasitism rates across Fort Hood (Kostecke et al. 2005). While researchers at Fort Hood largely attribute BCVI population increases to cowbird control efforts, they acknowledge that this would not have worked in the absence of ample early-successional habitat (Kostecke et al. 2005).

Between 1987 and 2004, researchers at Fort Hood found a strong negative correlation between the number of female cowbirds trapped during the BCVI breeding season and the incidence of cowbird parasitism on BCVI nests (Summers and Norman 2004, Kostecke et al. 2005). An experiment was conducted in 1997, in which cowbird trapping was stopped temporarily. The result was increased cowbird densities and parasitism levels, and decreased reproductive success of BCVIs (Cook et al. 1998). However, it is difficult to assess the true effects of cowbird trapping on BCVI success at Fort Hood because the effects are confounded by other, simultaneous management actions, such as manipulations of cattle grazing (Kostecke et al. 2005).

At several study sites in the Edwards Plateau between 1983 and 1990, cowbirds parasitized 72 percent of BCVI nests where no cowbird removal occurred, but only 24 percent of nests in areas where cowbirds were removed (Grzybowski 1990b). In the same study, BCVIs produced only 0.4 young per female per year in areas without cowbird control, but more than 2.0 young with cowbird control during the same sampling period.

Cowbird trapping across all known BCVI locations in Oklahoma in 1986 reduced parasitism from 85 percent (*n*=14) to 50 percent (*n*=2) (Grzybowski 1987). At Kerr WMA, cowbird parasitism of BCVI nests between 1985 and 1988 was 77 percent (*n*=69 nests) in areas without cowbird control, but only 18 percent between 1985 and 1991 (*n*=160) in areas with cowbird trapping (Grzybowski 1991). Between 1983 and 1987, at several sites in Oklahoma and Texas, parasitism rates on BCVI nests were 74 percent (*n*=35) in Oklahoma and 73 percent (*n*=91) in Texas without cowbird control, but only 44 percent (*n*=34) in Oklahoma and 36 percent (*n*=84) in Texas with cowbird control (Grzybowski 1988).

Influence of cowbird removal on host populations. While cowbird trapping programs decrease nest parasitism rates locally, the remaining question is whether this translates into an effect at the population level. Because cowbird trapping programs have often been implemented in conjunction with other conservation measures–primarily habitat enhancement–it is difficult to draw conclusions about the influence of cowbird removal alone. The BCVI population has undoubtedly increased dramatically at Fort Hood since the initiation of cowbird control efforts (Kostecke et al. 2005). But whether or not this can be attributed directly to cowbird management remains to be seen, because it is difficult to assess the individual effects of trapping, shooting or cattle grazing manipulations on parasitism when these management practices were implemented simultaneously (Kostecke et al. 2005). The positive effect of wildfires at Fort Hood also must be considered. In February 1996, crown fires burned 4,015 ha (9,917 acres), including 508 ha (1,255 acres) of BCVI habitat (Goering 1998, Hayden et al. 1999). The abundance of BCVIs has increased on burned areas, while remaining constant on unburned areas (Cimprich 2002). Therefore, it remains to be seen whether the increases in BCVI populations at Fort Hood (or anywhere else where management involves multiple practices) can be directly attributed to cowbird control.

Case studies with other species tend to suggest that the influence of cowbird removal is at least secondary to habitat issues. In one case, cowbird trapping that began in 1972 in Michigan to help the Kirtland's warbler was successful in reducing the nest parasitism rate from 70 percent in 1966-1971 to 6 percent in 1972-1977. The mean number of warbler fledglings per female increased from 0.80 to 3.11 over the same time period (Bocetti 1994). Yet, the warbler breeding population remained relatively unchanged (around 200 pairs) for the succeeding 18 years, despite continued cowbird control efforts. The Kirtland's warbler population finally experienced a dramatic increase beginning in 1990, following a major fire that enhanced the species' habitat (Kepler et al. 1996). The scientific consensus had been that cowbird parasitism was limiting the population of Kirtland's warblers, but in the end, an increase in available habitat produced dramatic population increases that nearly two decades of cowbird trapping had not (Mayfield 1978, Mayfield 1983).

The case of the Bell's vireo is also illustrative. In the late 1970s, the largest population of Bell's vireo occurred in Santa Barbara County, California (Goldwasser et al. 1980, Greaves 1987). Despite an aggressive cowbird trapping program, this population began to decline in the late 1980s and the number of breeding pairs decreased by 60 percent. This was largely attributed to the successional advancement of the riparian vegetation (Rothstein 2004). Kus and Whitfield (2005) argued that cowbird control for least Bell's vireo populations will increase the species' abundance only as long as suitable habitat is available to support population growth.

Similarly, cowbird trapping programs to help the southwestern willow flycatcher in California, Arizona and New Mexico have done little to benefit those populations (Rothstein 2004, Kus and Whitfield 2005). In most cases, trapping has increased the breeding production of southwestern willow flycatchers but has not increased the number of breeding birds (Rothstein et al. 2003). Even today, after years of trapping for cowbirds, known flycatcher territories in California number only about 200 (Kus et al. 2003). It appears that habitat loss has had a much larger effect on the southwestern willow flycatcher than has cowbird parasitism (Rothstein 2004).

Finally, an assessment of the real threat of cowbird parasitism to BCVIs requires more careful analysis than a simple enumeration of nesting loss from brood parasitism and/or the possible benefit of cowbird removal. The fact that the entire geographic range of the BCVI is within the cowbird's ancestral center of abundance in central North America (Mayfield 1965, Hahn and O'Connor 2002) suggests that the species has some adaptations for coexisting with cowbirds (Hall and Rothstein 1999, Hayden et al. 2000, Rothstein 2004). While cowbird control appears to be a reasonable stop-gap for preventing the extirpation of some populations, there is little evidence, for any host species, that cowbird control can actually increase the size of host populations (Rothstein and Peer 2005).

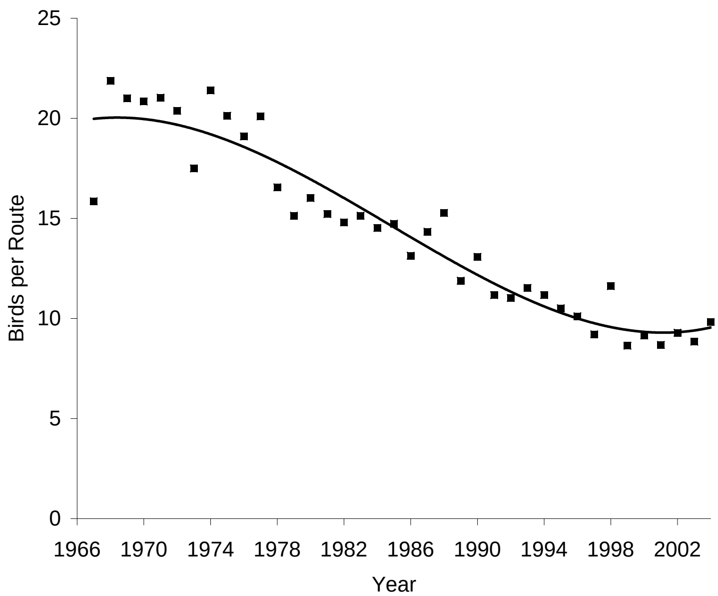

Figure 5.16. Relative abundance trend for brown-headed cowbirds in Texas based on Breeding Bird Survey data (Sauer et al. 2005). There has been a significant downward trend (trend estimate= -2.72, P<0.001, n=193).

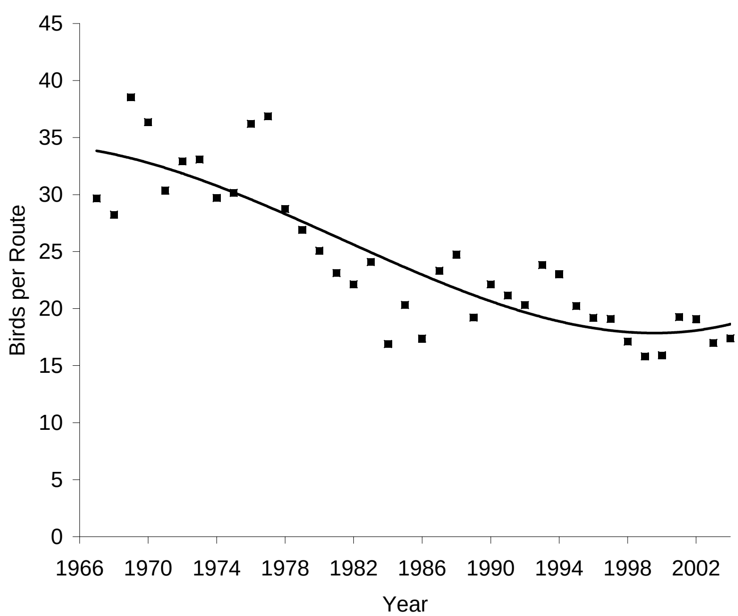

Figure 5.17. Relative abundance trend for brown-headed cowbirds in Oklahoma based on Breeding Bird Survey data (Sauer et al. 2005). There has been a significant downward trend (trend estimate= -1.93, P<0.001, n=60).

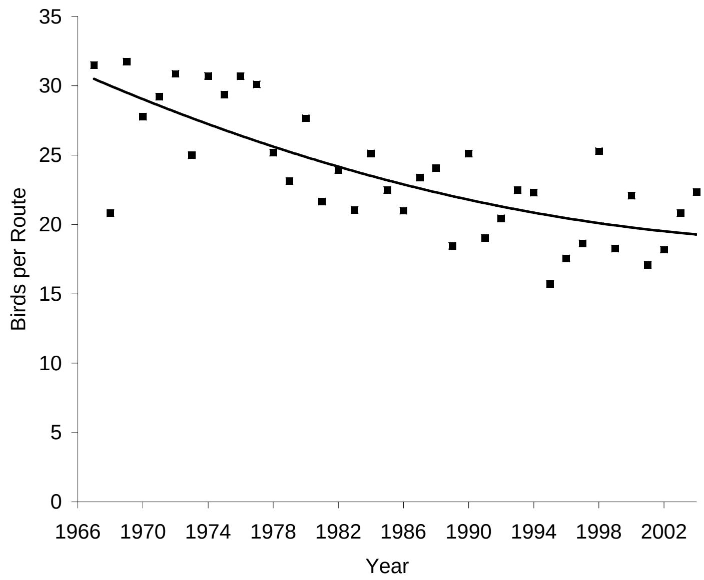

Figure 5.18. Relative abundance trend for brown-headed cowbirds in the U.S. breeding range of the black-capped vireo based on Breeding Bird Survey data (Sauer et al. 2005). Annual counts were estimated using a route selection procedure based on James et al. (1996). Of the 89 BBS routes within the range of black-capped vireos, 40 met the overall selection criteria.

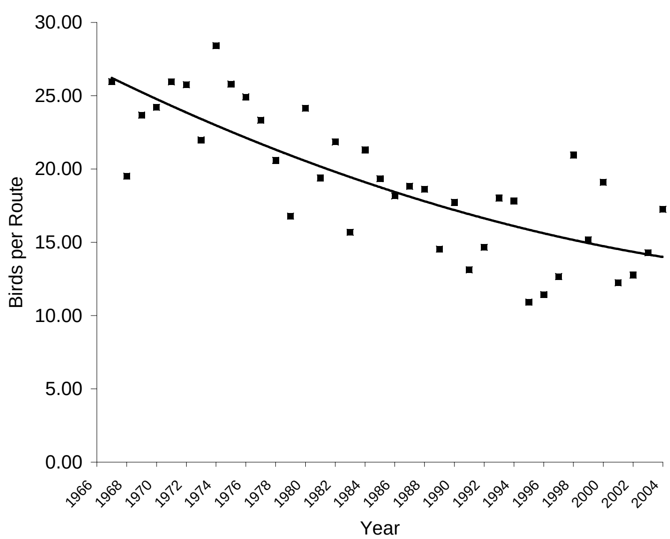

Figure 5.19. Relative abundance trend for brown-headed cowbirds in the Texas section of the breeding range of the black-capped vireo based on Breeding Bird Survey data (Sauer et al. 2005). Annual counts were estimated using a route selection procedure based on James et al. (1996). Of the 70 BBS routes within the Texas range of black-capped vireos, 31 met the overall selection criteria. Individual counts were square-root transformed before computation of annual means. Points presented represent back-transformed data.

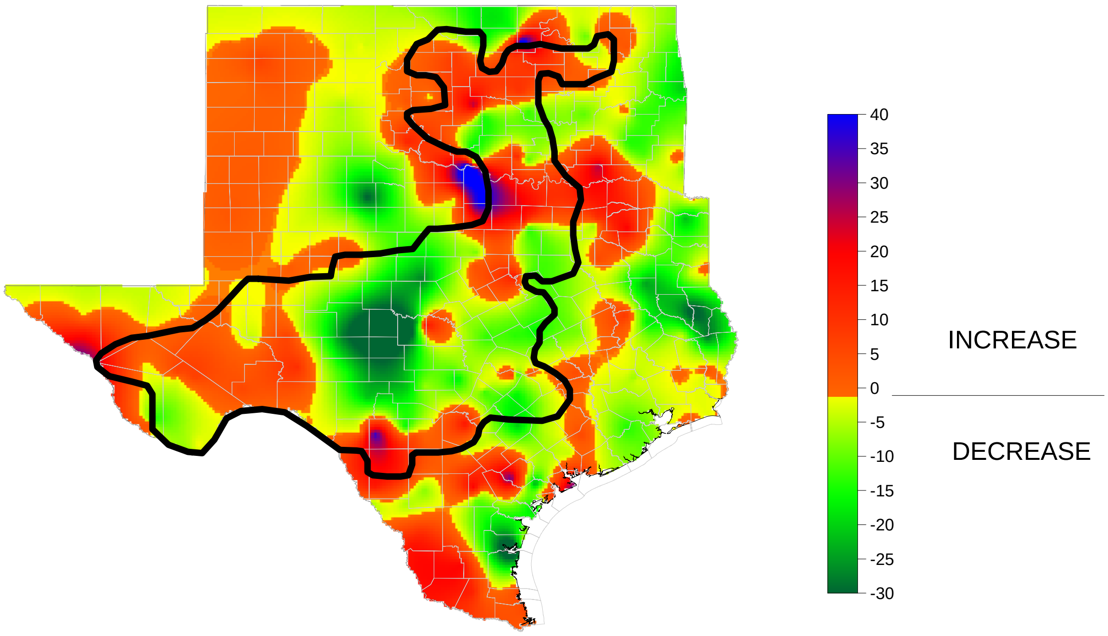

Figure 5.20. Percent change in breeding season brown-headed cowbird abundance from the period 1976-1987 to the period 1995-2004, based on Breeding Bird Survey data (Sauer et al. 2005). The black line represents the estimated U.S. breeding range of black-capped vireos. Mapped values are smoothed data (via kriging) representing differences in relative abundance values between the two periods.

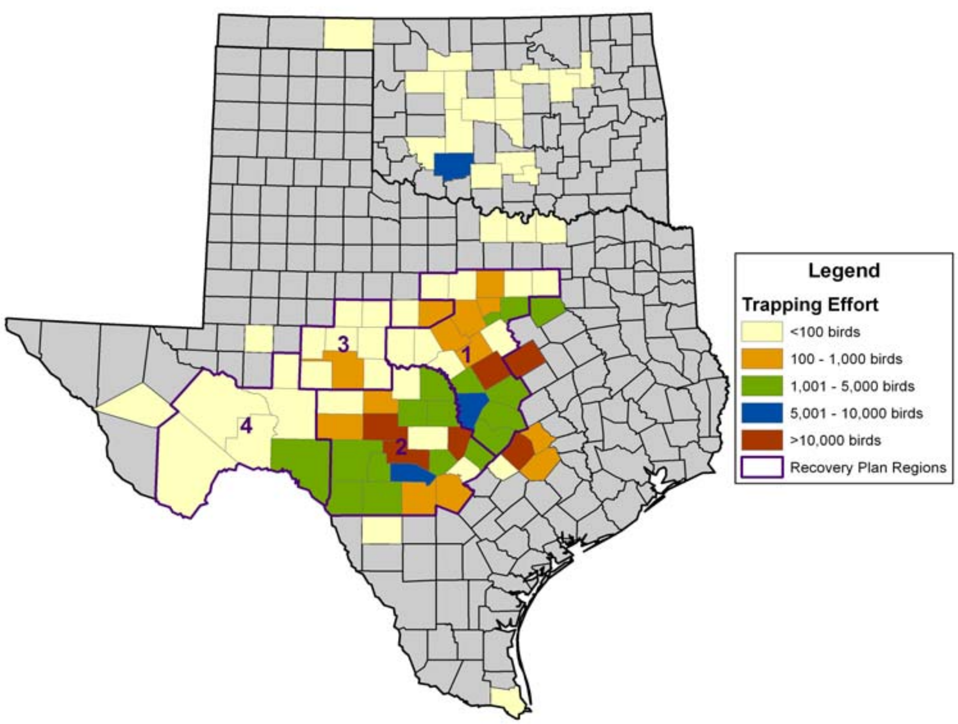

Figure 5.21. Brown-headed cowbird trapping efforts in the range of the black-capped vireo, 2000-2004. Numbered areas reflect current black-capped vireo recovery regions.

6.0 Management and Recovery Efforts

Beyond the active management programs in place at the four major population centers (Fort Hood Military Reservation (Texas), Kerr WMA (Texas), Wichita Mountains WR (Oklahoma), and Fort Sill Military Reservation (Oklahoma)), there are other programs and recovery efforts that may benefit BCVI populations.

Historic response to invasive woody plants has included large-scale brush removal projects that, at times, resulted in the removal of all broad-leaved, low, woody vegetation. While clearing rangelands of all shrubs can be detrimental to BCVIs, selectively controlling juniper, particularly in areas where juniper has recently invaded otherwise suitable breeding habitat, can enhance BCVI habitat while improving rangeland productivity. A recent NRCS Section 7 consultation and Biological Opinion for the implementation of the 2002 Farm Bill suggests a more progressive approach to brush management that protects and enhances BCVI habitats (USFWS 2004).

Under the authority of the recent Section 7 consultation and Biological Opinion, the NRCS can fund brush management projects for up to 50,765 acres of suitable habitat (3.5 percent of the total estimated suitable habitat) throughout the range of the BCVI in Texas (USFWS 2004). This project authority is distributed among the four recovery regions in proportion to the estimated amount of suitable occupied habitat in each. The program helps landowners who develop approved wildlife management plans with juniper removal and other practices such as brush management, prescribed burning, prescribed grazing, and range planting through cost-share agreements. With continued funding, the program could lead to a long-term increase in suitable habitat for the BCVI. As part of the agreement, brush management contractors are required to receive training and certification to operate in and around BCVI habitat. While brush control in BCVI habitat may have some short-term impacts on the species, the long-term benefits should be improved habitat conditions at the landscape level (USFWS 2004). This program has potential for conserving the species, although the participation rates and ultimate results are not yet documented.

Environmental Defense (ED) has initiated a program for establishing Safe Harbor Agreements with private landowners participating in habitat management programs likely to benefit black-capped vireos in 37 counties in Texas. Since December 2000, ED has enrolled 7 landowners accounting for 6,201 acres under the program.

Other BCVI habitat restoration efforts are occurring at several managed areas throughout the Edwards Plateau (USFWS 2004). The Nature Conservancy (TNC) is conducting prescribed fires and removing juniper at the Barton Creek Habitat Preserve in Travis County. The Nature Conservancy is also working to expand BCVI habitat at Dolan Falls Preserve in Val Verde County, Love Creek Preserve in Medina County, and Independence Creek Preserve in Terrell County. Habitat improvement efforts at Cedar Ridge Preserve in Dallas County have led to the first record of BCVI in that county since 1997 (Marsden 2005).

In Travis County, the City of Austin, the Lower Colorado River Authority, and the county itself all have land management programs focused on habitat restoration and management for BCVI at several sites. The Texas State Soil and Water Conservation Board's Brush Control Program is also developing management strategies that target areas where brush control is most needed. Between 2000 and 2004, this program spent approximately $3.6 million per year on brush control (USFWS 2004). Funding for this program was cut to about $600,000 in 2005.

One effort on private lands includes state agencies, federal agencies, non-governmental organizations, and university partners in monitoring and managing the habitat of endangered species throughout the Leon River basin in Coryell and Hamilton counties. Point surveys conducted across this 350,000-acre project area in 2003-2005 yielded baseline estimates that 5 to 7 percent of the area may be occupied by BCVIs (Juarez et al. 2004, N. Wilkins unpublished data). The project is actively enrolling landowners in management contracts to enhance rangeland, including selective juniper removal, grazing deferment and prescribed burning treatments. The project has recently become associated with a Department of Defense effort to provide incentives for the conservation of endangered species, including BCVIs, in an off-site conservation program for nearby Fort Hood.

While there are other locally-led efforts that have implications for BCVI recovery, there is not yet an inventory of these programs along with their associated impacts on BCVIs. This appears to be an informational need that might be addressed through future efforts.

7.0 Summary and Conclusions

The following section is a review of the most relevant findings related to the important conservation issues affecting black-capped vireos. The quality of available data, and therefore the strength of implications, varies with geography and topic. Throughout this analysis, it is apparent that a lack of data for many of the key issues makes it difficult to be direct and definitive in answering the final questions required for this status assessment. We nevertheless offer the following conclusions with the qualifications that are inherent to drawing inference from secondary data sources.

7.1 Geographic Range

At the time of listing, the black-capped vireo was known to have breeding populations distributed across four counties in Oklahoma, 21 counties in Texas, and in Coahuila, Mexico. The historic breeding distribution was thought to include an area stretching from Kansas southward through central Oklahoma and through west-central Texas, with a southern limit in central Coahuila, Mexico. While the overall survey effort has increased since listing, the effort has not been evenly applied across the species' potential breeding range. Even though the resulting data provide incomplete knowledge of the species breeding range, the accumulated results do provide some insight into the conservation status of the species. These results are summarized below.

- Since listing, breeding populations have been documented in 49 Texas counties, five Oklahoma counties and three Mexican states.

- The current black-capped vireo breeding range no longer appears to extend northward past central Oklahoma, and the species has not been documented in Kansas since the 1950s.

- Survey efforts since 2000 have confirmed that there are occupied breeding habitats in 38 counties in Texas, three counties in Oklahoma, and three states in Mexico.

- Recent survey results confirm that the black-capped vireo's breeding range extends substantially farther southward in Mexico than was known at the time of listing. The recent discovery of the southernmost breeding populations of the species significantly expands the known breeding range.

- Given recent observations in the wintering range of the species, black-capped vireos are now known to migrate to wintering habitats along a narrow range stretching from approximately 16 to 27 degrees latitude along the mountainous Pacific coast of Mexico. Recent observations suggest that most of the birds winter in the northern two-thirds of this area.

7.2 Habitat Availability

As identified when the species was listed, the amount and distribution of suitable breeding habitat was a major factor contributing to the species' endangerment. However, at the landscape level, the amounts and distribution of suitable breeding habitat were unknown at the time of listing. Despite some significant progress in refining species-habitat relationships and in estimating the area of potential breeding habitat, there is not yet an inventory that would make it possible to reliably estimate trends in suitable breeding habitat.

- Analysis of extensive roadside surveys conducted in 1996-1998 resulted in an estimate of 1.45 million acres of potential breeding habitat in 53 counties across the species' range in Texas. This amounts to 3.3 percent of the total land area within the counties considered. Due to sampling issues, this estimate lacks reliability and is of limited utility for assessing the species' status.

- The suitability of rangeland as breeding habitat for black-capped vireos largely depends on the composition and structure of woody shrubs and small trees. Habitat alteration by invasive junipers appears to be a major limitation in the maintenance and development of suitable breeding habitats in many portions of the species range.

- The influence of prescribed fire in maintaining habitat suitability in the eastern portion of the species' range appears to be more important than was generally expressed at the time of listing. Although the absence of wildfire "under natural conditions" was acknowledged in the listing decision as a factor in the successional advancement of suitable habitats, the successful application of prescribed fire in managing for black-capped vireos was not well documented or generally acknowledged at the time of listing.

- Fire interacts with a region's physical features and climate to produce different outcomes. Fire appears to contribute to the development of suitable breeding habitats in Oklahoma and the eastern portion of the species' Texas range. However, in the western portion of the species' breeding range in Texas and in Mexico, fire is not as important in maintaining habitat suitability.

7.3 Population Status

At the time of listing, the population status of black-capped vireos was largely established from survey efforts that yielded a known population of 191 pairs (Marshall et al. 1985). Extrapolating from their surveys, Marshall et al. (1985) expanded their survey results to estimate that there were more than 20 pairs in Oklahoma, 188 to 374 pairs in Texas, and 48 to 131 pairs in Mexico. By 1996, about 1,803 males were reported in the U.S. (USFWS 1996); by 2005, the known U.S. population was 5,996 males (This report). Including the breeding range in Mexico, the current known population is at 6,269. Important points concerning population status are summarized below:

- From available survey data it is clear that the overall breeding population of black-capped vireos is substantially larger than was known at the time of listing. However, it is not clear how much of the difference can be attributed to increased survey effort. Because of unequal survey efforts across the species' range, we cannot reliably estimate what proportion of the total breeding population is represented by the current known population.

- In many local cases, it could be that increased survey efforts alone have resulted in larger known populations of black-capped vireos. In other cases, however, it appears that breeding populations have likely increased since listing. For example, known breeding populations in three of the four areas with the most intensive survey efforts have increased almost 10-fold since surveys were reported in 1996 – these include Fort Hood Military Reservation (Texas), Wichita Mountains WR (Oklahoma), and Fort Sill Military Reservation (Oklahoma).

- To date, about 75 percent of the known population in the breeding range is found on four well-surveyed areas– Fort Hood Military Reservation (Texas), Kerr WMA (Texas), Wichita Mountains WR (Oklahoma), and Fort Sill Military Reservation (Oklahoma). Together, these facilities cover approximately 400,000 acres (161,877 ha) – an area representing only 1 percent of the total area of rangeland in the Texas/Oklahoma range of the species. The remaining 25 percent of the known population is the product of documented occurrences from at least 52 other properties, many of which are on private lands with only recent survey access.

- The current known breeding population in Mexico represents only 4 percent of the total known population. However, suitable breeding habitats in Mexico have been only sparsely surveyed, and most of the known breeding range has not been assessed for black-capped vireo occurrence. Where surveys have been conducted in Mexico, black-capped vireos are often found at densities higher than in the species' U.S. breeding range.

7.4. Analysis of Threats

At the time of listing, the identified major threats to the black-capped vireo included habitat loss through land use conversion, vegetation succession, grazing and browsing by domestic and wild herbivores, and brood parasitism by brown-headed cowbirds. While the relative importance of individual threats appears to have changed since listing, these remain the primary threats to the species.

7.4.1 Habitat conversion and land use change

When proposed for listing, the largest known concentration of black-capped vireos was in the immediate vicinity of Austin, Texas and the population was under immediate threat from development and road construction. Much of the subsequent development in the Austin area was mitigated through habitat conservation plans and the subsequent set-aside of mitigation lands, including the Balcones Canyonlands NWR. Habitat conversion and changes in land use continue to pose a threat throughout parts of the species' range. There are no data available for directly measuring trends in the amount of suitable habitat for the species, but some overall changes in land ownership and land use do suggest indirect trends that might be important for black-capped vireo conservation. However, these data were available only for the U.S. portion of the bird's breeding range.

- As of 2002, approximately 80 percent of the 68.8 million acres in the species' U.S. breeding range was classified as farm and ranchland. About 70 percent (33.9 million acres) of farm and ranchland in the area was classified as rangeland. This represents the land base on which suitable habitat for black-capped vireos might presently exist or be developed, either through management or natural processes.

- Recent trends in land use, land ownership and land fragmentation in the Texas part of the breeding range are quite different than those in Oklahoma.

- Over the period 1992-2002, the total area classified as rangeland declined by 8.6 percent across the breeding range in Texas. This apparent change in land use was partly driven by an overall loss in farm and ranchland, but the reported loss of rangeland was 37 percent more than the overall loss in farm and ranchland. The figures collected for Oklahoma suggest a stable or slightly increasing inventory of rangeland. All else being equal, a net loss in rangeland area likely represents a loss of potential habitat for the species – but the magnitude of loss as well as compensating factors are unknown.

- Over the period 1992-2002, about 2.8 million acres of large farms and ranches (more than 2,000 acres) were broken into smaller ownerships across the species' range in Texas. Oklahoma experienced a slight increase in large ownerships during the same period.

- During this same period, the numbers of smaller farms and ranches increased by about 40 percent across the species' breeding range in both states.

7.4.2 Vegetation change

Habitat changes resulting from the encroachment of woody shrubs and small trees (vegetational succession) were identified as a threat to the species at listing. In reviewing the relevant scientific literature, much of the current threat can largely be attributed to the invasion and growth of juniper species.

- The invasion and growth of native juniper species appears to be one of the most prevalent problems in maintaining existing suitable habitat throughout a major portion of the species' range in Texas and Oklahoma. Juniper invasion has contributed to an overall afforestation of rangeland habitats throughout much of the species' breeding range in both states.

- Since listing, both Ashe juniper and redberry juniper have increased in dominance throughout the Texas range of the species; in Oklahoma, eastern redcedar has increased substantially.

- Juniper invasion into suitable habitats appears to be a function of the combined influence of fire suppression and overgrazing, and it may be further influenced by drought. At least in the eastern portion of the species' U.S. breeding range, fire appears to exert an overriding influence on the development and maintenance of breeding habitat for the species by controlling invasive juniper.

- Since listing, the increased abundance of five species of woodland birds throughout the U.S. breeding range of the black-capped vireo suggests that woody shrubs and tree cover are increasing, which would have a negative impact on black-capped vireo conservation.

7.4.3 Grazing and browsing pressures

At the time of listing, overbrowsing by domestic goats, sheep, white-tailed deer and exotic herbivores was given as a primary cause of habitat loss, particularly in the Edwards Plateau of Texas (Marshall et al. 1985). Since listing, the numbers and densities of domestic livestock have decreased throughout much of the species' U.S. breeding range, and the specific areas where livestock numbers are decreasing have generally coincided with areas where overbrowsing was most threatening to the species. However, white-tailed deer populations appear to have increased in many of the same areas (i.e., Edwards Plateau).

- Grazing *per se* is neither beneficial nor detrimental to black-capped vireo habitats. The use of grazing and browsing animals, under proper management, for enhancing rangeland habitats, is well supported in the scientific literature. However, high stocking rates combined with poor management can remove the low-growing, shrubby vegetation black-capped vireos require for breeding habitat.

- Evidence continues to suggest that extremely high stocking rates of herbivores–especially goats, white-tailed deer and exotic ungulates–can degrade black-capped vireo breeding habitat. When grazing pressure is reduced, the breeding habitat may recover under some conditions.

- Given the apparent relationship between cattle and brown-headed cowbirds, grazing by cattle may have an indirect impact on black-capped vireos by increasing the risk of brood parasitism. This relationship is highly variable and may be mitigated with livestock management and, possibly, cowbird removal.

Trends in the numbers of grazing and browsing animals.

- Goat numbers have declined throughout a major portion of the black-capped vireo's range in Texas. For example, goat numbers declined by 22.6 percent during the period 1987-2002, including decreases of 58 percent in the Southwest and Trans-Pecos region and almost 35 percent in the Edwards Plateau.

- Since listing, cattle numbers have decreased by 9.6 percent within the Texas range of the species, while increasing by about 12.5 percent in the Oklahoma portion of the range. In general, cattle densities decreased in the western portion of the species' range in Texas and increased in northeastern Texas and Oklahoma.

- Data for determining trends in grazing animals in the Mexico portion of the species' range were not available.

- Although white-tailed deer populations appear to have decreased throughout Texas since listing, deer population numbers in the Edwards Plateau appear to have increased. The resulting browsing pressure by white-tailed deer may be limiting the development of suitable habitat in many areas of that region.

- Data for estimating trends in the numbers of exotic herbivores are incomplete. However, the most recent estimates, from 1994, suggested that populations of the most numerous species (axis deer, blackbuck antelope, aoudad, fallow deer and sika deer) were increasing in the Edwards Plateau of Texas.

- The densities of domestic livestock, particularly goats, have decreased substantially in recovery regions 2 and 4 (the Edwards Plateau and Southwest and Trans-Pecos regions, respectively). However, across the Edwards Plateau, estimates of white-tailed deer densities now exceed the density estimates for all other classes of domestic livestock.

7.4.4 Brood parasitism

At the time of listing, brood parasitism by brown-headed cowbirds was widely observed as a primary factor in the low reproductive success of black-capped vireos (Marshall et al. 1985). At that time, it was thought that brown-headed cowbirds were becoming more abundant throughout the mid-continent of the U.S. and that cowbird removal was a necessary step towards black-capped vireo recovery. Important new information concerning brood parasitism and brown-headed cowbirds is summarized below.

Factors influencing abundance and parasitism rates.

- Brood parasitism rates on black-capped vireos appear to be correlated with the densities of other more conspicuous host species; this suggests that female brown-headed cowbirds may parasitize black-capped vireo nests more in areas where populations of more abundant species (e.g., northern cardinals) are denser.

- Brown-headed cowbirds often commute daily between separate feeding and breeding areas. Feeding areas are most often located with cattle; the proximity of feeding areas to breeding areas and the number of feeding sites within commuting distance are often correlated with cowbird abundance.

- At the local scale, the relationship between brown-headed cowbird abundance and rates of brood parasitism appears to be influenced by site factors such as host species assemblage, host abundance, and vegetative cover.

- At the regional scale, the threat of brood parasitism appears correlated with the regional abundance of brown-headed cowbirds.

Cowbird abundance trends.

- Throughout North America (not including Mexico), the number of brown-headed cowbirds observed along Breeding Bird Survey routes has declined by approximately 39 percent in the period 1966-2003.

- Since listing, the relative abundance of brown-headed cowbirds declined in the black-capped vireo's range in Texas, but remained stable in the species' range in Oklahoma. Over the last 10 years (1995-2004), observations of brown-headed cowbirds on BBS routes in the black-capped vireo's range in Texas have declined by 25 percent as compared to the 10-year period prior to listing (1976-1987). There was essentially no change in that comparison for Oklahoma.

Observed variability in parasitism rates.

- Observed brood parasitism rates on black-capped vireos vary across the range, with those in North-central Texas and Oklahoma being relatively higher than in other regions.

- As with other host species, the observed brood parasitism rates on black-capped vireos also can vary from year to year on any one site.

Effect of cowbird parasitism.

- The effect of cowbird parasitism on black-capped vireos is not a simple function of parasitism rates on individual nests. The effect at the population level is best measured as seasonal fecundity, which takes into account the desertion of parasitized nests, renesting attempts, remating efforts, and fledging rates. There is some evidence that high levels of brood parasitism can decrease seasonal fecundity of black-capped vireos.

- The threat posed by cowbird parasitism is proportionately greater when a species' population is declining because of other factors, such as habitat loss. In general, as a host population increases, the relative threat from brood parasitism declines.

Cowbird removal programs.

- Cowbird control programs across the black-capped vireo's range resulted in the removal of more than 235,000 cowbirds (mostly female) from 2000 through 2004.

- To date, most cowbird removal efforts in the range of the black-capped vireo are in those areas where there are relatively large black-capped vireo populations – Fort Hood

Military Reservation (Texas), Kerr WMA (Texas), Wichita Mountains WR (Oklahoma), and Fort Sill Military Reservation (Oklahoma).

- Cowbird removal can decrease local parasitism rates on black-capped vireo nests resulting in an increase in individual nest success. However, most cowbird control efforts for the black-capped vireo are combined with habitat management and restoration efforts (e.g., coordinated brush control, controlled burning, and grazing management), which confounds most attempts to determine the overall population-level benefit of cowbird removal.

7.5 Objectives of Status Review

7.5.1 Does the black-capped vireo population appear to be declining, stable, or increasing?

Detecting long-term trends in black-capped vireo populations is difficult because survey efforts across the range of the species are largely inconsistent and unequal. Several pieces of evidence should be considered in combination. These are:

- There has been a large overall increase in the total known numbers of males in breeding surveys since the time of listing.

- Most of the apparent increases in population abundance have occurred in areas of most intense survey effort (Fort Hood, Fort Sill, Wichita Mountains WR, and Kerr WMA).

- The recent preliminary results from breeding surveys in the Mexican range of the species suggest relatively large and dense breeding populations there.

- The species occurs more frequently on private lands in Texas than was known at the time of listing.[14] This increase in occurrence is at least partly a function of increased survey

[14] Survey results from private lands in Oklahoma are lacking.

effort – therefore it remains uncertain whether populations on private lands have actually increased.

This evidence points to two likely conclusions:

1) At the time of listing, black-capped vireos were more numerous across their breeding range than what had been documented in the listing decision because distributional information on the species was limited to a few locations at that time. We now know that the species occurs on private lands in Texas and across areas in Mexico not thought to be part of the species' breeding range when listed.

2) The overall population of black-capped vireos appears to have increased, at least in those areas receiving the most management attention and where surveys have been conducted most intensely (Fort Hood Military Reservation , Kerr WMA, Wichita Mountains WR, and Fort Sill Military Reservation). These areas contain most of the present known breeding population, yet only comprise 1 percent of the total area of rangeland in the Texas/Oklahoma range of the species. Outside of these areas, it is difficult to assess trends due to a lack of information.

7.5.2 Are threats increasing, unchanged, reduced, or eliminated?

Since listing, it appears that some threats have increased, some have decreased, and others have likely remained unchanged. And, it appears that none of the original threats to the species has been completely eliminated.

7.5.2.1 Increased threat levels

Habitat conversion and land use change. The overall loss and potential fragmentation of native rangeland caused by land use conversion and ownership changes throughout major portions of the species' breeding range, especially in the Edwards Plateau and North-central Texas regions, has likely resulted in an overall decrease in the potential habitat available for the species. While the magnitude of this threat compared to others remains unclear, it is the rate of change that is of particular concern.

Vegetation change. The widespread shift toward juniper-dominated woodlands is an issue of increasing concern for this species and others that depend upon grassland savannas and shrubland habitats. Afforestation affects the black-capped vireo throughout its U.S. breeding range in all but the more western sections of the Edwards Plateau and Southwest and Trans-Pecos regions.

Overbrowsing by white-tailed deer and exotic ungulates. While the density and abundance of domestic livestock have declined substantially in those regions of greatest concern at the time of listing, it appears that the density and abundance of white-tailed deer and exotic herbivores may have increased in many of those same areas. This is of primary concern in the Edwards Plateau of Texas. In some locations within that region, exotic ungulates may out-compete white-tailed deer.

Predation. Where cowbird removal programs are successful in reducing brood parasitism, the threat of predation from fire ants and rat snakes may become more of a threat to the species. Whereas imported fire ants have increased in distribution and abundance since the species was listed, they likely pose an increasing threat to the species.

7.5.2.2 Decreased threat levels

Overbrowsing by domestic livestock. The density and abundance of domestic livestock, particularly goats, have declined substantially in those regions where this threat was of greatest concern at the time of listing, primarily in the Edwards Plateau and Southwest and Trans-Pecos regions. Therefore, the potential for livestock overbrowsing to destroy black-capped vireo habitat is probably not as widespread as it was before listing. At the local level, however, the effects of overbrowsing by domestic livestock can be quite variable and may put local breeding populations of black-capped vireos at risk. Overall, this specific threat appears to have declined.

Brood parasitism by brown-headed cowbirds in Texas. The threat posed by brood parasitism throughout major portions of the species' range in Texas has likely lessened since the species was listed due to a combination of an apparent decrease in cowbird abundance, an apparent increase in black-capped vireo breeding populations, and circumstantial evidence of a reduction in parasitism rates at some locations due to cowbird removal. Our conclusions concerning this threat factor are confined to major portions of the Texas breeding range of the species.

7.5.2.3 Unchanged threat levels

Brood parasitism by brown-headed cowbirds in Oklahoma. The threat posed by brood parasitism throughout the species' range in Oklahoma remains essentially unchanged since the time of listing. This conclusion is largely based on the fact that the relative abundance of brown-headed cowbirds in Oklahoma appears to be unchanged. However, it is possible that brood parasitism in that region may not now be as threatening as it was thought to be at the time of listing because of the apparent increase in known black-capped vireo populations in Oklahoma and the same circumstantial evidence of beneficial cowbird removal programs at the local level as has been observed elsewhere.

7.5.3 Are there any new threats to the species?

While we did not identify any new threats to the species that were not anticipated at the time of listing, there may be unanticipated threats to the species or those that remain unexplored. Of these, nest depredation by vertebrate predators and fire ants is an obvious area for future analysis and research. This possible threat will need to be explored as new recovery strategies for the species are developed in the future. In addition, factors that might negatively affect wintering black-capped vireos in Mexico, such as development or land conversion to agriculture, need to be carefully examined.

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9.0 Appendices

APPENDIX A. Current known population of black-capped vireos arranged by county and recovery regions.

REGION 1- North-central Texas

County	Specific Location	Current Population[1]	Current Source by Specific Location	Texas Wildlife Diversity Database[2]	1996 Population[3]
Bell/Coryell[4]		**1914**			
	Fort Hood		1,847 males (Cimprich 2003b)	594 males (1999)	
Bell					**150**
Coryell					**150**
	Private land		16 individuals (Butcher pers. comm. 2005)		
	Private land		50 males (Juarez et al. 2004)		
	Private land		1 male (Maresh and Rowell 2000)		
Burnet		**88**		39 males (2001)	**47**
	Balcones Canyonlands NWR		57 territories (Sexton 2002)		
	Private Land		8 territories (Sexton 2005)		
	LCRA Canyon of the Eagles		23 males (Pavlas pers. comm. 2004[6])		
Travis		**43**		5 males (2001)	**60**
	Balcones Canyonlands NWR		31 territories (Sexton 2002)		
	Balcones Canyonlands Preserve (BCP)		12 pairs (Ramirez pers. comm. 2004[5])		
Williamson		**14**		5 males (2001)	**13**
	Balcones Canyonlands NWR		14 territories (Sexton 2002)		

REGION 1- North-central Texas (continued)

County	Specific Location	Current	Current Source by Specific Location	Texas Wildlife	1996

		Population[1]		Diversity Database[2]	Population[3]
Somervell		**20**		16 males (2003)	**3**
	Private land		15 males (Maresh 2005a)		
	Private land		2 pairs (Pinkston et al. 2002)		
	Fossil Rim Wildlife Center		3 males (Pinkston et al. 2002)		
Bosque		**1**		1 male (1988)	**1**
	County Road 2130		1 pair (Maresh and Rowell 2000)		
Coleman		**6**		6 males (1999)	**unconfirmed**
	County Road 419		6 males (Maresh and Rowell 2000)		
Dallas	Cedar Ridge Preserve	**1**	1 male (Marsden 2005)	2 males (1993)	**"extirpated"**
Erath		**16**		16 males (2003)	**1**
Montague		**2**		1 male (2001)	**no record**
	Private land		1 pair (Maresh 2002)		
	Private land		1 pair (Garnett pers. comm. 2004[5])		
Palo Pinto		**1**		1 male (2002)	**1**
Brown					**unconfirmed**
Comanche					**unconfirmed**
Hood					**unconfirmed**
Hamilton		**4**			**1**
	Private land		4 males (Juarez et al. 2004)		
Johnson					**unconfirmed**
Lampasas					**1**
Mills				2 males (1989)	**2**
Parker					**unconfirmed**
Stephens					**1**
TOTAL		**2110**			**431**

REGION 2 - Edwards Plateau

County	Specific Location	Current Population[1]	Current Source by Specific Location	Texas Wildlife Diversity Database[2]	1996 Population[3]
Edwards/Kinney[4]		**265**			
	Kickapoo Caverns State Park		52 territories (Lockwood pers. comm. 2005)		
Edwards					**67**
	RM 674		135 males (Booher pers. comm. 2004[5])		
	Dobbs Run Ranch		59 males (Environmental Defense 2004[5])		
	Dobbs Mountain Ranch		17 territories (Maresh 2004a)	17 males (2003)	
Kinney				2 males (1998)	**105**
	FM 674		2 males (Maresh and Rowell 2000)		
Kerr		**436**		1 male (2001)	**602**
	Kerr Wildlife Management Area		358 males (Prochaska pers. comm. 2005)		
	Private land		78 males (Pfeffer pers. comm. 2005)		
Bandera		**28**		19 males (2000)	**48**
	Love Creek Preserve		10 males (Elliott 2004[5])		
	Hill Country State Natural Area		7 males (Lockwood and Hernandez 2000[3])		
	Private land		11 males (Wilkins et al. 2002)		
Bexar		**45**		32 males (2000)	**16**
	Camp Bullis		13 Territories (Cooksey and Thompson 2005)		
	City of San Antonio Rancho Diana		32 males (Lautzenheiser pers. comm. 2004[5])		

REGION 2 - Edwards Plateau (continued)

County	Specific Location	Current Population[1]	Current Source by Specific Location	Texas Wildlife Diversity Database[2]	1996 Population[3]
Blanco		**14**		14 males (2000)	**6**
Kimble		**35**		2 males (1996)	**26**
	Walter Buck WMA		35 males (Farquhar pers. comm. 2004[5])		
Mason		**77**		71 males (2001)	**2**
	Mason Mountain WMA		77 males (Mitchell pers. comm. 2005)		
Real		**93**		1 male (2001)	**23**
	Private land		93 males (Fushille and Ramirez 2004)		
San Saba		**11**		7 males (2001)	**22**
	Colorado Bend State Park		11 males (Lockwood and Hernandez 2001[5])		
Hays				2 males (1999)	**1**
Llano				1 male (1999)	**unconfirmed**
McCulloch		**1**		1 male (2001)	**unconfirmed**
	FM 1311		1 male (Maresh and Rowell 2000)		
Menard		**8**		8 males (2001)	**unconfirmed**
Sutton		**1**		1 male (1998)	**1**
	U.S. Highway 277		1 male (Maresh and Rowell 2000)		
Uvalde				2 males (1993)	**4**
Schleicher					**unconfirmed**
Comal					**unconfirmed**
Gillespie					**1 male seen in 1988**
Kendall					**1 male seen in 1985**
Medina		**4**		4 males (2000)	**unconfirmed**
TOTAL		**1018**			**923**

REGION 3 - Concho Valley

County	Specific Location	Current Population[1]	Current Source by Specific Location	Texas Wildlife Diversity Database[2]	1996 Population[3]
Coke		**12**		4 males (2002)	**32**
	Texas Highway 208		8 males (Maresh and Rowell 2000)		
	FM 2034		3 males (Maresh and Rowell 2000)		
	Mountain road		1 male (Maresh and Rowell 2000)		
Concho		**1**		1 male (2001)	**unconfirmed**
Nolan		**3**		1 male (1962)	**1**
	Private land		3 males (Turner pers. comm. 2004[5])		
Runnells		**2**		2 males (1998)	**5**
	County Roads 189 & 194		2 males (Maresh and Rowell 2000)		
Taylor		**125**		2 males (2003)	**1**
	Horse Hollow		60 territories (Maresh pers. comm. 2005)		
	Buffalo Gap wind farm		59 males (Maresh 2005b)		
	Camp Barkeley		6 males (Maresh 2005a)		
Tom Green		**6**		2 males (1999)	**13**
	FM 2034		4 males (Maresh and Rowell 2000)		
	Susan Peck Road		2 males (Maresh and Rowell 2000)		
Irion				3 individuals (1977)	**18**
Sterling					**1 male (last survey 1990)**
TOTAL		**149**			**70**

REGION 4 - Southwest and Trans-Pecos

County	Specific Location	Current Population[1]	Current Source by Specific Location	Texas Wildlife Diversity Database[2]	1996 Population[3]
Brewster		**15**		14 males (2003)	**16**
	Big Bend National Park		15 males (Maresh 2004c)		
	Black Gap Wildlife Management Area				
	Private land				
Terrell		**86**		26 males (2003)	**8**
	Oasis and Canon Ranches		60 pairs (Elliott pers comm. 2004[5])		
	Chandler Independence Creek Preserve		26 males (Maresh 2004b)		
Val Verde		**133**		43 males (1999)	**173**
	Devils River State Natural Area		78 males (Lockwood pers. comm. 2005)		
	Dolan Falls Ranch Preserve		55 males (Farquhar pers. comm. 2005)		
Crockett		**2**		26 males (2003)	**9**
	Texas Highway 290		1 male (Maresh pers. comm. 2004[5])		
	FM 2083/Howard Draw Road		1 male (Maresh and Rowell 2000)		
Pecos				1 individual (1975)	**3**
TOTAL		**236**			**209**

OTHER TEXAS COUNTIES

County	Specific Location	Current Population[1]	Current Source by Specific Location	Texas Wildlife Diversity Database[2]	1996 Population[3]
Callahan		**2**		2 males (2003)	**not mentioned**
Cooke					**not mentioned**
Eastland					**not mentioned**
Ellis					**not mentioned**
Grayson					**not mentioned**
McLellan					**not mentioned**
Tarrant					**not mentioned**
TOTAL		**2**			

OKLAHOMA

County	Specific Location	Current Population[1]	Current Source by Specific Location		1996 Population[3]
Comanche		**2474**			**150**
	Wichita Mountains Wildlife Refuge		2119 territories (Waldstein pers. comm. 2005)		
	Fort Sill		355 territories (Grzybowski 2005)		
Blaine		**17**			**17**
	Salt Creek Canyon area		17 males (Grzybowski 2003)		
Cleveland		**4**			**3**
	Lake Stanley Draper		4 males (Shackford 2004)		
Caddo					**last seen 1990**
Canadian					**last seen 1988**
Beaver					**not mentioned**
Creek					**not mentioned**
Dewey					**last seen 1964**

OKLAHOMA (continued)

County	Specific Location	Current Population[1]	Current Source by Specific Location		1996 Population[3]
Garvin					**last seen 1962**
Kiowa					**last seen 1963**
Logan					**last seen 1967**
Major					**not mentioned**
Murray					**not mentioned**
Oklahoma					**last seen 1984**
Payne					**not mentioned**
Tulsa					**not mentioned**
TOTAL		**2495**			**170**

U.S. TOTAL	**6,010**	**1,803**

MEXICO

State	Current Population[1]	Current Source by Specific Location
Coahuila	**139**	Farquhar et al. 2003
Nuevo Leon	**98**	Farquhar et al. 2003
Tamaulipas	**22**	Farquhar and Gonzalez 2005
MEXICO TOTAL	**259**	

GRAND TOTAL 6,269

[1] Most recent abundance estimates are those documented since 2000.

[2] TWDD as of 14 Sept. 2005. TWDD data is only included in Current Pop if year >1999 and TWDD is the only source (year of most recent observations in parentheses).

[3] Number of males documented in each county according to USFWS (1996).

[4] Fort Hood is in both Bell and Coryell Counties. Kickapoo Caverns State Park is in both Edwards and Kinney Counties.

[5] As cited in USFWS (2004).

APPENDIX B.

Museum records of black-capped vireos that were collected in Mexico outside of the breeding season.

State	Number of specimens	Museum
Sinaloa	1	Smithsonian Institution National Museum of Natural History, Washington, D.C., USA
	8	Moore Laboratory of Zoology, Occidental College, California, USA
	2	Natural History Museum of Los Angeles County, California, USA
	1	Field Museum of Natural History, Chicago, Illinois, USA
	1	University of Kansas Natural History Museum, Lawrence, Kansas, USA
	1	Delaware Museum of Natural History, Delaware, USA
	1	Museo Zoologico de la Facultad de Ciencias, Universidad Nacional de Mexico, Mexico
Durango	4	Moore Laboratory of Zoology, Occidental College, California, USA
Nayarit	3	Moore Laboratory of Zoology, Occidental College, California, USA
	7	Delaware Museum of Natural History, Delaware, USA
	2	Field Museum of Natural History, Chicago, Illinois, USA
	1	Burke Museum of Natural History, University of Washington, Seattle, Washington, USA
Jalisco	1	American Museum of Natural History, New York, USA
	2	Moore Laboratory of Zoology, Occidental College, California, USA
	1	Delaware Museum of Natural History, Delaware, USA
	2	Louisiana State University Museum of Natural History, Baton Rouge, Louisiana, USA
	1	Museo Zoologico de la Facultad de Ciencias, Universidad Nacional de Mexico, Mexico
Colima	1	Museum of Vertebrate Zoology, Univ. of California, Berkeley, California, USA
	1	Delaware Museum of Natural History, Delaware, USA
Michoacan	1	Moore Laboratory of Zoology, Occidental College, California, USA
Mexico	1	Smithsonian Institution National Museum of Natural History, Washington, D.C., USA
Guerrero	1	London Natural History Museum, United Kingdom
	1	Canadian Museum of Nature, Ottawa, Canada
Oaxaca	2	Delaware Museum of Natural History, Delaware, USA
	1	Museo Zoologico de la Facultad de Ciencias, Universidad Nacional de Mexico, Mexico

BLACK-CAPPED VIREO

RECOVERY PLAN

U.S. FISH AND WILDLIFE SERVICE
REGION 2, ALBUQUERQUE, NEW MEXICO
1991

BLACK-CAPPED VIREO
(Vireo atricapillus)
RECOVERY PLAN

Prepared by: Joseph A. Grzybowski, Ph.D.
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Region 2

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611 East Sixth Street, Fourth Floor
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Approved: ____________________
Regional Director, U.S. Fish and Wildlife Service

Date: 9/30/91

ACKNOWLEDGMENTS

Much information and current research presented in this plan is in progress, being developed for reports and/or publication, or otherwise unpublished. A number of individuals have made this information available through informal reports and manuscripts being developed. Individuals contributing in this manner include Kelly Bryan, John Cornelius, Charles Sexton, David Steed, David Stuart, and David Tazik.

Laura Hill and Craig Pease provided significant comment on an earlier draft of this plan. Jim Lewis assisted with the final revisions and responses to comments.

The cover drawing is by Mary P. Gilroy and was provided compliments of DLS Associates, Austin, Texas.

EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR THE BLACK-CAPPED VIREO

Current Species Status: This species is listed as endangered. The number of individuals is unknown. However, it has undergone substantial range reduction in Kansas, Oklahoma, and Texas. It is extirpated in Kansas, and the Oklahoma population is below 300 birds. Declines have also been documented over much of the species' range in Texas. Its status is uncertain in Coahuila, Mexico.

Habitat Requirements and Limiting Factors: The black-capped vireo occurs in mixed deciduous/evergreen shrubland. Breeding vireos use shrubby growth of irregular height and distribution with spaces between the small thickets and clumps and with vegetative cover extending to ground level. Habitat losses are occurring through development, overbrowsing, and suppression and alteration of natural disturbance regimes. Cowbird nest parasitism has been drastically reducing vireo reproduction in many areas.

Recovery Objective: Downlisting

Recovery Criteria: All existing populations are to be protected and stabilized; and at least one viable breeding population (of at least 500 to 1,000 breeding pairs each) should exist in each of six regions, including one in Oklahoma, one in Mexico, and four in Texas; and sufficient and sustainable area should exist to support the birds when they are on their winter range; and all of the previously mentioned criteria should have been maintained for at least 5 consecutive years and assurance should exist that they will continue to be maintained. Threats from habitat loss, cowbird parasitism, and other factors will need to be resolved.

Actions Needed:

1. Additional surveys.
2. Clarify population size, area requirements, and location needs for viable populations.
3. Maintain viable populations in target areas.
4. Conduct research on species' biology, habitat needs and management, threats, and winter range.
5. Eliminate threats from cowbird nest parasitism, habitat deterioration, and other agents.
6. Develop and conduct a program for monitoring the vireo's status.

Estimated Cost of Recovery for First Three Years:

FY 1 - $16,274,000.
FY 2 - $16,409,000.
FY 3 - $16,434,000.

Date of Recovery: Current requirements for downlisting to threatened should be met by 2020, assuming full implementation of this plan. However, these populations may not be self-sustaining because of cowbird impacts. More information is needed to determine the potential for complete recovery and delisting. Therefore, time of delisting is uncertain.

DISCLAIMER PAGE

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service **only** after they have been signed by the Regional Director or Director as **approved**. Approved recovery plans are subject to modification as dictated by new findings, changes in species' status, and the completion of recovery tasks.

LITERATURE CITATIONS

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1991. Black-capped Vireo (Vireo atricapillus) Recovery Plan. Austin, Texas. pp. vi + 74.

Additional copies may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814

(301) 492-6403

or

1-800-582-3421

The fee for the Plan varies depending on the number of pages of the Plan.

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Figures

I. INTRODUCTION AND BACKGROUND

A. TAXONOMIC AND LEGAL CLASSIFICATION:

Family: Vireonidae

Scientific name: *Vireo atricapillus* Woodhouse

Common name: Black-capped vireo

Original description: Woodhouse (1852)

Type specimen: National Museum Natural History no. 15040 collected 26 May 1851 "on the Rio San Pedro, two hundred and eight miles from San Antonio..." (= Devil's River, near Juno, Val Verde County, Texas (Sexton and Tomer 1991)).

Distinctiveness: Believed most closely related to *V. nelsoni*, the dwarf vireo of southwestern Mexico, which is similar in plumage (except cap color). A few authors believe that dwarf and black-capped vireos may be conspecific. With Bell's vireo (*V. bellii*), they may form a superspecies complex (Phillips 1968, Barlow 1980, Barlow pers. comm.).

Listed: Endangered, (Federal Register 52:37420-37423, October 6, 1987); became effective 30 days (November 5, 1987) after publication.

Recovery priority: 2C (According to the Service's criteria this indicates a species with a high degree of threats, high potential for recovery, and in conflict with construction or development projects or other forms of economic activity).

B. DESCRIPTION

General: One of the smallest of the vireos; 9-10 g, 11-12 cm (4.5 in.). Unique among vireos in being sexually dichromatic (sexes are different colorations), and in showing delayed plumage maturation (Rohwer et al. 1980) in first-year males.

Plumage and soft parts: Detailed descriptions are provided in Graber (1957) and Oberholser (1974). Adult males (=ASY male, after second calendar year in age) are olive green on the back, white below with flanks tinged yellow to yellowish green. The head is black with prominent spectacles, white on lores, but interrupted over the eye. The bill is black, iris brownish red to red, feet dull gray (plumbeous). The wings and tail are dark olive to blackish. The tertial and secondary coverts are broadly rimmed with pale yellow forming two wing bars. Some adult males show gray rather than black on the lower portions of the nape. The male in the first breeding season (=SY male, male in his second calendar year) is similar to the adult male, but the nape and posterior crown in most birds is extensively gray rather than black.

Adult females generally have a gray head but some look more like the SY male with blackish variably extending around the spectacles and forward portions of the crown. Young of the year in first winter plumage are similar to adult females, but with a brown rather than a reddish brown iris. Some variation occurs in gray on the cap and in the amount of buff on the spectacles and throat. Juveniles are like young in first winter plumage, but generally paler, more whitish underneath, and with less clearly delimited cap and spectacles.

Distinction from other vireos: A black and/or gray cap, and reddish eye separates adults from other vireo species. Most similar is the dwarf vireo, which is identical except for a greenish gray cap. Females and juveniles may be confused with the much larger solitary vireo (V. solitarius; at 20 g), but female black-capped vireos show a red eye, and the solitary vireo's spectacles are narrower on the lores and are not interrupted above the eye. Hutton's vireo (V. huttoni) can be distinguished by cap color, indistinct spectacle and buffy throat. However, some first winter black-capped vireos may have less distinctive caps, and buffier underparts and spectacles, and appear similar to dwarf vireo and Hutton's vireo.

Molt: The molt sequence is typical of many passerines (see Humphrey and Parkes 1959, Pyle et al. 1987). No down plumage occurs in nestlings. The adult molt (prebasic) is complete (all feathers) at the end of the breeding season. The prebasic molt of young of the year (from juvenile into first winter plumage) is incomplete. Juvenile primary coverts, primaries and tail feathers are retained. A partial pre-alternate molt, involving at least the cap of males, was noted by Graber (1957).

C. DISTRIBUTION AND POPULATION ESTIMATES

Historic breeding range: Black-capped vireos are believed to have bred in a strip from south-central Kansas, broadly through central Oklahoma south through central Texas to the Edwards Plateau, then south and west to central Coahuila (Mexico) and Big Bend National Park (Graber 1957, American Ornithologists' Union 1983) (Figure 1). The vireo may also have occasionally bred in Nuevo Leon and Tamaulipas (Marshall et al. 1984).

Historic winter range: The vireos' historic winter range is on the Pacific slope of Mexico. It is less well known than the breeding range. Records are primarily from Sinaloa and Nayarit but extend north to southern Sonora, and east to Oaxaca (Graber 1957, Marshall et al. 1985) (Figure 2).

Records considered accidental: Reports where vireos were considered to have occurred "accidentally" exist for eastern Nebraska, northeastern Kansas, Louisiana, Arizona, and Nuevo Leon (Mexico) (Marshall et al. 1985).

Current breeding range: *Kansas* - No recent breeding records exist. The last sight records of accidentals were noted in the 1950's (Tordoff 1956). Graber (1957) could not locate suitable areas during the early 1950's and believed that drought conditions and land uses in the 1930's eliminated potential habitat.

Oklahoma - Oklahoma has been extensively surveyed (Grzybowski et al. 1986, Grzybowski 1989a). Black-capped vireos have been reduced to three focal areas in west-central Oklahoma (Figure 3). Birds in one of these areas (on the border of Canadian and Caddo counties) will likely disappear within the next few years.

Only one bird could be located there in 1990 (Grzybowski 1990a). A group in Blaine County with only six breeding pairs during 1990 (Grzybowski 1990a) is at very high risk. In the Wichita Mountains Wildlife Refuge (WR) and adjacent Fort Sill Military Reservation (MR) (Comanche County), about 225+ adults were observed during 1990. This population, which may approach 300 birds, is currently being monitored (Grzybowski 1990b, Grzybowski and Tazik 1990). The black-capped vireo is believed extirpated from the Arbuckle Mountains (Figure 3) and central Oklahoma where it was noted as recently as 1942 and 1977, respectively (Grzybowski et al. 1986), and from intermediary portions of its current range.

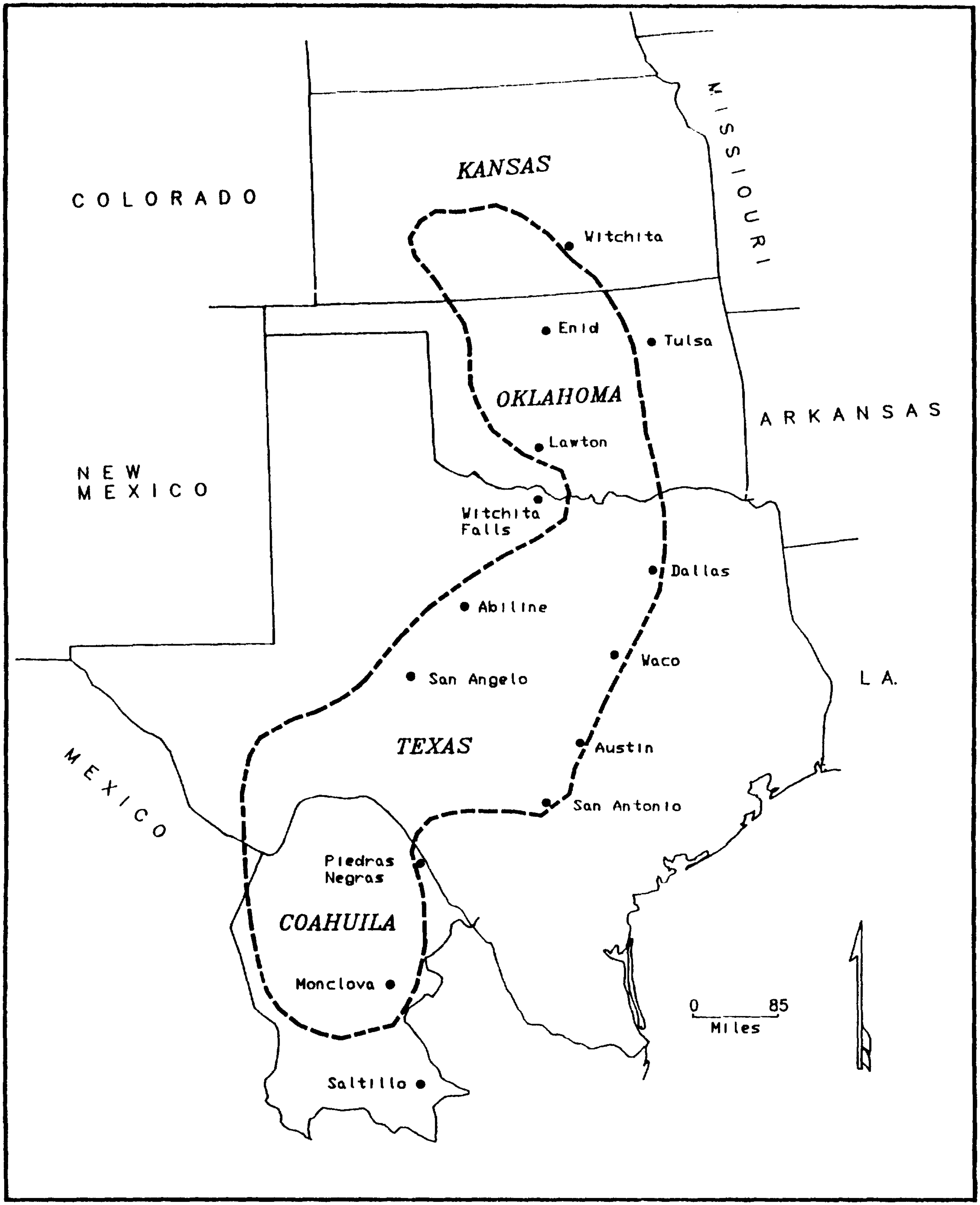


Figure 1. Probable historic breeding range of the black-capped vireo (Graber 1961).

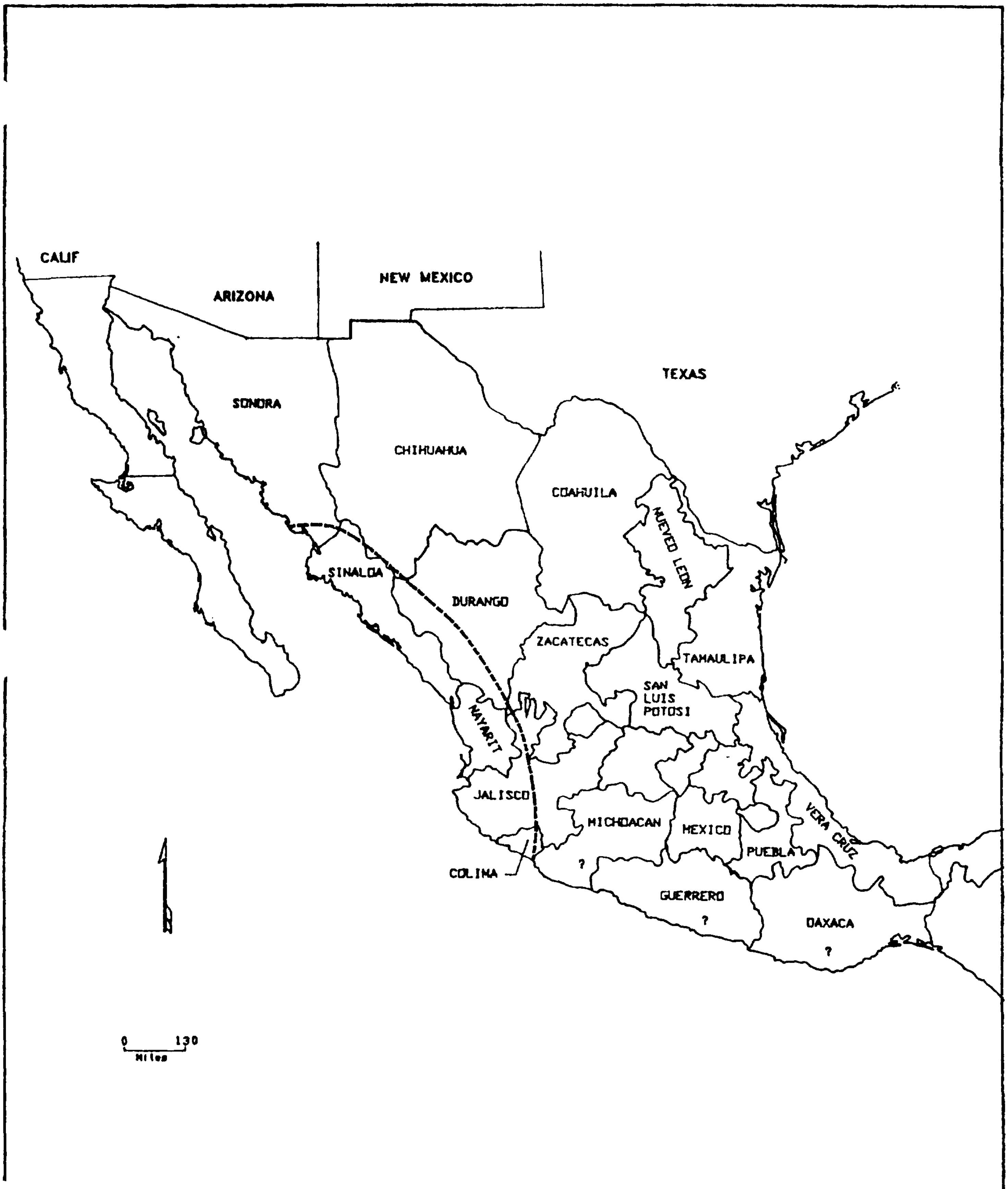


Figure 2. Documented and possible winter ranges of the black-capped vireo (adapted from Graber 1957, Marshall et al. 1985).

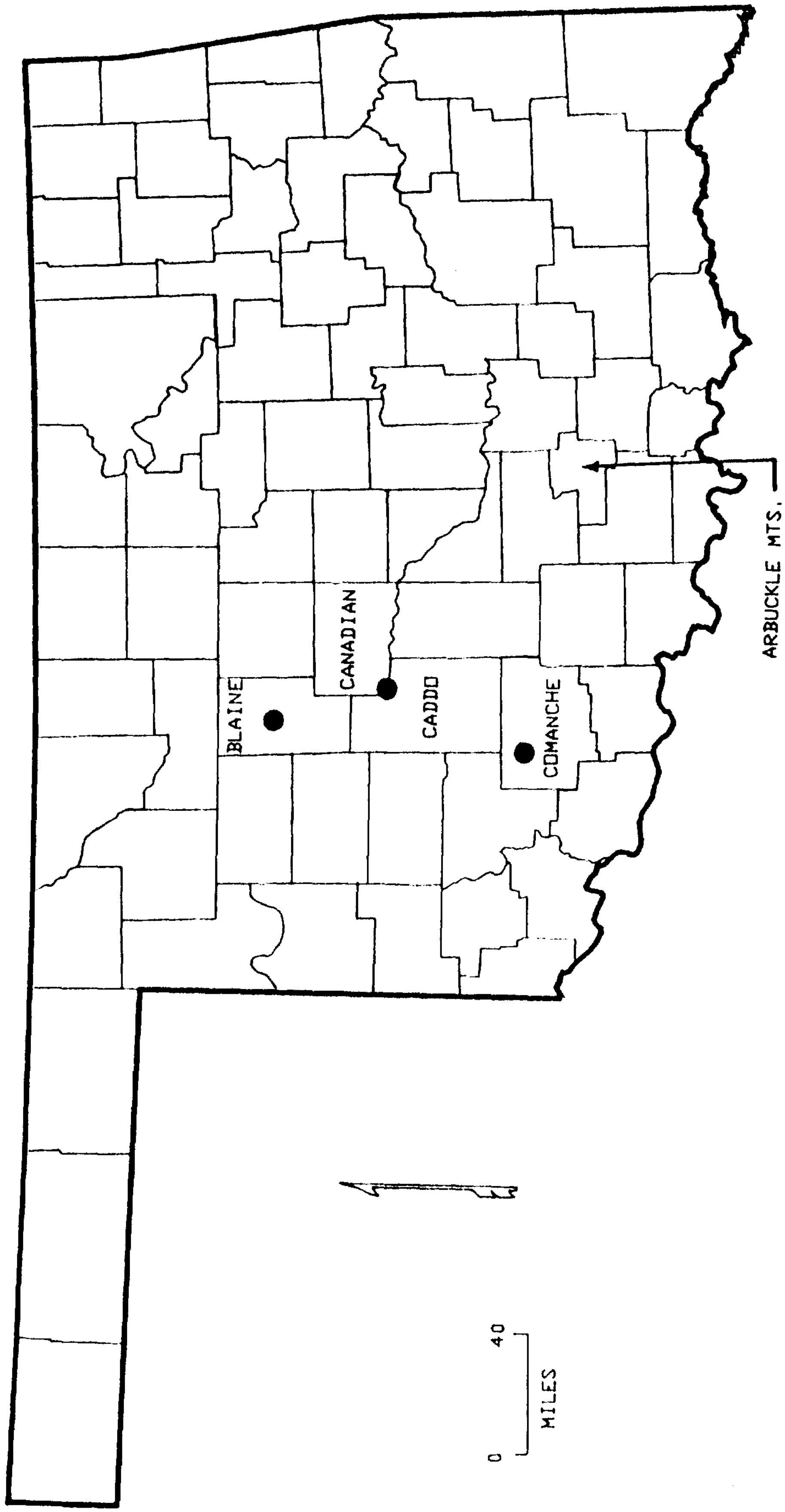


Figure 3. Current black-capped vireo distribution in Oklahoma.

Texas - Populations are still present in a number of localities in Texas, particularly on the Lampasas Cut Plains and Edwards Plateau (Figure 4, Table 1). The eastern and southern edges of the range follow the Balcones Escarpment closely from Waco (McLennan County) to Brackettville (Kinney County). However, the range is likely discontinuous across the Llano Uplift (Sexton et al. unpubl. MS), and deterioration of these populations may be extensive, particularly from north-central Texas south broadly to the San Antonio (Bexar County) Region.

Several hundred adults are known breeding on the Fort Hood MR, Bell and Coryell counties (Figures 4 and 5) (Tazik and Cornelius 1989). However, this may be the northernmost substantial group of vireos in Texas. Fewer than 100 adults were found in a detailed survey of the Austin area (Travis County) in 1990 (DLS Associates 1990). An additional 40-50 males were located northwest of Austin in the Post Oak Ridge area in 1989 (Sexton et al. unpublished MS).

About 450 adults were estimated in a 290 km^2 sample area in western Kerr County (Figure 4) during 1990 (Grzybowski 1990c) and probably form part of a larger population in that area. Between 18-26 territories were mapped at Lost Maples State Natural Area (SNA) (Figure 5), Bandera County, from 1989-1990 (Grzybowski 1990d, Bryan and Stuart 1990). Another 100+ males occupied an area focusing on the Kickapoo Caverns State Natural Area (SNA) (Figure 5), Kinney and Edwards counties (Stuart and Bryan, unpubl. data). The latter may form part of a more extensive metapopulation or series of populations south and westward in canyons traversing from the upper bend of the Rio Grande and including canyons of the Devil's River (Val Verde County) where 93 territories were mapped in 1990 (Bryan and Stuart 1990). The status of the vireo in this area is still not well determined, but appears more hopeful than in areas to the east.

The northernmost breeding locality currently known for Texas is in southwestern Dallas County. Three vireos were observed as recently as 1991 (Sexton et al. unpubl. MS and Randy Mock, in litt. 1991). They have not been observed along the Red River where they were common in the 1880's (Cooke 1888, Graber 1957), though detailed surveys have not been conducted. They have apparently declined substantially at Meridian State Park (Figure 5), Bosque County, since the 1970's. Although search efforts are very incomplete, few birds have been found in suitable appearing habitat in other areas (not mentioned above) from Bosque and Erath counties on the Lampasas Cut Plains south and west to Bexar and Uvalde counties on the Edwards Plateau (Sexton et al. unpubl.MS). Small groups of vireos may still exist in the Concho River Valley and tributaries near San Angelo (Maxwell 1979, Marshall et al. 1985, Maxwell in litt. 1991), and small numbers (from 12 to 16 birds) have also been detected in Big Bend National Park (Figure 5) from 1987 to 1990 (McKinney 1987, Barlow and Griffin 1988, Griffin and Barlow 1989, Neighbor 1990).

Population estimates for Texas are difficult to derive because of the variable and incomplete sampling and nature of the information. From 1985 to 1990, about 1,500 adult birds have been observed in Texas, summing only site maximums, or most recent counts for areas with multiple-year data (Sexton et al. unpubl.MS) (Table 2). Because the sex ratio is male biased (1 male: 0.73 females; Grzybowski 1988a), this probably corresponds to about 620 pairs.

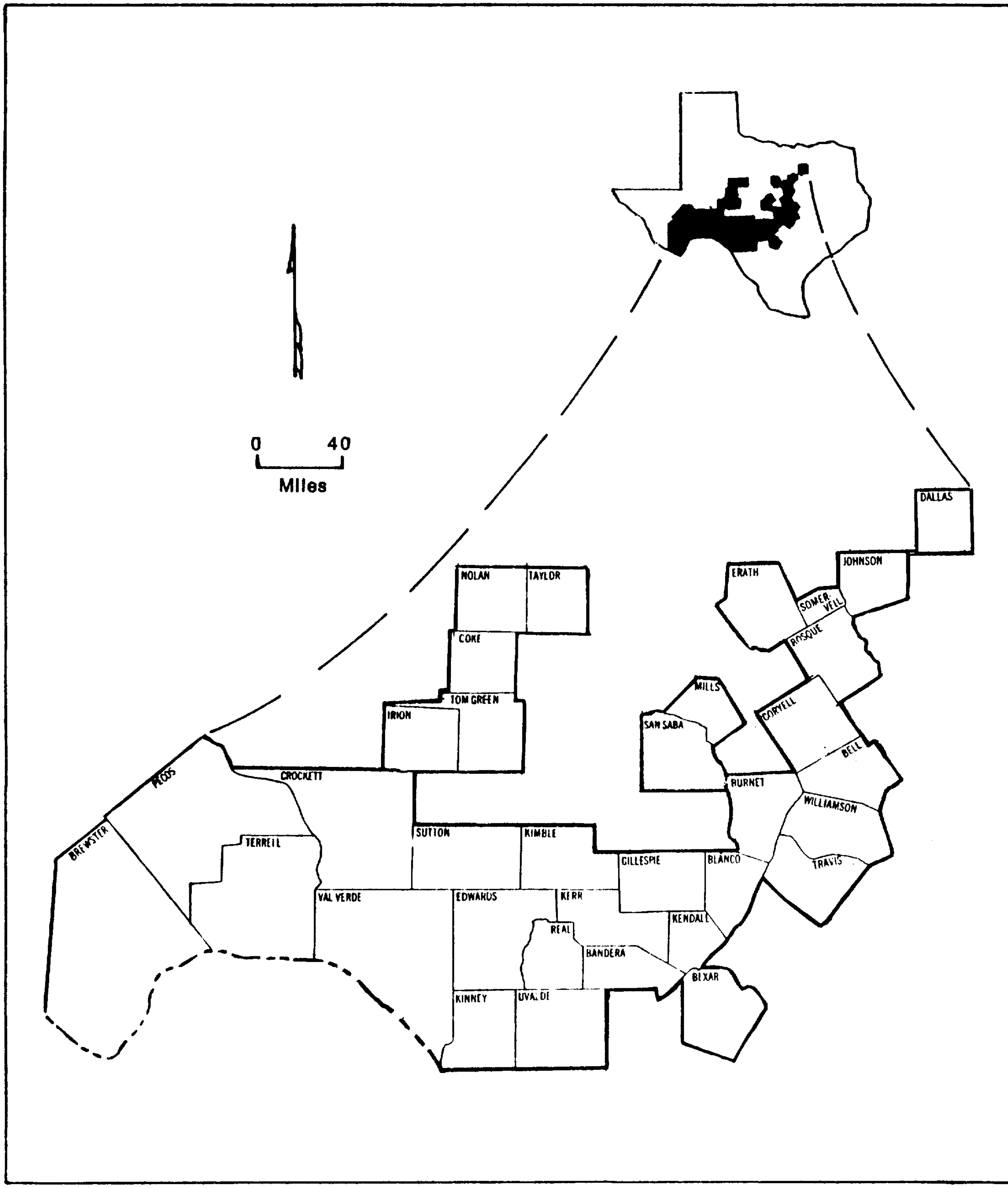


Figure 4. Texas counties known to be occupied by breeding black-capped vireo (Sexton et al. unpubl. MS) in 1990.

Table 1. Black-capped vireo recent (1970-1989) Texas localities.
(from: Marshall et al. 1985 and Sexton et al. unpubl. MS.)

County	Locality
Bandera	1) Lost Maples State Natural Area 2) Hill Country Natural Area
Bell	1) Fort Hood Military Reservation
Bexar	1) Friedrich Park 2) Camp Bullis
Blanco	1) along RM 2325 2) along Davis-Althaus Road
Bosque	1) Meridian State Park 1) Clayton SW Ranch
Brewster	1) Chisos Mountains 2) Big Brushy Canyon 3) Glass Mountains 4) Big Bend National Park
Burnet	1) Silver Creek Village 2) along RM 1869 3) Marble Falls
Coke	1) W. of Robert Lee 2) along RM 2034 3) along Texas 208 4) Callahan Divide
Crockett	1) Pecos River 2) Ft. Lancaster State Historic Park 3) Howard Draw 4) Fort Lancaster Ruins
Coryell	1) Fort Hood Military Reservation
Dallas	1) Dallas Nature Center
Jeff Davis	1) Davis Mountains
Edwards	1) FM 674 between Rocksprings and Kinney County line 2) Kickapoo Caverns State Park 3) N. of Barksdale 4) FM 2325 N. of Kinney Co. line

Table 1. continued

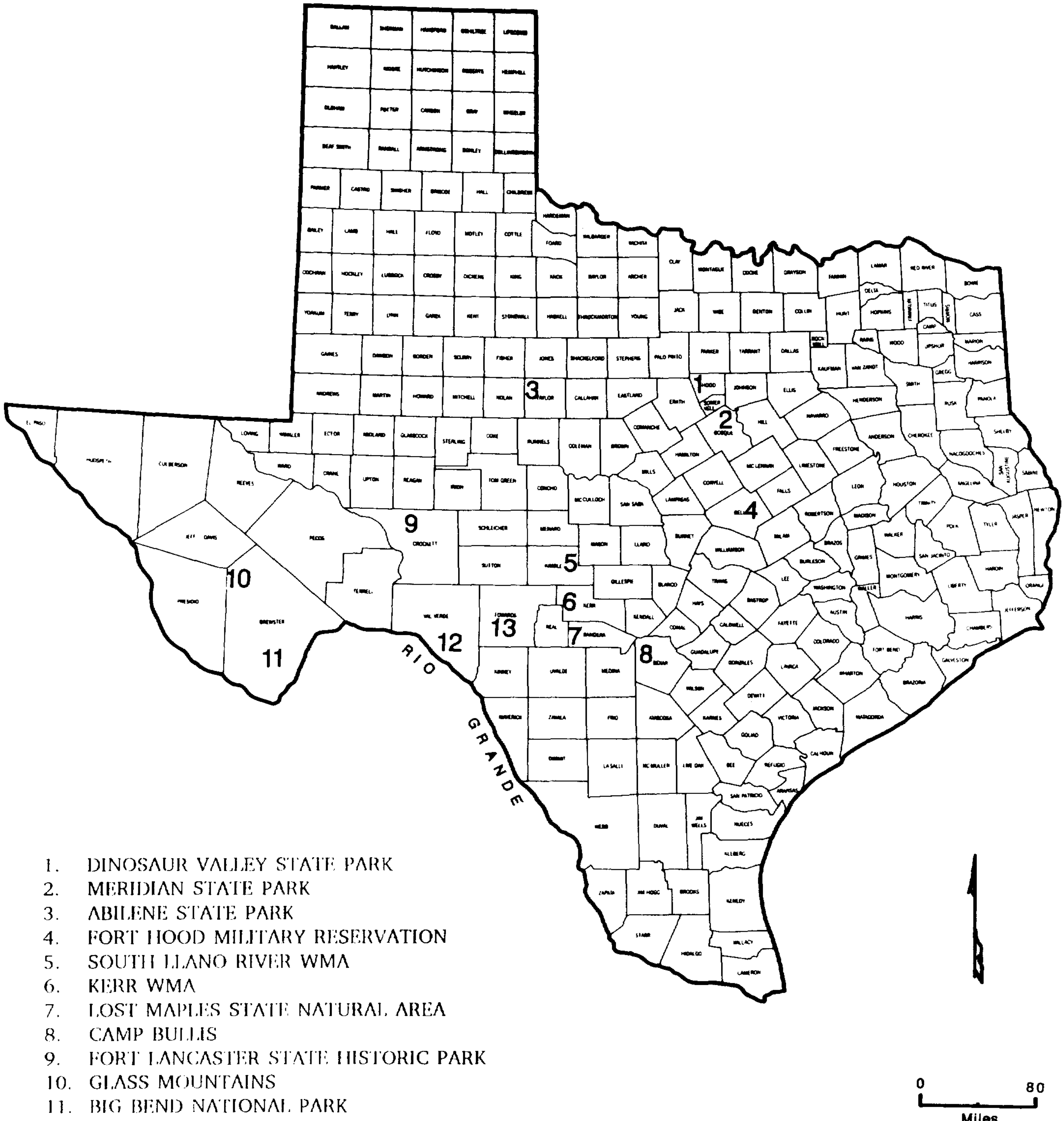
County	Locality
Erath	1) S. of Bluff Dale
Gillespie	1) NE Doss on HWY 783 2) Reservation Road near Kerr Co. line 3) W of Harper
Hamilton	1) West portion of County
Hays	1) Driftwood
Irion	1) Three localities
Kendall	1) North portion of County
Kerr	1) Auld Ranch 2) Eagle Nest Ranch 3) Elm Pass road 4) Kerr Wildlife Management Area a) Buck Pasture b) Rock Pasture 5) Lazy Hills Guest Ranch 6) Lion's/Shelton Ranch 7) Paradise Ranch 8) Reservation Road and vicinity 9) Rookery site 10) South Fork Ranch 11) Spicer Ranch 12) YO Ranch 13) Priour Ranch 14) Dewberry Hollow
Kimble	1) Junction area 2) Walter Buck Wildlife Management Area 3) S. Llano River State Park 4) along US 290 5 mi E of I-10 5) along RM 479 3 mi E. of I-10
Kinney	1) Kickapoo Caverns State Park
Lampasas	1) no specific location
Midland	1) no specific location
Mills	1) along RR 2005 6 mi E of Goldthwaite

Table 1. continued

County	Locality
Nolan	1) Callahan Divide
Pecos	1) Road side rest stop along US 285 35 mi S. of Ft. Stockton
Real	1) W of Garvin 2) Auld Ranch 3) Eagle Nest Ranch 4) South Fork Ranch
San Saba	1) Colorado Bend State Park
Sommervell	1) Dinosaur Valley State Park 2) Chalk Mountains 3) Picnic area along HWY 67
Sutton	1) 4.3 mi S of Sonora on US 277
Taylor	1) Abilene State Park NW on US 277
Terrell	1) mouth of Independence Creek 2) Sanderson Canyon 5 mi W of Sanderson
Tom Green	1) South Ranch in N Tom Green Co. 2) Near Coke County line
Travis	1) Wild Basin/Davenport Ranch 2) Comanche Trail/Four Points/ Steiner Ranch/Mansfield Dam 3) Gainer Ranch 4) The Parke 5) Hudson Bend/N shore Lake Travis/ S. Jonestown 6) Uplands Development 7) Ball Creek Knolls 8) Nameless Valley Ranch 9) City Park Road 10) Post Oak Ridge
Uvalde	1) along TX 127 2 mi E of Frio River 2) Neal's Lodge at Concan 3) S facing hillside on HWY 1050 W of Utopia
Val Verde	1) Howard Draw N of Pandale 2) TX 163 crossing of Devil's River S of Juno 3) Devil's River State Natural Area

Table 1. continued

County	Locality
Jim Wells	1) as migrant, no specific location
Williamson	1) SW extreme section of Co. near Travis Co. line 2) Gainer Ranch Travis-Williamson Co. line
Zapata	1) as migrant, no specific location



1. DINOSAUR VALLEY STATE PARK
2. MERIDIAN STATE PARK
3. ABILENE STATE PARK
4. FORT HOOD MILITARY RESERVATION
5. SOUTH LLANO RIVER WMA
6. KERR WMA
7. LOST MAPLES STATE NATURAL AREA
8. CAMP BULLIS
9. FORT LANCASTER STATE HISTORIC PARK
10. GLASS MOUNTAINS
11. BIG BEND NATIONAL PARK
12. DEVIL'S RIVER STATE NATURAL AREA
13. KICKAPOO CAVERNS STATE NATURAL AREA

Figure 5. Locations of some key sites mentioned in the text.

Table 2. Numbers of black-capped vireos counted by state and region (1985 to 1990).

State/Region	Numbers counted
Kansas	0
Oklahoma	
Blaine Co.	12
Caddo-Canadian Cos.	1
Wichita Mountains	225
	238
Texas*	
North-central Texas	10
Lampasas Cut Plains	463
Edwards Plateau	771
Concho Valley	22
Southwest Edwards Plateau	192
Trans-Pecos (Brewster Co.)	19
	1,477
Coahuila, Mexico	28+

* from Sexton et al. unpubl. MS

Coahuila, Mexico - The vireo is believed to occupy a rich, dense, desert shrub flora at the north base of several mountain ranges, and up a mile or so into the north-flowing canyons in the northern part of the state south to Sierra San Marcos (Marshall, in litt. 1991) (Figure 6). Extensive habitat has been noted in some areas of northern Coahuila, and substantial population(s) may exist in these areas. Marshall et al. (1985) observed 21 male vireos in incomplete surveys of areas that could support more. Marshall (in litt. 1991) also believes that this population extends along the north base of the Encantada range throughout a mining area, which is fenced off from livestock (cattle, sheep, and goats). He believes that this population could contain several hundred pairs. Benson and Benson (1990) recently published an estimate for northern Coahuila of 3,139-9,463 pairs ($P<0.1$). They assumed that all canyons in that area contained some suitable habitat and were occupied. However, few (28) birds were actually observed by Benson and Benson. For discussions on the accuracy of their estimates see Scott and Garton (1991) and Benson and Benson (1991).

Current wintering range: Few observations have been reported for wintering areas in Mexico. Most recent observations have come from Durango, Sinaloa, Nayarit and Jalisco (Graber 1957, Marshall et al. 1985, Harden pers. comm., Hutto pers. comm., Rowlett pers. comm.) (Figure 2). None of these observers found many individual vireos, even though Graber and Marshall specifically searched for them. Marshall (in litt. 1991) comments that the "winter birds are extremely shy of taped breeding season songs."

A few scattered winter records exist for Guerrero and Oaxaca, and one for southern Sonora (Marshall et al. 1985). The relations between populations on the wintering and summering grounds are not known.

Migration routes: Few records exist. Those that do imply northward migration through southern Coahuila, Nuevo Leon, and western Tamaulipas. Marshall et al. (1985) mapped all known migration records, which indicate migration around the Mexican Plateau -- clockwise in the fall; counter-clockwise in the spring.

Observations during the fall migration period overlap the wintering or breeding areas, and may indicate birds that have not departed or already arrived on summering and wintering areas, respectively.

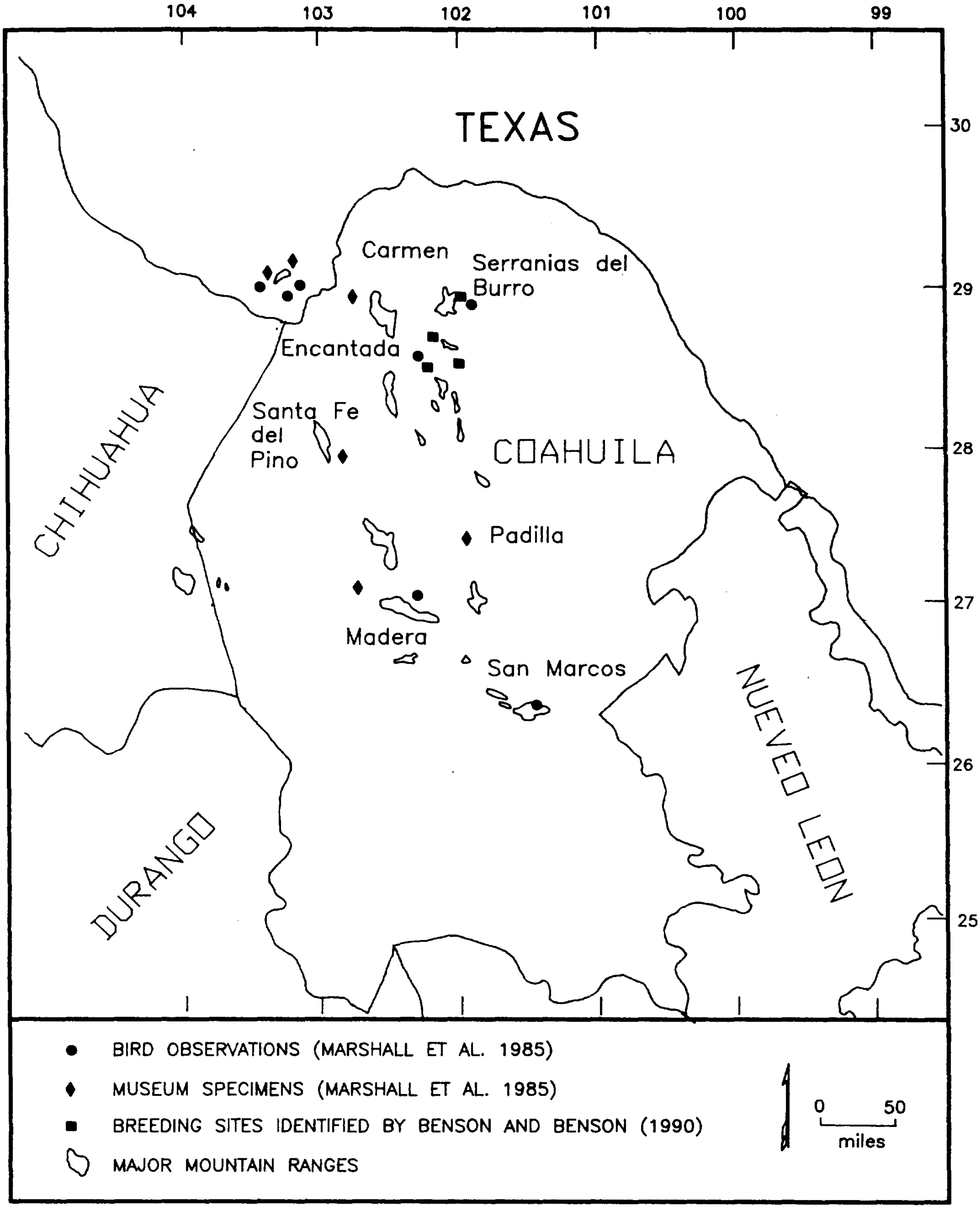


Figure 6. Northern Coahuila, Mexico, showing mountain ranges that may provide black-capped vireo habitat. Symbols indicate location of museum records and sightings (Benson and Benson 1990, Marshall et al. 1985).

D. LIFE HISTORY

Migration Phenology: Black-capped vireos arrive in Texas from late March to mid-April (late April in dry years). They arrive in Oklahoma from mid-April to early May (mid-May in dry years) (Graber 1957, Grzybowski pers. obs.). The vireo usually migrates southward from Oklahaoma by late August-September and from Texas by mid-September. Adult males arrive before females and first-year males, and depart after females and young in fall (Graber 1957, Oberholser 1974, Grzybowski pers. obs, O'Donnell pers. obs.).

Distribution pattern: Vireos' territories are often clustered in patches of suitable habitat. Larger groupings of 15 or more territories in Kerr County, Texas, and in the Wichita Mountains, Oklahoma, contained proportionately more ASY (after second calendar year) males than smaller groupings. Conversely, the smaller groupings (usually fewer than 10 territories) contained proportionately more SY (in second calendar year) males (Grzybowski 1990d, unpubl data). Reproductive success is greater in the larger than the smaller groupings. Males from the smaller groupings have been observed moving to the larger groupings within and between seasons, but none have been noted moving in the opposite directions (Grzybowski 1989a, 1990b,d). This pattern may cluster birds non-randomly in some areas.

Clusters of 20 or more territories have been observed at Kerr WMA, in the Austin area, and in the Wichita Mountains (Grzybowski 1988a, 1989a, 1990b,c). The clusters of territories were smaller on Fort Hood MR (Tazik and Cornelius 1989) and Kickapoo Caverns SP (Stuart and Bryan unpubl. data) although these areas have relatively large populations, perhaps indicating that patches of suitable habitat were smaller in these areas.

Territory size: Documented at between 1 and 10 acres, mostly 2-4 acres (Graber 1957, Tazik and Cornelius 1989).

Nesting (sources include Graber 1957, Grzybowski 1985a, 1986, 1988a, 1989a, 1990d, pers. obs., O'Donnell pers. comm.): Nesting begins when the females arrive and continues through August. Nest-building requires 2-5 days; usually 2-3. Male and female start the nest; the female finishes. Bachelor males build nest platforms. The platform function is unclear, but it may help attract females. Complete clutches have been found as early as April 4 in Texas (Austin) and April 30 in Oklahoma. The latest known nesting start (i.e., beginning of nest construction) is July 21.

The clutch contains 3-4 white eggs. Four eggs are usually laid in the first two nesting attempts, but only three eggs may be laid in later clutches. Seasonal clutch size is unknown but is likely between 12-20 eggs (as in many other passerines) allowing for up to six nesting attempts per nesting season. One egg is normally laid per day. The first egg is usually laid one day after completion of the nest. The male vireo guards the nest considerably during this period.

Incubation requires 14-19 days, usually 15-16 days. Incubation is lengthy; most small passerines with open-cup nests incubate 10-14 days. Incubation usually begins with the second or third egg and is shared by male and female (female incubates at night).

The nestling stage lasts 9-12 days, but is usually 11 days. The young born naked and blind, are fed by both adults. Females brood the young for 4-6 days after hatching and do most of the nest sanitation and removal of ectoparasites. Fledgling stage (when young have left the nest but are attended by adults) is 30-45 days (occasionally to 52 days). This stage is longer than in most other passerines. The young may leave the nest 1-2 days before they can fly. They may be attended by the male alone, the female alone, or both parents. The parents may split the brood, and each care for several young. The female may leave care of the young to the male and attempt another nesting effort or she may desert the male to remate with another male. Females may also desert a male after an unsuccessful nesting attempt and remate with another male. Males will often keep the young within the confines of their territories, but females attending young often wander off the male's territory.

Vocalizations: Primary songs of males are a complicated series of modestly melodious phrases. Seasonal variation is likely in repertoire selection. Some males have individually recognizable notes in their phrases. Variation in repertoire is greater than that in most other vireos, except the dwarf vireo (Barlow 1981, Marshall et al. 1985).

Males begin developing rudimentary songs when 20-30 days out of nest. One male about 55 days out of nest was heard countersinging with a territory-holding adult and could not be readily distinguished from this adult male (Grzybowski pers. obs.).

Other vocalizations include more complex whisper-songs of males, muttering notes (both males and females), distinctive alarm calls described as "shradding" by Graber (1957), and also a light chatter call very similar to that of a ruby-crowned kinglet (Regulus calendula).

Band returns (as indicators of survivorship): Annual returns of males in the larger groupings have been documented between 60 and 70% and indicate relatively high survival for a small passerine. Returns of adult females and males in smaller groupings, however, is lower, about 39-61% (Grzybowski 1989a, 1990a,b,c). Survival of females may be lower. More males are detected than females, and about 69-76% of males are mated (Grzybowski 1988a, 1989a, Tazik and Cornelius 1989). However, site fidelity is also greatest for males in the larger groupings, and the differences in return percentages may reflect off-site dispersal, particularly for SY males in the smaller groupings (Grzybowski 1989a, 1990a,b,c). Dispersing birds, however, may place themselves at higher risk, and thus have lower survivorship.

Limited data are available for return of hatch-year birds. Only about 14-23% of the young are detected the following season (Grzybowski 1990b,c). However, this group is the primary dispersal component of vireo populations and is the most likely to disperse off-site and thus evade detection. A preliminary estimate of juvenile returns at the Kerr WMA, generated from a broad scale search of adjacent ranches, was 35-52% and approached that of females (Grzybowski 1990c). However, more data on survivorship, particularly for females and young, are needed to establish more useful estimates.

Dispersal: Adult males breeding in the larger groupings exhibit the greatest site fidelity, returning to virtually the same territory, and have never been detected moving to another location in subsequent years. Females in the larger groupings exhibit the next greatest site fidelity, more frequently moving among territories both within and between seasons (Grzybowski 1989a, 1990d, unpubl. data). Males and females breeding in the smaller groupings have been detected at new localities in subsequent years. Tazik and Cornelius (1989) observed 4 of 85 returning males (4.7%) and 4 of 21 females (19%) undergo dispersals of 5.7 to 24 and 1.2 to 28 km, respectively, on Fort Hood. One female in Travis County moved 10 km (DLS Associates 1989a). Grzybowski (1989b) has detected males moving up to 8 km in the Wichita Mountains. Hatch-year birds have been detected between 0.15 and 21 km distant from their natal territory the following or subsequent seasons. Mean dispersal distance for returns at Kerr WMA (3.72 km, S.D.=4.15, Grzybowski 1990c) is an underestimate because some dispersing birds are undetected. More data and additional analyses are needed.

Behavior on wintering grounds: Little is known about behavior on the wintering grounds. Marshall et al. (1985) found the bird very secretive, retreating very quickly after an initial approach to taped calls. Encounters by other individuals have been equally brief (Arvin pers. comm.; Hutto pers. comm; Rowlett pers. comm.).

E. HABITAT

General characteristics of breeding habitat: The black-capped vireo breeds in shrubby growth of a forest-grassland ecotone from Kansas (formerly) to Coahuila, Mexico. Breeding vireos use shrubby growth of irregular height and distribution, with spaces between the small thickets and clumps, and with vegetation cover extending to ground level (Graber 1961). From Oklahoma through most of Texas, this type of vegetational configuration occurs most frequently on rocky substrates with shallow soils, in rocky gullies, on edges of ravines, and on eroded slopes.

Shrubland habitat can be successional and pass through periods of suitability and unsuitability for the vireo. How long it can remain suitable will likely depend on a number of factors affecting vegetation structure, including underlying geology, soil type, slope, and species composition. The extent and height of this habitat may also be determined by secondary factors such as fire, grazing, or other forms of periodic site disturbance (Graber 1961). This process, however, is not well studied.

Structural characteristics of breeding habitat: While restricted to essentially shrubland areas, habitats occupied by vireos nonetheless vary considerably in vegetational characteristics. Vireo territories and non-vireo shrubland plots were sampled from the Wichita Mountains, Lampasas Cut Plains, and the central Edwards Plateau. Analysis revealed that a factor common to the vireo territories, and distinguishing them from non-vireo plots, was a high density of deciduous vegetation from 0 to 3 m (Grzybowski et al. unpubl. MS).

The analysis sampled a habitat gradient ranging from maturing shrubland habitats to more open areas. The vireos occupied semi-open habitats in the middle of the gradient (established by a first Principal Component) indicating the analysis had accurately identified the range of suitable habitats. The average amounts of deciduous cover among three regions varied from 30 to 50%. Total woody cover (including junipers) was about 36 to 53%.

Low deciduous cover was the key element in vireo habitat, but three other characters or suites of characters were of secondary importance and related to maintaining this primary component. One secondary character was greater within-territory heterogeneity in vegetation structure than on non-vireo plots. The primary component of this heterogeneity was the number of changes between woody vegetation and openings or separations between bushes, as well as within-territory variance in other deciduous variables. This characteristic occurs where bushes in an irregular matrix become more closely spaced, but still separated, and can thus have the best light penetration, and provide dense deciduous cover in the lower height zones. This heterogeneity may also set the upper limits of acceptable total woody cover.

Juniper cover (another secondary character) averaged from 3 to 6% in the different regions. On the portion of the gradient with greater deciduous and juniper cover, vireos occupied habitats with fewer junipers (regional averages of 3 and 5% juniper cover compared to 6 and 11%, respectively, in non-vireo plots for these regions). At least three other independent analyses have also indicated that junipers are underrepresented in vireo territories relative to non-vireo plots, and that vireos use junipers for nesting much less frequently than they occur in their territories (Grzybowski 1986, Tazik and Cornelius 1989, Tazik et al. 1989). Vireos may be indifferent to the presence of junipers, but the presence of junipers may reduce the key element--deciduous vegetation in the lower height zones. In Travis County, Texas, some "poorer" quality vireo territories with noticeably more juniper were larger in area (DLS Associates 1989a) than higher quality vireo territories elsewhere with fewer junipers.

The third character of secondary importance was openness. Deciduous vegetation in the lower height zones appears to be maximized where total woody cover is between 35 and 55%, leaving 45 to 65% open. However, the form of this openness was heterogeneous and related to maintaining spacing between individual bushes.

Floristic components of breeding habitat: Though the vireo's range is relatively small compared to many other passerine species, a wide diversity of plant species can provide suitable vegetational structure. No single plant species dominated most of the localities containing vireos, though oak was the most frequently encountered taxon.

In Oklahoma, blackjack oak (Quercus marilandica) was the most abundant plant species. Post oak (Q. stellata) was also an important component in this area. In contrast, however, oaks were entirely absent at one eroded site (Blaine County). A diversity of non-oak taxa replaced the oaks (Grzybowski 1986, unpubl. data).

On Fort Hood, Texas, shin oak (Q. sinuata var. breviloba) occurred more commonly in vireo territories than in non-vireo plots (Tazik et al. 1989). At Kerr WMA, Texas, shin oak was the most common species in vireo territories (Grzybowski 1986). Plateau live oak (Q. fusiformis) was of secondary importance. Various oak species figure importantly in the southwestern portion of the range. Quercus mohriana is reported to be a key indicator of black-capped vireo habitat in the Concho Valley region (Terry Maxwell, Professor, Angelo State University, in litt. 1991) A dwarf form of wavy-leaf oak (Quercus undulata) and evergreen sumac (Rhus virens) were the most common woody plants in black-capped vireo habitat in Coahuila (Graber 1961).

Nest sites: Nests are placed in small forks of bushes. Different species are used in different areas, but the frequently used species are deciduous. Blackjack oak was the most frequently used species in Oklahoma, shin oak on the Kerr WMA in Texas, sumac (Rhus spp.) species in the Austin area (Grzybowski 1986), shin oak and Texas oak (Q. buckleyi) on Fort Hood MR (Tazik and Cornelius 1989), Texas persimmon (Diospyros texana) on Kickapoo Caverns SP (Bryan and Stuart 1990), and Texas mountain laurel (Sophora secundiflora) at Devils River SNA and Lost Maples SNA (Bryan and Stuart 1990). Most nests were between heights of 40 and 120 cm in the zone of densest deciduous vegetation.

Habitat distribution: There are no estimates of the historical or recent amount and distribution of vireo habitat. Several studies employing LANDSAT imagery and attempting to obtain these estimates have met with disappointing results (Shaw et al. 1989a,b, Shaw 1989). Geographic Information Systems (GIS) have been used by the BCCP (Balcones Canyonlands Conservation Plan) Committees (Butler/EH&A Team 1991) to delimit areas potentially capable of maintaining vireo habitat on the basis of geologic substrate, slope, aspect, and soil depth. However, areas with habitat could not be extracted, and this process is untested. Aerial photographs have been used to subjectively assess areas with potential vireo habitat and may prove more useful if information can be digitized.

Fire: In areas that undergo relatively rapid succession, fire may play a role in maintaining black-capped vireo habitat. The time from previous fire disturbance to initial re-ocupancy by vireos has not been well documented and likely depends on location and site. Occupied areas that had been substantially burned in the Wichita Mountains were fully recolonized the second year after the burn.

In areas that may generate vireo habitat, fire appears to retard invading junipers and enhance regrowth of fire-adapted Quercus and Rhus species. Vireos were commonly found on sites subjected to burns (Graber 1957). The largest population groupings in the Wichita Mountains, Fort Hood MR, Kerr WMA, and Austin occur in areas recovering from significant burning. Benson and Benson (pers. comm.) noted that suitable areas in Coahuila were subject to regular wild fires, creating dense low oak growth. Other forms of disturbance may provide adequate substitutes for burning, but fire may be an important management tool in some areas.

However, some areas of black-capped vireo habitat are relatively stable. Fire will not be an appropriate tool in all black-capped vireo areas. Determinations will have to be made on a site-by-site basis. Additional study is needed for use in making these determinations.

Geology and soil: The appropriate vegetational configuration appears to occur most frequently in areas with eroded gullies, poor soils, or rocky substrates. Sexton et al. (unpubl. MS) appears to have found a link between occurrence of black-capped vireos and Fredricksburg limestone in Texas. Graber (1961) comments that vireos in the Sierra Madera in Coahuila were found only on dry limestone hillsides. This association with limestone does not persist in Oklahoma where the vireo has been found on a variety of soil types and other geologic substrates (Grzybowski, pers. obs.).

Although geology and soil are a step removed from the most proximate feature of vireo habitat--namely vegetational configuration--certain geologic substrates, soil, and features of topography are more likely to maintain suitable vegetational configuration and structure. This association needs to be investigated more thoroughly.

Wintering habitat: Very little is known of the vireos' winter habitat on the Pacific slope of Mexico. Graber (1961) describes two somewhat disparate habitat types used by wintering vireos--arid scrub 1-3 m tall and an incredibly diverse, luxuriant and more mesic cut-over second growth forest. Both habitats, however, contained low deciduous growth. Marshall et al. (1985) found the vireos on higher, drier slopes. Hutto (pers. comm.) located his only bird in the more luxuriant subtropical forest. Harden (pers. comm.) found a bird in an area of cane.

F. THREATS/REASONS FOR LISTING

Population decline: The black-capped vireo has undergone a substantial reduction in range since documentable times. Fragmentation and reduction of numbers within the current range has also occurred. The black-capped vireo no longer nests in Kansas. Its range has been reduced to three locales in Oklahoma, and it will likely occur in only two, possibly one, of those shortly; it is secure in none of these areas. This vireo is likely extirpated from much of its former range in north-central Texas and soon may become extirpated on the southeastern edge of the Edwards Plateau (i.e., Bexar, Comal, and adjacent counties) (Graber 1961, Marshall et al. 1985, Grzybowski et al. 1986, Sexton et al. unpubl.MS). These areas with extirpated or declining populations comprise over 50% of the historical range.

To the west, it is not well studied, but numbers are more encouraging at several localities in the southwestern portions of the Edwards Plateau (Stuart and Bryan unpubl. data). Few have been observed in Coahuila, Mexico, but large areas of suitable-appearing habitat have been reported (Graber 1961, Marshall et al. 1985, Benson and Benson 1990). However, numbers observed in Big Bend and in the Concho Valley area near San Angelo are small (Maxwell 1979, Marshall et al. 1985, McKinney 1987, Barlow and Griffin 1988, Neighbor 1990). There the vireo appears to be at the western limits of its potential range, and birds in those areas may be the outliers of current viable populations, parts of deteriorating populations, or parts of larger populations still undetected.

Reproductive success: Reproductive success is low at sites investigated in Oklahoma and on the central Edwards Plateau. No young were produced by the vireos monitored in Caddo and Canadian counties, Oklahoma, from 1984 to 1989 where cowbird parasitism was not controlled (Grzybowski 1985b, 1989a,b). Adult numbers were already very low in 1985 (13), and only one male could be found in 1990 (Grzybowski 1990a). No young were produced during two of three years of monitoring in Blaine County, Oklahoma without human intervention (in the form of removal of cowbirds and/or their eggs). In the third year, 8-10 young were produced by four females (Grzybowski 1989c). Reproductive success without human intervention in the Wichita Mountains averaged 0.94 young/female from 1986-1990 (Grzybowski 1990b). At the Kerr WMA, Texas, reproductive success without human intervention was 0.66 young/female from 1985-1988 (Grzybowski 1988a, 1990d).

Annual population change (R), growth rate, can be estimated by the formula: $R=fj+a$, where "f" is annual fecundity (number of female young produced/adult female/year), "j" is annual juvenile survivorship rate, and "a" is annual adult female survivorship rate. For stable populations, $R=1$. Pooling band returns of adult females (Grzybowski 1990a,b,c) provides an estimate of minimum female survivorship of 0.47. Using values 0.2 (approximate observed juvenile survivorship) and 0.44 (possible juvenile survivorship; Grzybowski 1990c), a stable population would have to maintain a fecundity of 2.65 and 1.20 female young produced/adult female/year, respectively (5.3 and 2.4 total young, respectively) to maintain a stable population. Although only minimum adult female survivorship is estimated from band returns, the reproductive success observed without human intervention is far below that required for population stability. At productions of one young produced/adult female/year (0.5 female young), female survivorship would need to be 0.90 or 0.78 if juvenile survivorships were 0.2 and 0.44, respectively. The calculated female survivorship rates are much higher than those observed among wild females, and also higher than those observed in wild males. Thus, natural production in these areas was clearly deficient.

Low recruitment (number of young entering the breeding population): Estimates of reproductive success and survivorship are subject to biases, including the potential depressing influence of investigators on reproductive success, difficulty in counting young already fledged, and the inability to detect individual banded birds dispersing off study sites (which will lower estimates of survivorship). However, the proportion of SY males (pSY), which are males in their first potential breeding season, to total number of SY plus ASY males can be used as an estimate of recruitment (i.e., PSY = SY/(SY+ASY) = an estimate of recruitment). It is not a perfect estimate because many SY males are unmated. In stable populations, adult male survivorship plus pSY should equal one. Using the higher (and perhaps optimistic) estimates of adult male survivorship from the Wichita Mountains and the larger grouping at Kerr WMA (0.71) (Grzybowski 1990b,c), the expected pSY in a stable population should approximate at least 0.29.

Observed pSY for populations or groups without or before management have been lower, much lower in some instances. No SY males have been detected in the Caddo-Canadian counties area in Oklahoma during the monitoring period from 1984-1990 (Grzybowski 1989a, 1990a). In the Wichita Mountains, pSY was 0.19 (from a sample of 42 birds) in 1987, a year after initial management actions were begun (Grzybowski 1989a). Initial estimates for the Davenport Ranch site in Austin showed only 0.05 pSY males; for the Kerr WMA, 0.21 pSY males; for the South Fork Ranch in Kerr County, 0.19 pSY males (Grzybowski 1988a, 1990d). On Fort Hood MR, pSY was 0.11 during a period of management (Cornelius, pers. comm.). An estimate from Devils River State Natural Area, Val Verde County, Texas, was 0.31 in 1990; from Kickapoo Cavern State Park was 0.36 in 1990 (0.14 in 1989); and from Lost Maples State Natural Area was 0.17 in 1990 (Bryan and Stuart 1990).

In west-central Oklahoma and the Austin, Texas, area, where vireo numbers are seriously declining, pSY was very low (0, and 0.05, respectively). On Fort Hood MR, the estimate was also low. For the Wichita Mountains and Kerr County, where natural reproductive success was about one young/female/year, pSY was higher -- 0.19-0.21 -- but still below that expected for a stable population. Only in Val Verde, Kinney, and Edwards Counties did the estimated pSY achieve that expected for a stable population. Thus, in data collected from a substantial portion of the range, recruitment did not achieve levels expected for a stable population and is generally consistent with conclusions from reproductive success.

However, according to Tazik (in litt., 1991), on Fort Hood more SY males were located during 1991, in conjunction with surveys for the golden-cheeked warbler. They were found in areas where the vireos had not ordinarily been searched for in the past. Thus, Tazik believes the pSY of 0.11 observed on Fort

Hood during 1987-1989 is undoubtedly low. The usefulness of pSY as an index of population status and stability needs to be further evaluated.

Nest parasitism by Cowbirds: In recent times, three cowbird (Molothrus spp.) species have shown dramatic increases in numbers and range across this hemisphere (Friedmann 1929, Grinnel and Miller 1944, Mayfield 1965, Post and Wiley 1977a, Dolbeer and Stehn 1979, Brittingham and Temple 1983, Cruz et al. 1985). Breeding bird surveys conducted by the U.S. Fish and Wildlife Service show that brown-headed cowbirds (M. ater) are more abundant in mid-continent areas (which includes the southern Great Plains) and their numbers are increasing (Robbins et al. 1986). The brown-headed cowbird has expanded its range and numbers north, east, and west of its traditional mid-continental range (Snyder 1957, Friedmann 1963, Mayfield 1965, Hanka 1985) and is now breeding south into peninsular Florida (Paul 1989).

The bronzed cowbird (M. aeneus) has also been increasing and expanding its range from Texas into Louisiana and Florida and west in California (Grzybowski 1987, Paul 1989). The shiny cowbird (M. bonariensis), since its arrival as an exotic in 1860 (Newton 1860), also has spread across the Antilles (Cruz et al. 1985) and is now invading the southeastern United States (Langridge 1989, LeGrand 1990, Jackson 1990). Shiny cowbirds were observed in Texas and Oklahoma in 1990 (Grzybowski and Fazio 1991).

A number of factors may be involved in the increase in cowbirds. These factors range from an increase in suitable cowbird habitat beginning in colonial times with the opening of the forests (Friedmann 1929, Mayfield 1965) to increased urban development, grazing impacts, and a speculated higher overwinter survival caused by favorable habitat conditions during winter due to rice fields, feed lots, etc. (Brittingham and Temple 1983). Whatever the causes, the impacts are being felt by the black-capped vireo and other species such as the Kirtland's warbler (Dendroica kirtlandi) (Mayfield 1960, Walkinshaw 1983), least Bell's vireo (V. bellii pusillus) (Goldwasser et al. 1980, Franzreb 1989), and yellow-shouldered blackbird (Agelaius xanthomus) (Post and Wiley 1977b).

Early this century, Bunker (1910) commented that black-capped vireos were frequent victims of nest parasitism by brown-headed cowbirds (M. ater). Graber (1957), the first to quantify cowbird impacts on the vireo, found that 50% of the eggs, (49% of the nests; Graber unpubl. data) were affected by cowbird parasitism in Caddo County, Oklahoma during the mid-1950's. In the 1980's, more than 70% of the nests were parasitized across the range examined. At some localities in some years, parasitism exceeded 90% for fairly large samples (Grzybowski 1990c, Tazik and Cornelius 1989). This parasitism has been credited for the alarmingly low annual pair success, which has been much less than one young per pair at a number of sites studied in Texas and less than 0.5 young per pair for areas in Oklahoma (Grzybowski 1985b, 1988a, 1989a,b,c, 1990b,d).

The bronzed cowbird has been recorded only once as a parasite in black-capped vireo nests (Bryan pers. comm.). However, the first shiny cowbirds detected in Texas and Oklahoma appeared in black-capped vireo nesting areas (Grzybowski and Fazio 1991, Lasley and Sexton 1990).

Nest parasitism shows annual variation. Even at sites with high parasitism, parasitism may drop to 50 or 60% some years (Grzybowski 1990c). This variation may allow for higher production in those years, but it may simply slow the rates of decline in vireo populations. Average annual parasitism is still relatively high, and average reproductive success is still less than that needed to maintain populations in many areas even assuming optimistic survival rates (Grzybowski 1986, Pease and Gingerich 1989).

Cowbirds have been noted laying from 1-4 eggs in vireo nests (Grzybowski 1985a, Tazik and Cornelius 1989). One egg is optimal for cowbird survival because the vireo nests (with few exceptions) are too small to accommodate more than one cowbird beyond age 5 days. Where cowbirds are more numerous, however, the number of nests with multiple cowbird eggs in them increases.

Cowbird egg incubation time is 10-12 days, usually 11. Time from hatching to fledging is 10-11 days. Cowbird young leave their foster parents 14-20 days after fledging (Friedmann 1929).

Cowbirds interfere with vireo nesting in one or more of the following ways:

a) Cowbirds lay an egg in the vireo nest. Because incubation time of the cowbird egg is 4-5 days less than that of the vireo, the cowbird young is much larger than the vireo young (if the vireo eggs even hatch). Thus, no vireo young can be produced from a parasitized nest unless the cowbird egg is infertile or laid late in the vireo's incubation period.
b) Cowbirds often remove a vireo egg for every cowbird egg they lay.
c) Vireos may attempt to complete a full clutch of four vireo eggs (although laying more than four) despite the presence of a cowbird egg(s). The remaining vireo eggs may be spaced farther apart in time than in a normal egg-laying sequence. If cowbird eggs are infertile, or are removed, the most recently laid vireo eggs may not be incubated long enough to hatch, thus reducing brood size (Grzybowski pers. obs.).
d) Cowbirds may poke tiny holes in the vireo eggs they do not remove (intentionally, or in attempts to remove them).

The black-capped vireo's small size precludes several options, including physically deterring the cowbirds or ejecting cowbird eggs. Defense from parasitism is limited and includes the following:

a) Vireos may abandon parasitized nests. Tazik and Cornelius (1989) recorded 37% of nests were abandoned and credited 28% to parasitism. Abandoning nests may reduce the impact of parasitism, as a portion of the renesting will be unparasitized.
b) Vireos may bury the cowbird egg with nesting material. This has been observed on several occasions and can occur when the cowbird egg is laid before completion of the nest lining (Grzybowski pers. obs, Rothstein 1990).
c) Nest concealment may offer some protection from parasitism. However, cowbirds often watch adults building nests, and many vireos build in pendulent nests which tend to be more visible than nests of other species.

The impact of cowbirds on the southwestern vireo populations needs further investigation to evaluate the ability of vireo populations in these areas to maintain themselves with cowbird nest parasitism without human intervention. Trapping is not recommended until such background data are collected over at least 2 years (unless cowbird parasitism is demonstrated to be very extreme in the first year). This step may significantly reduce costs of recovery if parasitism is not a serious threat in a given area.

The following are methods that have been used for local cowbird removal:

a) Use of cowbird decoy traps (USDI 1973) at or near breeding sites. This method has been the most commonly employed and has generated some level of success at all sites used (see Conservation Measures section). Some refinements in their use may need attention, both from the perspective of their design (to prevent escapes and predation) and perhaps more importantly in their placement in ways that substantially improve their influence zones. Information from current and past and proposed trapping efforts should be used to address this issue.
b) Trapping at cowbird feeding sites may help enhance influence zones of the traps, or reduce local numbers of female cowbirds, thus reducing their overall impact. Significantly more females have been captured near cattle or buffalo than in traps away from these animals (Grzybowski 1990b) Rotational grazing at the Kerr WMA placed cattle adjacent to vireo nesting areas at the beginning of the nesting season (Grzybowski 1990c). In both of these studies, parasitism was substantially reduced, and vireo reproductive success enhanced. Where cattle are present in the landscape near vireo breeding areas, this trap placement may be a useful strategy.
c) Shooting at breeding sites: Tazik and Cornelius (1989) have demonstrated some success using this method with the aid of cowbird recordings which attract cowbirds to the gunmen. (Note: This technique may be disruptive to nesting viroes.)

Direct habitat destruction: Conversion of potential vireo habitat to urban and suburban development may threaten the vireo in some areas. Such development has been a factor in western Travis County, Texas, where road construction and subdivision development have impacted or threatened vireo nesting areas (Espey, Huston & Associates 1988, DLS Associates 1989b).

A significant "colony" on the Davenport Ranch has declined dramatically from 27 pairs in 1985 to 4 pairs in 1990 (Grzybowski 1990c). This site is now surrounded by suburban development and has become isolated from other vireo breeding areas by 10 km. The problem may be further compounded by the addition of several predators (i.e., house cats and dogs) and an increase in numbers of other predators (eg. raccoons, skunks, jays, squirrels, etc.). This form of development may have been or be impacting vireos in Dallas, Bexar, and Kerr counties, but it has not been studied in these areas.

Range management that removes low woody vegetation is widespread across the vireo's range, but may be most extensive on the Edwards Plateau (Marshall et al. 1985). This process destroys vireo habitat and can substantially impair recovery of these areas; however, in some instances it provides a disturbance regime which creates vireo habitat. Many areas cleared by ranchers are then grazed by cattle, goats, and sheep, and thus restrained from again becoming vireo habitat. However, some sites bulldozed in Kerr County and on the Fort Hood MR have grown into vireo habitat.

Overbrowsing, particularly by goats (but also deer and some exotic animals), can remove vegetation in the lower height zones required by vireos for nesting. The substantial Angora goat enterprise and proliferation of browsing exotic game animals on the Edwards Plateau have removed large areas of vireo habitat (Marshall et al. 1985). If the root structures of deciduous plants can still support growth, the results of overbrowsing may be reversed if the animals are removed. Regrowth of browsed vegetation may develop into vireo habitat, as has occurred on the South Fork Ranch in Kerr County (Fuchs, pers. comm., Grzybowski pers.obs.).

Habitat loss or deterioration through control of natural processes: Some areas of black-capped vireo habitat appear to be relatively stable, but in other areas vireos occupy a successional habitat which passes through a period of suitability. Control of natural processes may prevent the creation and maintenance of vireo habitat in certain areas. The expectation under natural conditions is that a mosaic of habitats exist with differing histories of disturbance and thus a certain proportion of land will likely be in the successional stage suitable for vireos.

Fire was likely responsible for maintaining or periodically returning some areas to vireo habitat in the past. Fires still occur, but are suppressed in many areas, so the probability of an area being in the appropriate successional stage is probably lower than in the past. Lands in public ownership may not be large enough (or may be in multiple use settings) to depend on random disturbance events, such as fire, to maintain adequate amounts of vireo habitat.

Habitat deterioration due to control of natural processes may result in (a) decreasing amounts of suitable habitat as the habitat matures (b) increased fragmentation of what may historically have been large patches or series of patches of suitable habitat, (c) increasing isolation between vireos in occupied patches, (d) decreasing probabilities of young vireos dispersing successfully between these patches, (e) increased potential for nest predators such as jays and squirrels from the surrounding, more mature habitat to invade and impact nesting success of black-capped vireos in the remaining smaller patches, and (f) increased potential for extinction as probabilities for successful dispersal and reproductive success decline.

The circumstances in this scenario appear relevant to much of the range from Oklahoma to the southeastern edge of the Edwards Plateau. These conditions may currently exist in most of west-central and central Oklahoma outside of the Wichita Mountains. A number of formerly occupied sites have matured substantially (to heights over 40 feet), and west-central and central Oklahoma now contain significant numbers of junipers. More suitable patches were observed than occupied, but these patches were often relatively small (<50 ha) and isolated by distances measured in kilometers from each other (Grzybowski et al. 1986, pers. obs.). The trend of this influence in Texas is uncertain, but may be impacting significant areas of the Lampasas Cut Plains and Balcones Canyonlands as represented in southern Dallas County, western Travis County, and Bexar and Uvalde counties. Additional research is needed to determine which areas of vireo habitat are relatively stable and which will need periodic disturbance to maintain.

Indirect effects of land uses: Some land uses or habitat modifications that do not necessarily directly impact vireo habitat may indirectly impact vireos. For example, in a broad sense, the threat of cowbird nest parasitism results from changes in the habitat that increase cowbird abundances in vireo nesting areas. The cause(s) of these increases can be local, as in increasing suitability of habitat for cowbirds in or adjacent to suitable vireo habitat, and/or it can be remote, as in increasing suitability or availability of cowbird wintering habitat enhancing overwinter survival and thus increasing cowbird numbers. Land uses may also increase suitable environments for certain predators (i.e., raccoons, skunks, house cats, jays).

Increased effects from predators and nest parasites are sometimes attributed to "edge effects". Patch size is sometimes used to evaluate edge effects. Studies have indicated that both cowbird nest parasitism and nest predation on open-cup nesting passerines decreases with distance from edge (Gates and Gysel 1978, Brittingham and Temple 1983, Andren and Angelstam 1988). A few studies, however, have indicated that the dispersal potential of cowbirds is high (Rothstein et al. 1984), and that parasitism rates may be more species-specific and not as closely linked to edge as other studies indicate (Robinson pers. comm.). However, edge effects can still occur as specified below.

Cattle in or near vireo habitats can attract cowbirds. On Fort Hood MR, where cattle numbers were over 3500 animal units during 1987 and 1988, parasitism rates were 90% (even with cowbird trapping (Tazik, in litt 1991). A reduction in cattle numbers on Fort Hood to 1500-2000 during 1989 and 1990 resulted in a decrease in parasitism to 60 to 65 percent and a dramatic increase in vireo production (Tazik, in litt 1991).

However, cattle have been used effectively to significantly increase cowbird capture on the Kerr WMA (Grzybowski 1990c). Where cowbirds are not being removed however, cattle grazing in or near vireo nesting areas may pose a substantial local threat to vireo nesting success. Cattle may also create disturbances if concentrated in vireo nesting areas at the beginning of the nesting period and may cause vireos to abandon the site. Data supporting this contention are limited and subjective.

Species such as scrub jays (Aphelocoma coerulescens), squirrels, raccoons, and skunks may increase vireo nest predation where food sources for these species (which are often omnivorous) allow their populations to be maintained at artificially high levels. This may be a particular problem where urbanization is occurring. In urban settings, these predators have had a demonstrated influence (Wilcove 1985). The longer incubation time in vireos may make them more sensitive to increases in predator numbers than other passerines. Thus, in some situations, these predators may need to be controlled.

Comparative data on nest predation are limited. However, significantly fewer ($P < 0.05$) vireo nests were predated (Grzybowski unpubl. data) in areas where cowbirds were trapped at Kerr WMA than in areas where cowbirds were trapped in the Austin area (DLS Associates 1990) (24% of 134, and 54% of 102 nests, respectively). This higher number in the Austin area may be related to an increase in scrub jays benefiting from urbanization and/or to the increased successional maturity of the habitat (Grzybowski et al. MS). Very few nests were predated by mammals. However, as the incidence of parasitism declines, predation may become limiting to production.

Fire ants may create local problems. They tend to invade habitats along corridors of disturbance. Fire ants may have caused vireos to abandon their nests and eggs on a few territories in Travis County (O'Donnell pers. obs.). They may be a local problem in other urbanized areas, but have not been noted as a general problem rangewide. According to Tazik (in litt, 1991) few if any problems have been observed on Fort Hood.

Direct human disturbances: Human disturbance near and in nesting areas during the breeding season, particularly at the onset, may alter vireo behavior and/or cause vireos to abandon nests or territories. Use of taped songs may also have adverse effects (Marshall et al. 1985). Excessive use of tapes may have adversely affected the birds' behavior in some areas.

Pesticides: Pesticides, particularly systemics, may be a problem on vireo breeding and wintering areas.

G. CONSERVATION MEASURES ALREADY INITIATED

Cowbird removal at vireo nesting locations: Grzybowski (1985a,b) observed high nest parasitism by cowbirds at several sites in Oklahoma and Texas at an early date. Subsequent work confirmed generally high parasitism at other localities (Grzybowski 1989a, 1990c, Tazik and Cornelius 1989). Thus, cowbird control was perceived as an early management need to enhance vireo reproductive success.

Control occurs by trapping and removing cowbirds (including shooting) from vireo breeding sites and by removing cowbird eggs and young from vireo nests. Cowbirds are being removed from sites across Oklahoma and Texas including Blaine County, Oklahoma (Oklahoma Nature Conservancy; Hamilton 1991); the Wichita Mountains WR, Oklahoma (Grzybowski 1990b); Fort Hood MR, Texas (Tazik and Cornelius 1989); western Travis County and adjacent Burnet and Williamson counties, Texas (Texas Animal Damage Control Service 1990); the Kerr WMA, Kerr County, Texas and the Walter Buck WMA, Kimble County, Texas (Grzybowski 1990c); Lost Maples SNA, Bandera County, Texas (Bryan and Stuart 1990); and Big Bend NP, Brewster County, Texas (Mike Fleming, Big Bend NP, pers. comm.). A cowbird trap was operated at the Methodist Canyon Camp in Canadian County, Oklahoma from 1985 to 1987, but was moved in 1987 to protect greater numbers of vireos in the Wichita Mountains (Grzybowski 1989a). Additionally, traps were constructed and operated during 1986 in Texas at the Hill Country SNA, Bandera County; Meridian SP, Bosque County; and Dinosaur Valley SP, Somervell County (Wahl 1986).

Cowbird removal has substantially decreased parasitism of vireo nests at most of these sites and increased vireo reproductive success. The most dramatic results have been obtained at the Kerr WMA where trapping has reduced parasitism from 77% to 15%. Reproductive success in trapped areas exceeded 2.5 young per female for three consecutive years (Grzybowski 1990c). In western Travis County, parasitism was reduced to 15% in 1989, when production of young/female was 3.15-3.30 (DLS Associates 1989b).

However, trapping at Fort Hood has been less successful. From 1987 to 1989, 86% of vireo nests were parasitized in areas without trapping compared to 76% in areas with trapping. Females on Fort Hood fledged only 0.91 young per year in this period. Cowbird numbers are apparently high, and the primary effect of the trapping has been to reduce the number of cowbird eggs laid in vireo nests (Tazik and Cornelius 1989).

Cowbird eggs and young are being removed from vireo nests at some sites in conjunction with studies and monitoring of vireos. The benefit of this action, however, is limited to specific nests.

National Wildlife Refuge: A National Wildlife Refuge is being established by the U.S. Fish and Wildlife Service and will be managed significantly for the black-capped vireo and protecting extant vireo groupings in the Post Oak Ridge area near Austin, Texas.

Balcones Canyonlands Conservation Plan: The Endangered Species Act authorizes the U.S. Fish and Wildlife Service (Service) to permit the taking of federally listed wildlife species if such taking is "incidental to, and not the purpose of carrying out otherwise lawful activities (16 U.S.C. Section 1539)." This process is intended to reduce conflicts between listed species and private development and to encourage "creative partnerships" between the private sector and local, State, and Federal agencies in the interests of endangered species and habitat conservation. Before issuing a permit, the Service must be assured that the applicant will implement certain conservation measures. These measures are detailed in a conservation plan that the applicant is required to develop and submit with their application for an incidental take permit.

Development of such a plan is currently underway in the Austin, Texas, area and is being called the Balcones Canyonlands Conservation Plan (BCCP) (formerly called the Balcones Canyonlands Habitat Conservation Plan and before that the Austin Regional Habitat Conservation Plan). Under this plan, the population of black-capped vireos in this area would be protected and enhanced. Several preserves would be created under the BCCP, along with other conservation measures. It is hoped that a sustainable population of vireos can be maintained in this area under the BCCP in conjunction with the new National Wildlife Refuge. The BCCP is still developing and has not yet been submitted to the U.S. Fish and Wildlife Service for approval.

H. RECOVERY STRATEGY

The plan is designed to preserve, protect, and enhance (in some cases) the vireo populations that we now have until we can obtain a better understanding of whether full recovery is possible and, if so, what it will take to fully recover this species.

As part of recovery, these goals need to be further evaluated and refined, especially regarding population numbers, area, and habitat configurations needed to maintain viable populations. It is also desirable that populations maintain the capability for gene flow between regions. This genetic exchange should be considered as part of the design in their selection.

To further refine these goals, additional surveys should be conducted and various other information collected for use in population viability analyses. However, until this refinement occurs, all existing populations should be protected and maintained.

In addition, at least one viable population should be maintained in each of six regions throughout the vireos current breeding range. These six regions include Oklahoma, Mexico, and four of the six regions in Texas (see Figure 7).

Within the target regions, recovery activities may include the development of cowbird removal programs, habitat protection (including land acquisition, easements, and cooperative land management practices with private landowners), habitat management, and considerations for local threats (possibly including control of nest predators [such as scrub jays], browsers [such as deer and goats], and cattle [which attract cowbirds]) where necessary. Results of these activities should be monitored relative to changes in black-capped vireo numbers and other parameters deemed useful from recommended analyses. It is important to understand that populations transcend individual property boundaries, except where these property holdings are very large (> 10,000 hectares). Implementation will require focus on populations.

Regarding the cowbird threat, the current practice of site-specific cowbird removal, by itself, will not provide for long-term recovery of specific populations. Additional methods of reducing the threat from cowbirds need to be investigated.

Human-caused losses to any individual vireos or groups of vireos, whether they are in or outside of target regions or populations, would be considered "take" under provisions of the Endangered Species Act (Act) unless appropriate permits have been issued. ("Take" as defined by the Act means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, to attempt to engage in any such conduct.")

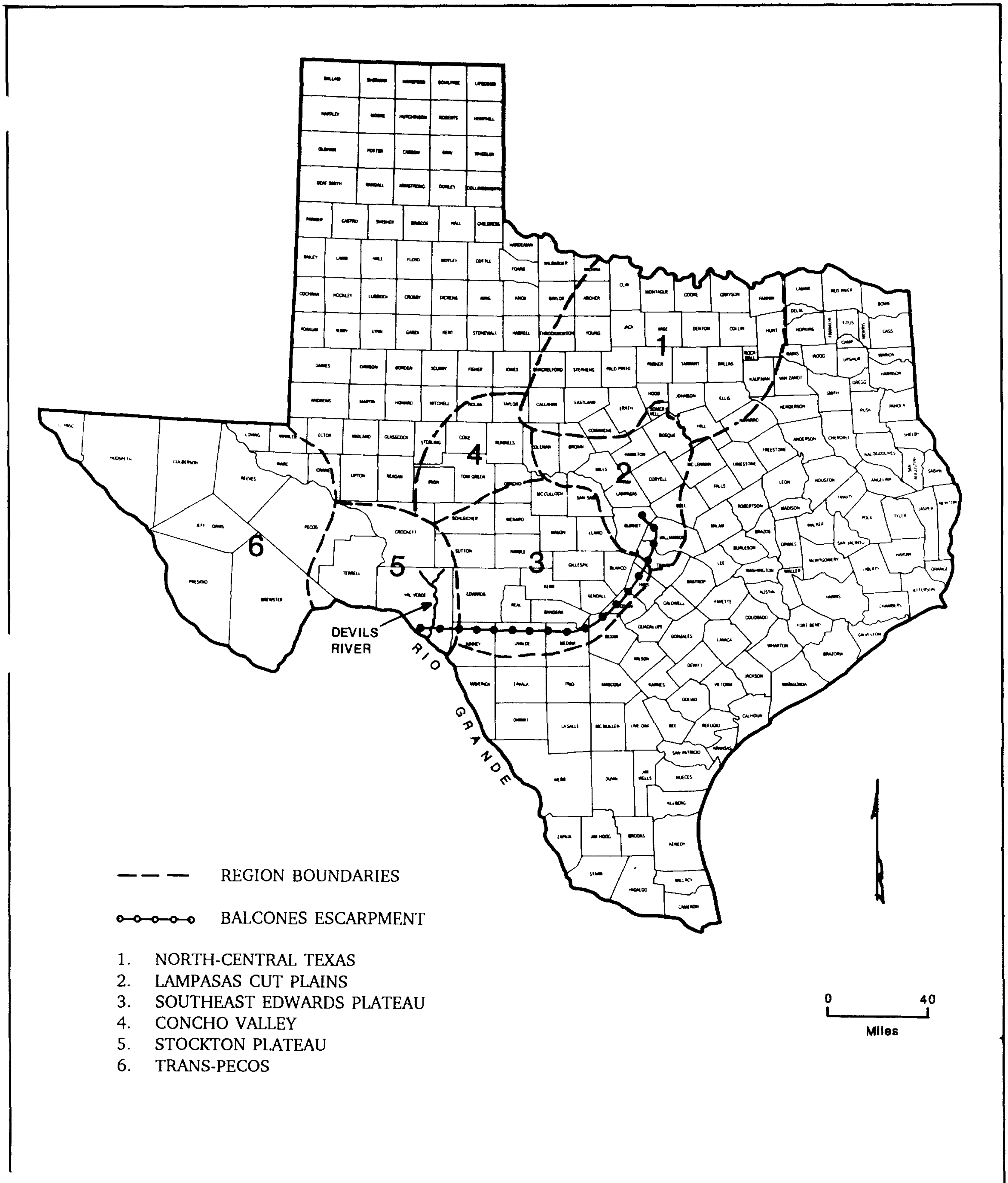


Figure 7. Natural regions and subregions of Texas as modified from Oberholser (1974) and U.S. Fish and Wildlife Service (1979).

II. RECOVERY

A. OBJECTIVES AND CRITERIA

Objective: The prospects for complete recovery and delisting of this species are uncertain. Therefore, an interim recovery objective is being identified for this plan. The interim objective is downlisting the black-capped vireo to threatened status. Criteria for this interim objective are given below.

Criteria: The black-capped vireo will be considered for reclassification from endangered to threatened when:

(1) all existing populations are protected and maintained,
(2) at least one viable breeding population exists in each of the following six locations:
- Oklahoma
- Mexico
- four of the six Texas regions (designated in Figure 7),
(3) sufficient and sustainable area and habitat on the winter range exists to support the breeding populations outlined in (1) and (2) above, and
(4) all of the above have been maintained for at least 5 consecutive years and available data indicate that they will continue to be maintained.

Pease and Gingerich (1989) conducted some viability analyses for this species, and their approximations are similar to general estimates (i.e., not specific to the black-capped vireo) by Franklin (1980) and Frankel and Soulé (1981). Using the Pease and Gingerich (1989) estimate, a viable population should comprise at least 500 to 1,000 breeding pairs. The median value of 750 pairs should be achieved for at least 50% of the target viable populations. This viable population estimate may change with additional analyses (called for in this plan) and may differ from region-to-region.

This recovery plan is intended to preserve, protect, and enhance (in some cases) the vireo populations that now occur until we can obtain a better understanding of whether full recovery is possible and, if so, what it will take to fully recover this species. The feasibility of total recovery and delisting will be examined as part of this plan. If found to be feasible, criteria for determining when delisting could occur, in terms of viable populations (including population sizes, locations, and configurations), will be developed as part of this plan, and the plan will be revised to incorporate these new objectives and criteria.

These reclassification criteria are preliminary and may be revised based on new information (including research specified as recovery tasks in this plan). The estimated date for attaining the objective of this plan (downlisting to threatened) is the year 2020.

B. RECOVERY OUTLINE

The following is an outline of the recovery tasks needed to attain the objective of this plan. The following section (C.) includes more detailed information on the tasks.

1. Specific research and information needs

    1.1 Surveys

        1.11 Regional surveys
        1.12 Supplemental surveys

    1.2 Determine population configurations needed for long-term species survival and viability

        1.21 Obtain information necessary to develop viability model
        1.22 Develop viability model and recommend areas where viable populations exist and should be maintained and areas that have potential for development of viable populations

    1.3 Cowbird threat

        1.31 Determine where cowbirds are a serious threat
        1.32 Determine the role of cattle in cowbird threat
        1.33 Determine if feasible, and if so how, to manage cattle so they will not negatively impact vireo viability
        1.34 Develop a long-term solution to the threat

    1.4 Habitat

        1.41 Determine habitat use throughout the range
        1.42 Develop methods for identifying probable habitat
        1.43 Determine how to manage habitat for the vireo
        1.44 Identify areas where vireo habitat can be most easily created and maintained
            1.441 Habitat substrates
            1.442 Successional changes in habitat
        1.45 Determine if habitat management techniques for deer (and exotic ungulates) and black-capped vireos are compatible

    1.5 Determine extent of other threats

    1.6 Winter range

        1.61 Distribution and threats
        1.62 Habitat

    1.7 Determine usefulness of age structure data as an index to population health of the vireo

2. Maintain existing populations and assure at least six viable populations as called for in the recovery criteria

2.1 Habitat management

2.11 Vegetation manipulation
2.12 Manage browsers as needed

2.2 Protection of areas

2.21 Acquisition and lease
2.22 Work cooperatively with private landowners
2.23 Work with other agencies and organizations
2.24 Regulatory

2.3 Address cowbird threat

2.31 Site-specific/local cowbird control
2.32 Long-term solution to cowbird problem/threat

2.4 Manage for other threats where necessary and warranted

3. Monitoring

3.1 Develop monitoring techniques

3.2 Monitor populations within areas deemed necessary for recovery

3.3 Monitor habitat within areas deemed necessary for recovery

3.4 Monitor threats

4. Winter range

C. NARRATIVE OUTLINE FOR RECOVERY ACTIONS

1. Specific research and information needs

1.1 Surveys

1.11 Regional surveys. From the regional perspective, additional assessments of population status are still needed in (a) north-central Texas, (b) the southeastern portion of the Edwards Plateau (Austin/San Antonio/ Kerrville triangle), (c) the Concho Valley area near San Angelo, (d) the Devils's River and adjacent drainages in western Texas, and (e) the mountains of Coahuila, Mexico. In north-central Texas, these surveys should include areas along the Red River, Dallas and Ellis counties, and Palo Pinto and Parker counties. The first priority for status surveys should be those areas where the potential contribution to or role in the recovery of the species is greatest (for example areas that may have sizeable populations of vireos that have not yet been discovered).

1.12 Supplemental surveys. These may still be needed in the Big Bend region, in Travis and adjacent counties, in Lampasas, Hamilton, and Mills counties, Texas and in Blaine and Dewey counties, Oklahoma. The mentioned areas may have potential for development of viable populations. The first priority for these surveys should be areas on the Lampasas Cut Plains.

1.2 Determine population configurations needed for long-term species survival and viability

The concept of viable populations is an important part of the recovery plan. Data and analyses are needed to better refine population sizes, amount of area, and necessary configuration between specific habitat patches, including corridors, needed to meet recovery objectives with a reasonable probability of success. Data analyses will also disclose what levels of reproductive success are needed. Analysis may need to be conducted individually for different regions. These analyses should also evaluate whether full recovery of this species is possible and, if so, what would be required in terms of viable populations, including population sizes, locations, and configurations.

1.21 Obtain information necessary to develop viability model. While Pease and Gingerich (1989) have conducted some viability analyses for this species, and their approximations are similar to general estimates by Franklin (1980) and Frankel and Soulé (1981), this analysis can be improved by refining or developing empirical estimates of various population parameters. In particular, better estimates of the survivorships, dispersal, and movement of females and juveniles, and the coefficients of variation of fecundity and survivorship, are needed. Accommodations for dispersal also need to be considered. Better information is needed on dispersal distances of young and females so one can better identify the required area and configuration of viable populations.

Some of the information needed for viability models can be obtained by using existing data. Some empirical data are still needed for these models, particularly for survivorship of females and juveniles. Females determine reproductive potential and are key components of population dynamics models. The young are the primary dispersing component in vireo populations and determine the area encompassing gene flow.

Banding studies that assess survivorship, dispersal, and movement should continue. These studies are best pursued where dispersal can be accurately assessed. Three sites currently offer the highest value for intensive banding studies: the Wichita Mountains WR and adjacent Fort Sill MR, Oklahoma; Fort Hood MR, Texas; and the area encompassed by the Balcones Canyonlands Conservation Plan, Texas.

1.22 Develop viability model and recommend areas where viable populations exist and should be maintained and areas that have potential for development of viable populations. The model should include necessary population configurations and corridors needed, as well as population sizes and areas needed.

A consideration in positioning potential populations is the relations between them, particularly the potential for gene flow and enhancement of adaptive genetic variation. This positioning should be evaluated from a theoretical perspective, but the proposed population areas and corridors need to be designed with existing populations and habitat in mind.

Specific locations, within the target regions, for the viable populations need to be further evaluated. Many can currently be identified, but other sites should be assessed. These sites should be selected to retain a diversity of habitats. Site selection should also be influenced by the distance to and location of other viable sites. Priority should also be given to those areas with the best currently exist- ing populations, those in gaps or unique areas, and those requiring the least management.

Information obtained from surveys called for in task 1.1 and habitat research called for in 1.4 of this plan should play an important part in completing this task.

1.3 Cowbird threat

To date, the threat of cowbird parasitism on black-capped vireos has been addressed by attempting to remove cowbirds from select black-capped vireo nesting areas. However, this human intervention is labor intensive and will not result in a long-term, permanent solution to this threat. A long-term approach needs to be considered in terms of recovery and eventual delisting of the black-capped vireo. Cowbird removal should continue, in the interim, wherever parasitism poses a serious threat to the vireo.

1.31 Determine where cowbirds are a serious threat. Black-capped vireos do not appear to be as seriously impacted by cowbirds in some parts of their range. Cowbird removal should not be initiated in any new areas (i.e., areas not trapped, etc. in the last 5 years) until at least 2 years of data indicate cowbird control is warranted (unless cowbird parasitism is demonstrated to be very extreme in the first year).

1.32 Determine the role of cattle in cowbird threat. Cattle in or near vireo habitats can attract cowbirds and increase vireo nest parasitism. This task should identify the extent that cattle influence cowbird populations and thereby affect nest parasitism, and determine the extent this relationship is influenced by site.

1.33 Determine if feasible, and if so how, to manage cattle so they will not negatively impact vireo viability.
Cattle are widespread throughout the vireo's range. This task should endeavor to identify livestock management methods that will not negatively impact the vireo.

1.34 Develop a long-term solution to the threat.
The cowbird threat is currently being addressed by cowbird removal in specific black-capped vireo breeding sites. This approach may temporarily stabilize some vireo populations. However, it will not provide for long-term recovery because when cowbird removal is stopped, the threat increases again. Therefore, a long-term solution to the cowbird threat needs to be developed. In developing a solution, one needs to consider the cause of the threat. Various possibilities should be explored to determine which are feasible, ecologically sound, and most likely to be effective.

One particular alternative that should be considered is trying to control/reduce cowbirds with various management strategies, including management of land, habitat, and cattle. The long-term solution may involve a wide variety and combination of strategies, and may involve additional research on cowbird ecology. Among the possible strategies are habitat protection (through a variety of means discussed elsewhere in this plan) in particular configurations that are less advantageous for cowbirds -- perhaps contiguous, unfragmented tracts, located away from major cowbird food sources or feeding areas. Another strategy that may be investigated is land use practices that can be used to discourage high numbers of cowbirds. Management strategies may include removal of cowbirds and/or cattle in some cases, particularly on public lands. However, an attempt should be made to find management strategies that would not require continual cowbird removal or removal of cattle where cattle are desired on private lands.

1.4 Habitat

1.41 Determine habitat use throughout the range. The black-capped vireos' habitat varies in different parts of its range. Grzybowski et al. (unpubl. MS) have conducted a study of vireo habitat in parts of the range. However, additional work is needed to clarify important habitat components rangewide and to develop the information in ways more directly useful to managers and landowners.

Identifying important habitat components is important in understanding limitations on populations, effects of future development, and application of recovery strategies.

1.42 Develop methods for identifying probable habitat. There are no mechanisms for assessing amount and distribution of habitat other than on-site inspection. Various remote sensing methods should be further investigated. Methods may include looking at various factors besides vegetation, such as soils, aspect, etc. (see task 1.441).

Information on habitat distribution may prove useful in developing proposed configurations of habitat, in monitoring habitat changes, in identifying areas that may contain previously unknown black-capped vireo locations, and in evaluating particular activities which may impact vireos.

1.43 Determine how to manage habitat for the vireo. Techniques for managing vireo habitat should be developed for: (1) converting an area into vireo habitat and (2) keeping an area in vireo habitat. The best techniques may vary from site-to-site. In other areas, vireo habitat may be fairly stable and require little to no management. In other areas, where succession would result in conversion of the area out of vireo habitat, management may be necessary. This task is to determine the best methods to manage habitat for vireos in various locations.

1.44 Identify areas where vireo habitat can be most easily created and maintained, where it does not currently exist, but is needed for recovery.

1.441 Habitat substrates. Slope, aspect, and soil depth have been used in the Austin area to delimit areas with potential for vireo habitat (Butler/EH&A Team 1991). Sexton et al.(unpubl. MS) has found some relationship between occupied vireo habitats and Fredricksburg limestones. These databases and information should be tested. If useful, they can be exploited rangewide to determine the breadths and combinations of conditions conducive to producing vireo habitat. Substrates that maintain vireo habitats for an extended time should be identified. Knowledge of these substrates will help identify and choose sites for vireo habitat development.

1.442 Successional changes in habitat. Some black-capped vireo habitat undergoes successional changes. An assessment should be made of areas which have relatively stable habitat and areas undergoing succession that will result in loss of black-capped vireo habitat. This assessment should also include estimates of the rates of these changes and life expectancies of vireo habitat under various conditions. This knowledge will be important in developing specific habitat planning and management.

Several possible approaches to answering these questions include:

a) Assemble and evaluate information on histories of occupied sites.

b) Assemble or collect data on vegetational changes occurring in shrubland habitats. Much of this may be available through various rangeland monitoring databases.

c) Investigate application of some remote but high resolution approaches, such as using high resolution imagery from aerial photos.

1.45 Determine if habitat management techniques for deer (and exotic ungulates) and black-capped vireos are compatible. Many landowners on the Edwards Plateau and elsewhere generate substantial income from hunting leases. Many of these landowners actively manage for deer (and exotic game ungulates). Deer are browsers and vireos seem to occupy habitats that provide good browse. This task should examine the compatibility of management practices for these two species. Recommendations should be made for maximizing compatibility and avoiding any adverse impacts to vireos from incompatible practices. This information could be used by a variety of federal and state extension service programs.

1.5 Determine extent of other threats

Where warranted (i.e., where threat, possibly on site-by-site basis, may be seriously impacting the vireo population). In some areas, vireos may be seriously impacted by threats that are not a problem rangewide. These other threats may include such things as fire ants, predation by scrub jays or other predators, unusual human disturbance, pesticides, etc.

If predators are seriously impacting a vireo population, other contributing factors such as habitat quality and proximity to humans should also be assessed.

1.6 Winter range

1.61 Distribution and threats. Determine black-capped vireo distribution and the extent and types of threats to the vireo and the habitat in the winter range.

1.62 Habitat. Determine habitat use, habitat condition, and the extent of probable vireo habitat on the winter range.

1.7 Determine usefulness of age structure data as an index to population health of the vireo

Age-structure data can, with survivorship, provide an index to population growth rate in stable populations. Age-structure data are easier to obtain than fecundity, consequently the reliability of this index should be explored. This index may greatly benefit the efficiency of current monitoring activities of reproductive success and future monitoring of the effects of conservation efforts.

2. Maintain existing populations and assure at least six viable populations as called for in the recovery criteria

2.1 Habitat management

Management will be necessary to create or maintain vireo habitat in certain areas. This management should consider other resource values, such as other species like the golden-cheeked warbler, and avoid or minimize negative impacts to these resources.

2.11 Vegetation manipulation. Recommendations for habitat management should be assembled into a series of guidelines useful for managers. These guidelines will be needed for site-specific management of public lands, and for consulting with private landowners.

These recommendations may vary from region-to-region. Information obtained in task 1.43 should be used to develop the guidelines; however, preliminary guidelines should be developed before that task is completed. Guidelines will be updated as new information becomes available. Habitat manipulation should proceed cautiously for the first few years until the preliminary guidelines are proven effective. All habitat manipulation should be preceded by collection of baseline data and followed by monitoring to evaluate results. Consideration should also be given to effects of management on other ecological values.

2.12 Manage browsers as needed. Management of browsing animals, such as deer and goats, should be considered where these species are negatively impacting vireo habitat.

2.2 Protection of areas

Vireo habitat and corridors can be protected in a number of ways. This protection will involve working with various landowners and other agencies and organizations.

2.21 Acquisition and lease. Habitat acquisition and easements will be needed in some areas to maintain target groupings of vireos. Various lease arrangements are appropriate for encouraging management on private lands.

The U.S. Fish and Wildlife Service has identified land in thePost Oak Ridge area west of Austin, Texas, for potential acquisition as a National Wildlife Refuge. The Texas Parks and Wildlife Department recently purchased lands containing vireos, including Kickapoo Caverns SP and Devils River SNA. Land acquisition is also one of the options being recommended by the BCCP (Butler/EH&A Team 1991).

Potential sites available for purchase should be identified within designated population areas, and prime sites obtained. U.S. Fish and Wildlife Service policy stipulates the agency will only acquire land from a willing seller.

2.22 Work cooperatively with private landowners. Use various methods to protect vireos and their habitat on private lands. This should be a major part of recovery because little public land occurs in the vireo's range.

Identify beneficial management practices and convey this information to landowners and managers through the various federal and state programs and extension services such as those of the Soil Conservation Service, state wildlife agencies, and the Fish and Wildlife Service. This process will be essential to recovery because private lands are a key component of areas needed to retain viable populations. Habitat management guidelines to be developed under task 2.11 will be useful to implement this task.

2.23 Work with other agencies and organizations. Some vireo habitat occurs on public land. Several agencies and organizations have roles or activities that could influence vireo recovery. The Service should work with these various agencies and organizations to aid in the conservation and recovery of the black-capped vireo.

2.24 Regulatory. The protective provisions in the Endangered Species Act and regulations should be enforced. These provisions include "take" prohibitions, among others. Enforcement of these provisions involves such things as Fish and Wildlife Service law enforcement, Section 7 consultations with Federal agencies, and review of permit applications.

2.3 Address cowbird threat

2.31 Site-specific/local cowbird control. Cowbird removal will be necessary at vireo breeding localities where cowbirds are a threat to reproductive success (see task 1.31). In those areas where cowbirds will be removed, removal should begin about 2 weeks prior to the arrival time of vireos at the breeding area.

2.32 Long-term solution to cowbird problem/threat. Use techniques identified under task 1.3. This solution will require cooperative work with private landowners and other agencies and organizations.

2.4 Manage for other threats where necessary and warranted

Localized threats may have to be addressed at some sites where they are seriously impacting the vireo population (see task 1.5). These determinations will be made on a site-by-site basis. Other threats may include fire ants, predation by scrub jays and other predators, unusual human disturbance, and pesticides. **Note**: If predator control is contemplated, careful consideration should be given to determining its necessity and ecological impact prior to any implementation. Other alternatives should be investigated.

3. Monitoring

Monitoring should occur across the range to determine the success of conservation actions and/or status of vireo populations. A number of items should be addressed in such monitoring.

3.1 Develop monitoring techniques

A general techniques should be established for each type of monitoring (habitat, vireos). These techniques should describe standardized data collection procedures so that results will be comparable. These techniques should be designed to minimize observer or other biases.

3.2 Monitor populations within areas deemed necessary for recovery

Monitor numbers, some measure of reproductive success and/or recruitment at designated sites within all targeted populations. This monitoring should include vireos in small and large groups because the large groups may be more stable. The small groups may be more sensitive to change and allow rapid detection of changes in local populations.

The percent of first year males may be a very useful indicator of the health and status of a population, and may be much more efficient than measuring reproductive success. The usefulness of this indicator is to be evaluated as part of task 1.7.

3.3 Monitor habitat within areas deemed necessary for recovery

Monitor habitat loss and gain within each population area. Such monitoring should also accompany management.

3.4 Monitor threats

The degree of vireo nest parasitism by cowbirds should be monitored to determine the level of threat and the potential benefit of cowbird removal. Monitor other threats which may be impacting vireo populations and the benefit of efforts to reduce these threats.

4. Winter range

Various cooperative international activities should be used to work with Mexico to address threats and to protect black-capped vireo wintering and breeding habitat. Activities that may provide opportunities for cooperative management include the U.S./Mexico Agreement, the International Affairs office of the Fish and Wildlife Service, and debt-for-nature swap programs.

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III. RECOVERY PLAN IMPLEMENTATION SCHEDULE

Priorities in column one of the following implementation schedule are assigned using the following guidelines:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objectives.

Key to Acronyms used in Implementation Schedule

- BCCP - Balcones Canyonlands Conservation Plan
- DOD - Department of Defense
- FWS - U.S. Fish and Wildlife Service
  - FWE - Fish and Wildlife Enhancement
  - IA - International Affairs
  - LE - Law Enforcement
  - RF - Refuges
- NPS - National Park Service
- SCS - Soil Conservation Service
- TPWD - Texas Parks and Wildlife Department
- TNC - The Nature Conservacy
- USDA - U.S. Department of Agriculture

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY FWS REG	FWS PROGRAM	OTHER	COST ESTIMATES ($000) FY 1	FY 2	FY 3	COMMENTS
1	1.31	Determine where cowbirds are serious threat	5	2	FWE		30	30	30	
						TPWD	10	10	10	
1	1.43	Determine how to manage habitat for vireo	10	2	FWE Refuges	 TPWD	30 80 10	30 80 10	30 80 10	
1	1.61	Winter range-distribution and threats	3	2,8	FWE Research		50 25	50 25	50 25	
1	2.22	Work cooperatively with private landowners	Ongoing		FWE Refuges		40 40	40 40	40 40	
						USDA* SCS TPWD	10 10 10	10 10 10	10 10 10	*Extension service
1	2.23	Work with other agencies and organizations	Ongoing	2	FWE	* Various	20	20	20	*includes a large number including TPWD, NPS, DOD, SCS, USDA, BCCP, TNC

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRI-ORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY FWS REG	FWS PROGRAM	OTHER	COST ESTIMATES ($000) FY 1	FY 2	FY 3	COMMENTS
1	2.24	Regulatory	Ongoing	2	FWE LE Refuges		30 10	30 10	30 10	
1	2.31	Site-specific/local cowbird control	Ongoing	2	FWE Refuges		15 20	15 20	15 20	
						USDA* TPWD DOD	20 10 30	20 10 30	20 10 30	*Animal Damage Control
1	4.	Winter range	Ongoing	2,9	FWE I.A.	NPS	5 100	5 100	5 100	
2	1.11	Regional surveys	10	2	FWE	TPWD	37.5 12.5	56.25 18.75	56.25 18.75	
2	1.21	Obtain information for viability models	4	2,8	FWE Refuges Research		20	20	20	
						DOD BCCP	20 20	20 20	20 20	

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY FWS REG	FWS PROGRAM	OTHER	COST ESTIMATES ($000) FY 1	FY 2	FY 3	COMMENTS
2	1.22	Develop viability model and recommend areas for viable populations	1	2,8	FWE Research					This task will depend on tasks 1.1, 1.21, and 1.4
2	1.32	Determine role of cattle in cowbird threat	5	2	FWE Refuges		30	30	30	
						DOD TWPD	20 10	20 10	20 10	
2	1.33	Determine if feasible and if so how, to manage cattle so they will not negatively impact vireo viability	3	2	FWE Refuges			15 20	15 20	
						DOD TPWD		20 5	20 5	
2	1.34	Develop long-term solution to cowbird threat	15	2	FWE Research Refuges		100	100	100	
2	1.41	Determine habitat use throughout range	10	2	FWE		50	50	50	

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRI-ORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY FWS REG	FWS PROGRAM	OTHER	COST ESTIMATES ($000) FY 1	FY 2	FY 3	COMMENTS
2	1.42	Develop methods for identifying probable habitat	3	2	FWE			25	25	
2	1.45	Determine compatibility between habitat management for deer and black-capped vireos	3	2	FWE		15	15	15	
						SCS USDA TPWD	5	5	5	
2	1.5	Determine extent of other threats	3	2	FWE Refuges		15	15	15	
						BCCP TPWD USDA	20 10 20	20 10 20	20 10 20	
2	1.62	Winter range-habitat	3	2,8	FWE Refuges		35	35	35	
2	2.11	Vegetation manipulation	Ongoing	2	FWE Refuges	 TPWD		15 30 5	15 30 5	

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RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY FWS REG	RESPONSIBLE PARTY FWS PROGRAM	RESPONSIBLE PARTY OTHER	COST ESTIMATES ($000) FY 1	COST ESTIMATES ($000) FY 2	COST ESTIMATES ($000) FY 3	COMMENTS
2	2.12	Manage browsers as needed	Ongoing	2	FWE Refuges		10	10	10	
						SCS TPWD DOD USDA				
2	2.21	Aquisition and lease	10 years	2	Refuges, Realty		5,000	5,000	5,000	Service costs are for Balcones National Wildlife Refuge
						BCCP	10,000	10,000	10,000	
2	2.32	Long-term solution to cowbird threat/problem	Undeterminable at this time	2, 8	FWE, Research					Costs unknown at this time
						USDA				
2	2.4	Manage for other threats where necessary and warranted	Ongoing	2	FWE Refuges				10	
						BCCP			15	

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RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRI-ORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY FWS REG	FWS PROGRAM	OTHER	COST ESTIMATES ($000) FY 1	FY 2	FY 3	COMMENTS
2	3.1	Develop monitoring techniques	1	2,8	FWE Refuges Research		20			
2	3.2	Monitor populations within areas deemed necessary for recovery	Ongoing	2	FWE Refuges		10 5	10 5	10 5	
						DOD NPS TPWD BCCP	7 4 5 10	7 4 5 10	7 4 5 10	
2	3.3	Monitor habitat within areas deemed necessary for recovery	Ongoing	2	FWE Refuges		10 5	10 5	10 5	
						DOD NPS TPWD BCCP	7 4 5 10	7 4 5 10	7 4 5 10	

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY FWS REG	FWS PROGRAM	OTHER	COST ESTIMATES ($000) FY 1	FY 2	FY 3	COMMENTS
2	3.4	Monitor threats	Ongoing	2	FWE		5	5	5	
					Refuges		3	3	3	
						DOD	4	4	4	
						NPS	2	2	2	
						TPWD	3	3	3	
						BCCP	5	5	5	
						TPWD			10	
3	1.12	Supplemental surveys	2	2	FWE		10	10		
						NPS	5			
3	1.441	Habitat substrates	3	2	FWE Refuges		15	15	15	
3	1.442	Successional changes in habitat	3	2	FWE Refuges		30	30	30	
						DOD	15	15	15	
						TPWD	10	10	10	

16420

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY FWS REG	RESPONSIBLE PARTY FWS PROGRAM	RESPONSIBLE PARTY OTHER	COST ESTIMATES ($000) FY 1	FY 2	FY 3	COMMENTS
3	1.7	Determine usefulness of age structure data as index to vireo population health	6	2,8	FWE Research		10	10	10	

[illegible]

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[illegible]

IV. Appendix

INDIVIDUALS AND AGENCIES PROVIDING COMMENTS ON THE DRAFT BLACK-CAPPED VIREO RECOVERY PLAN

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PRINCIPAL COMMENTS RECEIVED ON THE BLACK-CAPPED VIREO TECHNICAL/AGENCY DRAFT RECOVERY PLAN

Comments were received from 57 individuals or agencies. Some groups or individuals submitted more than one comment letter. All comments were considered when revising the draft plan. Many relevant and helpful comments were submitted on the draft recovery plan. The Service appreciates the time that each of the commenters took to review the draft and to submit their comments.

The comments discussed below represent a composite of those received. Comments of similar content are combined into general groups. Only critical comments, those raising a question, or suggestions are included in this discussion. Many favorable, supportive comments were also received.

Comment 1. Not enough emphasis has been given to winter range and population viability analysis of the black-capped vireo in Mexico.

Service Response: We agree that additional emphasis on winter habitat and population studies and conservation of the vireo in Mexico are needed and have endeavored to incorporate such tasks in the final recovery plan.

Comment 2. The feasibility and effectiveness of cowbird reduction efforts was questioned. Such control efforts are overemphasized in the recovery plan.

Service Response: Preliminary studies have shown increased vireo reproductive success in most areas where cowbird control has occurred. We agree that baseline information on the level of parasitism and vireo reproductive success should be collected prior to initiation of cowbird removal at any new sites. The Service does not anticipate broadscale reduction or eradication of cowbirds in the nation, state, or even in large subunits of a state. Past control efforts by the Animal Damage Control section that formerly was part of U.S. Fish and Wildlife Service, and more recently by the U.S. Department of Agriculture, indicate widespread efforts to eradicate or seriously reduce the numbers of the species would be too costly, unsuccessful, and probably ecologically unwise. The Service does anticipate continued use of localized control of cowbirds wherever it appears essential to maintain nesting populations of vireos. Appropriate balance is needed between cowbird control measures and other types of management techniques which may be less temporal and more cost effective.

Comment 3. Cowbird reduction sites need to be compared against "control" sites to assess the effectiveness of the cowbird reduction efforts.

Service Response: As noted in the response to Comment 2, baseline data on the level of parasitism and vireo reproductive success should be collected prior to initiation of cowbird removal on any new sites. In addition, monitoring to assess the effectiveness of cowbird reduction efforts is called for in the plan.

Comment 4. The cowbird reduction program is flawed because compensatory cowbird recruitment was not considered. Also, cowbird population size estimates are unrealistic.

Service Response: Cowbird removal activities in black-capped vireo nesting areas have not been designed to eliminate the species from an area. Control activities have been designed to reduce vireo nest parasitism in a localized area and the control efforts appear to have been successful in meeting this objective in most areas where cowbirds have been removed. Compensatory recruitment by cowbirds is a distinct possibility. Cowbirds definitely number in the millions nationwide, but the term billions cannot be documented.

Comment 5. A blackbird hunting season was proposed along with a cowbird management program in cooperation with Agricultural organizations.

Service Response: A special blackbird hunting season might accomplish little more than removal of the annual population surplus. Traditional fall hunting activities would not coincide with timing of the vireo nesting season when cowbird removal is beneficial to the vireo. Hunting activities would not be acceptable in the immediate vicinity of nesting vireos because of the associated disturbance and possible nest abandonment. Cowbird management programs in cooperation with Agricultural organizations have definite potential for benefiting vireos. Such opportunities will be investigated.

Comment 6. It may be unwise to shoot cowbirds in nesting areas of black-capped vireo because of the associated harassment, injury, or accidental killings of vireos which may result.

Service Response: We agree that such shooting must be permitted only on the periphery of nesting areas and at a great enough distance from any individual vireo nest to ensure that vireo nesting success will not be affected detrimentally. Shooters would need sufficient training and experience to ensure they only shot at cowbirds. Some assurance would also be necessary that the cowbirds being killed were those that potentially, because of such things as distance from the nesting area, might parasitize vireo nesting areas.

Comment 7. When implemented, the plan may violate the rights of private landowners if it regulates land clearing, burning, planting, etc. on private property.

Service Response: The Service has no intention of infringing on the rights of private landowners. The plan is intended to be a guide for recovery of the black-capped vireo. Implementation of any task is subject to national and international law.

Comment 8. Land acquisition should involve a willing seller relationship and should not be acquired through eminent domain.

Service Response: U.S. Fish and Wildlife Service policy stipulates the agency will only acquire land from a willing seller. Various conservation easements, cooperative agreements, or lease arrangements are also possible options to outright purchase.

Comment 9. Evaluation is needed of the plan's implications on other flora and fauna. What are the implications to the endangered golden-cheeked warbler?

Service Response: We agree that the management activities for vireos must be carefully planned and monitored to ensure that other scarce flora or fauna are not being detrimentally impacted by efforts to recover the vireo.

Comment 10. How feasible are management aspects of this plan?

Service Response: We believe it is feasible to attain the management (recovery) goals of the revised plan.

Comment 11. There appear to be some oversights on cost figures to implement the recovery plan. The total cost was not listed. Costs of browser/grazer control are not included. Predator control costs were not included.

Service Response: The total cost for each of the first three years is estimated. Future costs will likely be lower, but they are difficult to predict until we evaluate the success of the early efforts. At this time we are unable to predict the costs of browser/grazer control because the extent of use of this management technique is unknown. The need for predator control has not been determined, but has been identified as an area for further study. Therefore, because we do not know if this management technique will ever be called for or to what extent, we cannot estimate costs.

Comment 12. Are the baseline data, on which the plan is based, valid when one considers the small sample sizes, inadequate habitat descriptions, biased reproductive success data which only compared large versus small groupings, nesting habitat descriptions potentially biased toward studied sites, and drier portions of present vireo range were not included in vegetational analyses.

Service Response: A frequent difficulty in working with endangered species is that of small sample sizes, limited information, few studies, and incomplete information rangewide. Recovery actions must often be initiated with the best information available even though it is less than ideal. Delay of recovery action might ensure loss of the species. Therefore, recovery activities are initiated cautiously while additional baseline data gathering continues.

Comment 13. Will the proposed prescribed burning conflict with provisions of the Clean Air Act.

Service Response: Prescribed burning need not conflict with the Clean Air Act. The timing, location, and type of burning, however, is important. Prescribed burning will not be initiated if it violates State or Federal air quality standards.

Comment 14. Evapotranspiration was not addressed in the recovery plan as a secondary habitat factor.

Service Response: The statement is correct. A number of secondary habitat factors have not been considered in the research to date. These factors may deserve consideration in future research.

Comment 15. Short-term and long-term recovery goals should be delineated.

Service Response: Short-term goals are identified for downlisting the vireo to the Threatened category. We have insufficient information at this time to justify setting goals for delisting the species. Current policy requires that recovery plans be revised every 5 years as new information becomes available. A future revision will be an appropriate time to consider setting the long-term goals for delisting.

Comment 16. Climatic change is a definite factor and global warming may be beneficial for the vireo.

Service Response: Climatic change certainly influences the vireo. What effect (positive or negative) global warming would have on the vireo is unknown.

Comment 17. Habitat loss and modification were not addressed in the plan.

Service Response: Habitat loss and modification is discussed in the plan to the extent that it is known. Precise historical habitat acreages and distribution of the vireo are unknown so the loss and changes in distribution are discussed in general terms.

Comment 18. Land acquisition and preserve creation is not the solution. The U.S. Fish and Wildlife Service should work with landowners to create cost share incentive programs for conservation of the vireo. Why not develop incentives such as paying the private landowner $200 for each successful vireo nesting effort on his property?

Service Response: Some types of management are best implemented on large units of land owned by the public. However, conservation on private lands is also essential to recovery of the vireo and is discussed and called for in the plan. Cost share and other incentive programs have the potential for significantly benefiting the vireo and we agree they should be evaluated as a recovery measure.

Comment 19. A 90 day extension is needed for the period permitting comments on the plan because there was insufficient public notice.

Service Response: Public notice was published in local newspapers and in the Federal Register. Letters inviting review of the draft plan were mailed to key agencies and individuals. An extension was granted but it was less than 30 days. The extension was less than the requested 90 days because the Service had to comply with other deadline dates established for plan completion. Notification of the extension was sent to all people who had requested a copy of the draft plan from us prior to reopening of the comment period. In addition, notification of the extension was published in the Federal Register.

Comment 20. The expertise of a plant ecologist is needed to develop an unbiased sample analysis of vireo habitat.

Service Response: We agree that plant ecologists have an important role in helping design habitat research. Plant ecologists were involved in review and revision of the plan.

Comment 21. Wildfire suppression could be considered take.

Service Response: Wildfire is not always synonymous with good management of vireo habitat. Prescribed burning differs from wildfire in the choice of time, fire intensity, fire duration, soil moisture conditions, location and other factors which may make wildfire detrimental. A judgement about whether wildfire suppression constitutes take (as defined by the Endangered Species Act) would appropriately be determined by the courts.

Comment 22. The downlisting and recovery criteria are arbitrary and too stringent.

Service Response: Downlisting and recovery criteria may appear arbitrary when one is dealing with an endangered species about which biological information is incomplete. For example, we do not known what population size is necessary to ensure long-term viability. Small population dynamics differ from that of large populations and they are influenced more by stochastic events. The endangered species biologist is forced to make

a "best estimate" of what constitutes sufficient recovery for downlisting. Fortunately, the revision of the recovery plan at 5 year intervals provides an opportunity for reevaluating the previously stated goals on the basis of new information.
Current downlisting goals may be modified in the future if warranted by new information.

Comment 23. Developing habitat and/or captive breeding and reintroduction into historic range of the vireo should be considered in the plan.

Service Response: This recovery plan concentrates on actions necessary to stop population decline and to preserve existing population units. Development of habitat in areas within the historic range, but where it does not currently exist, may be necessary and is discussed in the plan. Captive propagation has an important role in recovery of some endangered species, but we do not currently believe it is necessary or justified for recovery of the black-capped vireo.

Comment 24. Critical habitat designation needs to be very specific.

Service Response: Critical habitat (as defined by the Endangered Species Act) has not been designated for the black-capped vireo. If such habitat is designated in the future it will be as specific as possible and will go through the required procedural rulemaking process.

Comment 25. More emphasis should be given to fire ant control within black-capped vireo habitat.

Service Response: At the present time we have no information suggesting that fire ants are an important factor limiting the populations of vireos. We will continue to be alert to their possible significance as biological studies of the vireo continue.

Comment 26. Enforcement actions were not described in detail.

Service Response: The statement is correct. Copies of the appropriate Federal and State laws are available from the agencies responsible for enforcing these laws. Interpretation of some aspects of the law may vary with unique individual circumstances which require interpretation by solicitors or legal experts. Recovery plans deal primarily with biological aspects of recovery. However, in the final plan we have included more detail on the general kinds of actions referred to as "enforcement".

Comment 27. Cost estimates appear to be underestimates.

Service Response: As estimates they may vary in their accuracy, depending on the number of unknowns involved. Some estimates may be overestimates. Some adjustments have been made in the final plan.

Comment 28. Status surveys, habitat distribution, and cowbird research should be given priority 1 on the implementation schedule.

Service Response: Priority 1 is an action absolutely essential to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future. We believe that status surveys, habitat distribution, and most cowbird research is more appropriately assigned a priority 2, which is "an action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction."

Comment 29. A recovery team should be formed for the vireo.

Service Response: Recovery teams are optional and when used are usually involved in drafting recovery plans. The Service has no plans to appoint a recovery team for the black-capped vireo. However, input from various biologists, agencies, etc. involved in vireo recovery have been considered in finalizing this plan and will be important in implementing this plan.

Comment 30. The dogmatic assumptions of rapid dynamics and successional nature of vireo habitat are erroneous. Some vireo populations like those in west Texas are in rather stable habitats.

Service Response: It is possible that some vireo habitats are fairly stable over time and other vireo habitats in other geographic locations exhibit rather rapid successional changes. It is not the intent of the Service to imply that all vireo habitats experience rapid successional changes, and revisions to the draft have been made to try to clarify this point.

Comment 31. Black-capped vireo population estimates of Benson and Benson (1990) are as good as many vireo population estimates from other regions.

Service Response: The statement is generally correct because census of small populations is usually fraught with the potential for error.

Comment 32. The reproductive ecology of black-capped vireo should be compared with that of other vireos and small passerines in the region.

Service Response: The comparison seems worthwhile in those species where sufficient information is available on their ecology. Unfortunately, we know even less about the biology and ecology of some other vireos and small passerines.

Comment 33. Areas with livestock and heavy human use have high cowbird densities. The most effective way to control cowbird parasitism is to remove the reason the cowbirds are there. This should be a management principle.

Service Response: There may be instances where it will be practical to regulate livestock use and human activities to benefit the vireo. In those circumstances these practices will be implemented.

Comment 34. The distribution of these vireos is not discussed in detail (ie., in Big Bend National Park, Camp Bullis, etc.).

Service Response: The statement is correct. Such detail is not a component of recovery plans. The interested reader/scientist is expected to refer to references listed for such detailed information.

Comment 35. Inadequate emphasis was placed on additional status and distribution surveys.

Service Response: Such additional surveys are important on the wintering grounds and in breeding habitat in Mexico and southwestern Texas. These should be accomplished as funds and priorities permit. The first priority is to protect known populations while simultaneously learning more about distribution and status at other sites.

Comment 36. The plan should be delayed several years and only written when information on the bird and its ecology is sufficient to implement better designated recovery actions.

Service Response: Under the Endangered Species Act recovery actions are to be implemented with the best available biological information. A plan with known limitations is better than no plan. Recovery actions that cautiously follow a plan and appropriate priorities are more likely to be successful than actions implemented without a plan. In addition, the plan identifies needs for and includes additional research as tasks in the plan. Future revisions to the plan will consider results of this research.

Comment 37. There are conflicting data about whether grazing by sheep and goats is detrimental or beneficial.

Service Response: Overbrowsing, particularly by goats, can be detrimental to black-capped vireos' habitat. However, in some cases, negative effects can be reversed if the animals are removed. Individual situations require onsite evaluation by a wildlife ecologist.

Comment 38. Recovery costs per bird are excessive.

Service Response: Recovery of endangered species is often expensive. However, rarely are recovery plans fully funded in any given year. How much is actually spent depends on annual budgets and appropriations. Perhaps this is one reason why so few species have ever been recovered.

Comment 39. There seems to be reasonable doubt the species is recoverable.

Service Response: The objectives of the plan have been revised. Delisting criteria are not given, pending further evaluation of whether total recovery is possible. Downlisting criteria are included in this final plan and the Service believes there is a high probability that these criteria can be met if sufficient funds are available to implement the recovery plan. There is always some element of uncertainty about success. The Endangered Species Act requires the development of recovery plans for the conservation and survival of listed species.

Comment 40. There is evidence the vireo has coexisted for centuries with cowbirds. The plan should concentrate on habitat acquisition and maintenance, not cowbird control.

Service Response: The vireo has coexisted for centuries with cowbirds. However, when man introduced large numbers of livestock, and altered habitat by his other activities, it appears he promoted an increase in numbers and distribution of cowbirds. Before man's intervention, the cowbird may not have been a factor limiting vireo populations. Man's intervention, however, may have changed the situation sufficiently to make the cowbird a significantly more effective nest parasite and, thus, a key factor limiting vireo populations. The draft plan may have overemphasized the role of cowbird control.

Habitat management and acquisition will be important parts of recovery. The draft plan was revised accordingly.

Comment 41. The plan places too much emphasis on research and not enough on application of current management knowledge.

Service Response: We do hope to fully use our current management knowledge. There is much to learn by refining our management techniques, by ascertaining that our techniques will accomplish what preliminary results suggest, and by researching new innovative recovery actions. Perhaps the wording of recovery implementation gave the impression that research is overemphasized.

Comment 42. The preferred citation (pg. ii) should be Grzybowski, J.A. 1991. .... He wrote it and should get credit as author.

Service Response: When contractors are hired to develop a draft plan, the Service retains the option of modifying the plan. The final published plan may not resemble the draft product provided by the contractor. The Service may include in the final plan some features that the original author opposes. For those reasons, the Service takes full responsibility as the final author but indicates in the plan the role of the contractor (in this case, on the title page).

Comment 43. Few studies of vireos on private lands were mentioned, but over 90 percent of the land base in Texas is privately owned. The land use and habitat structure on public lands is diverse and may not be similar to that of private lands.

Service Response: Some private lands have not been accessible because of trespass restrictions. Public ownership is also conducive to long-term studies. We are aware of the limitations of extant research and expect to be cautious in extrapolating them to all types of habitat in private ownership.

Comment 44. A reasonably accurate total population estimate, with appropriate estimates of standard deviation, is needed. Some individuals believe the vireo is more abundant than originally thought.

Service Response: The statement is correct. As time and funds permit, we hope to derive a total population estimate with appropriate statistical confidences.

Comment 45. No mention was made of the types of feeding areas needed during pre-nesting, nesting, and post-nesting periods.

Service Response: Information is lacking on food habits and the precise habitat needs for the periods mentioned.

Comment 46. Could artificial vireo nests with artificial eggs be placed in vireo nesting habitat to reduce the reproductive effectiveness of the cowbird? Why not develop sterilization techniques for cowbirds as an alternative to costly, eternal eradication programs?

Service Response: Yes, artificial vireo nests may prove to be a useful management technique aiding in reducing the detrimental impact of nest parasitism by cowbirds.

Sterilization techniques also have potential for minimizing the cost and efforts currently needed to control cowbirds in localized areas.

Comment 47. The plan should include a means of monitoring the cost effectiveness of recovery techniques.

Service Response: Management costs in relation to the resulting recovery benefits are the typical way in which we assess cost effectiveness.

Great Trinity Forest Management Plan

Threatened and Endangered Species

Golden-cheeked Warbler

(Dendroica chrysoparia)

Golden-cheeked Warbler

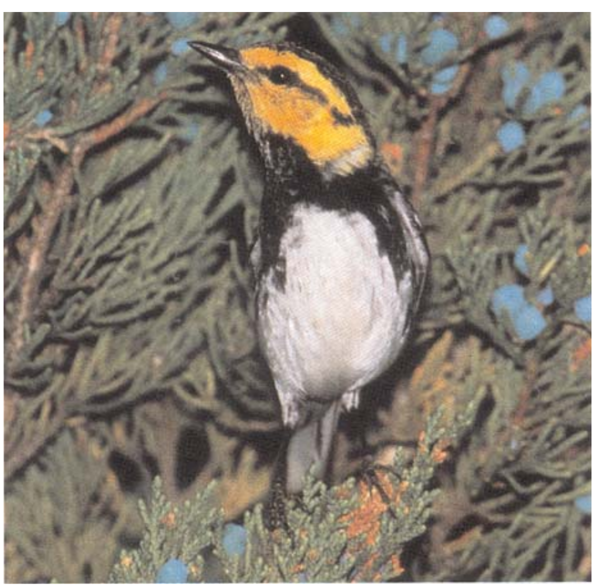
Scientific Name: *Dendroica chrysoparia*

Federal Status: Endangered, 5/4/90 • State Status: Endangered

Description

The Golden-cheeked Warbler is a small, migratory songbird, 4.5 to 5 inches long, with a wingspan of about 8 inches. The male has a black back, throat, and cap; and yellow cheeks with a black stripe through the eye. Females are similar, but less colorful. The lower breast and belly of both sexes are white with black streaks on the flanks.

Male Golden-cheeked Warbler
© Greg W. Lasley



Female Golden-cheeked Warbler
© Greg W. Lasley

Habitat

Typical nesting habitat is found in tall, dense, mature stands of Ashe juniper (blueberry cedar) mixed with trees such as Texas (Spanish) oak, Lacey oak, shin (scalybark) oak, live oak, post oak, Texas ash, cedar elm, hackberry, bigtooth maple, sycamore, Arizona walnut, escarpment cherry, and pecan. This type of woodland generally grows in relatively moist areas such as steep-sided canyons, slopes, and adjacent uplands. A mix of juniper and deciduous trees on the slopes, along drainage bottoms, and in creeks and draws provide an ideal mix of vegetation for these birds. Warblers can also be found in drier, upland juniper-oak (i.e., Texas oak, live oak, post oak, blackjack oak) woodlands over flat topography.

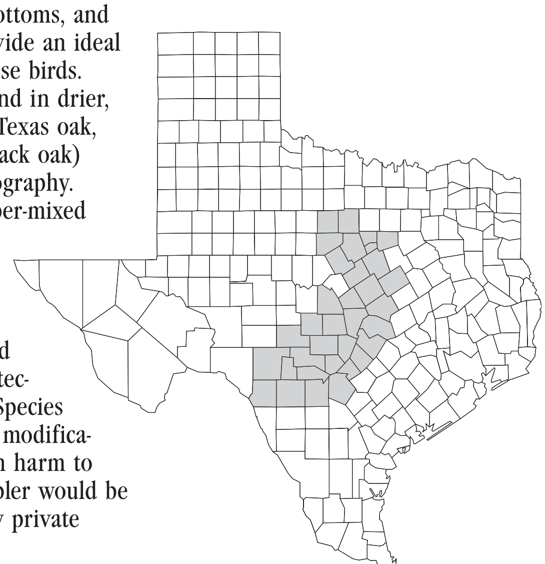
Not all mature juniper-mixed deciduous woodlands are used by Golden-cheeked Warblers. Only habitat actually used by endangered or threatened animals is subject to protection by the Endangered Species Act (ESA). (Only habitat modifications that would result in harm to the Golden-cheeked Warbler would be considered a violation by private actions under the ESA.)

Warblers need a combination of mature Ashe juniper and hardwood trees in their nesting habitat. Mature juniper trees vary in age and growth form, depending on site factors. Generally, trees required for nesting habitat are at least 15 feet tall with a trunk diameter of about five inches at four feet above the ground. The essential element is that juniper trees have shredding bark, at least near the base of the tree.

Although the composition of woody vegetation varies within suitable warbler habitat, Ashe juniper is often, but not always, the dominant species. One study showed that juniper comprises anywhere from 10-90% of total trees in occupied habitat at 27 sites scattered throughout the breeding range.

Golden-cheeked Warblers have been found in patches of habitat smaller than 12 acres, although populations of warblers in larger tracts of woodland habitats will persist longer than populations in small tracts of land. With increasingly fragmented habitat, smaller patches may become more important to warblers, particularly those located near areas of occupied habitat.

In general, Golden-cheeked Warblers occur in areas with a moderate to high density of older trees, and dense foliage in the upper canopy. Higher warbler densities are associated with larger contiguous patches, greater average tree height, greater variability in tree heights, and greater density of deciduous trees.



Life History

The Golden-cheeked Warbler's entire nesting range is currently confined to habitat in 33 counties in central Texas. The birds are dependent on Ashe juniper (blueberry juniper or cedar) for fine bark strips used in nest construction. Although nests may be placed in various species of trees, such as juniper, Texas oak, live oak, and cedar elm, all nests contain strips of Ashe juniper bark woven together with spider webs.

Warblers feed almost entirely on caterpillars, spiders, beetles, and other insects found in foliage. The birds are thought to take advantage of insect blooms associated with different plants as the growing season progresses. For example, broad-leaved trees and shrubs, especially oaks, are particularly important in providing habitat for insects during the first part of the nesting season. Later in the season, warblers are frequently seen foraging in Ashe juniper. Mesic (relatively moist) conditions, such as those found on wooded slopes, canyon bottoms, and along creeks and draws, are especially favorable for the production of insect foods.

Depending on the location and quality of habitat, Golden-cheeked Warblers forage and nest in areas of habitat ranging in size from five to 20 acres per pair. Within suitable nesting habitat, male Golden-cheeked Warblers occupy an area, called a territory, which is vigorously defended against all other male Golden-cheeked Warblers. Nesting territories range in size from three to ten acres, depending on habitat quality. Banding studies show that males often occupy the same territory in subsequent breeding seasons. Male warblers can often be located through their territorial song, described as a rather hurried, buzzy “tweah-tweah-twee-sy.” Single, sharp “chipping” calls can frequently be heard as Golden-cheeks forage among the trees.

The female does most of the work of nest building and incubating the eggs. The cup-like nest is often neatly tucked into the fork of a vertical limb and camouflaged to blend with the bark of the tree. Nests are constructed at an average height of 15 feet above ground, although they have been found as low as five feet and as high as 32 feet. The male stays close by, singing his distinctive song and defending his territory during incubation.

During April, a single clutch of three to four eggs is laid. Warblers usually nest only once per season, unless a nest is lost to accident or predation. The eggs hatch in 12 days, and both parents care for the young. After the young hatch, male singing declines, although they can still be heard into June. Nestlings fledge eight or nine days after hatching, but remain in the vicinity of the territory for at least four weeks while being cared for by both parents.

Golden-cheeked Warblers migrate to their wintering grounds in the pine-oak woodlands of southern Mexico (Chiapas), Guatemala, Honduras, and Nicaragua from late June to mid August. They return to Texas in early to mid-March.

Threats and Reasons for Decline

The most serious problems facing the Golden-cheeked Warbler today, as in the recent past, are habitat loss and fragmentation. Since warblers have limited and specific habitat requirements, direct habitat loss has resulted in population reduction, although precise comparisons of historic and current populations are not available.

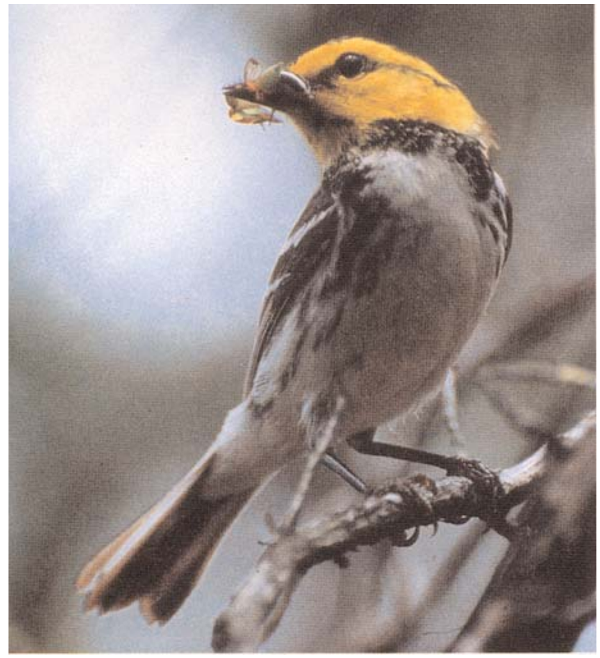
Recently, serious losses in nesting habitat have occurred in counties such as Travis, Williamson, and Bexar, where rapid urban development has spread into oak-juniper woodlands associated with canyonlands. Flood control and other impoundments have also reduced habitat for the warbler by inundating the juniper-oak woodlands existing on canyon slopes and bottoms along springs, streams, and rivers. Construction of large reservoirs has also led to loss of warbler habitat due to development of lake-side communities.

Historically, some warbler habitat was lost as a result of clearing juniper/oak woodlands for increased livestock production or improved livestock handling. Stands of large juniper trees were also cut for sale as fence posts and other timber products, especially before 1940. Over-browsing by white-tailed deer, goats, and exotic ungulates is believed to contribute to habitat degradation by reducing the survival of seedling oaks and other deciduous trees, which are a vital component of warbler habitat. Also, many of the deeper and more fertile soils in much of the Hill Country are found in small floodplains along creeks or intermittent streams associated with hillside drainage. Many of these areas, some of them supporting a variety of deciduous trees, were cleared and converted to forage crops and pasture, often resulting in a decrease in the amount of warbler habitat.

Habitat loss may be obscured by the increase in juniper on rangeland throughout central Texas. The invasion of juniper on upland sites is often the result of fire suppression, overgrazing, or a combination of both. These young juniper stands invading open rangelands generally lack the kinds and numbers of hardwood trees required by warblers. Warblers are usually not found in monocultures (pure stands) where juniper comprises over 90% of the composition throughout a large area.

Poor grazing management practices and fire suppression result in a decline in the diversity and productivity of rangeland. The decline in range condition associated with improper management has led to increases in juniper throughout the Hill Country.

Brood parasitism by Brown-headed Cowbirds may threaten successful reproduction of Golden-cheeked Warblers, although the degree of



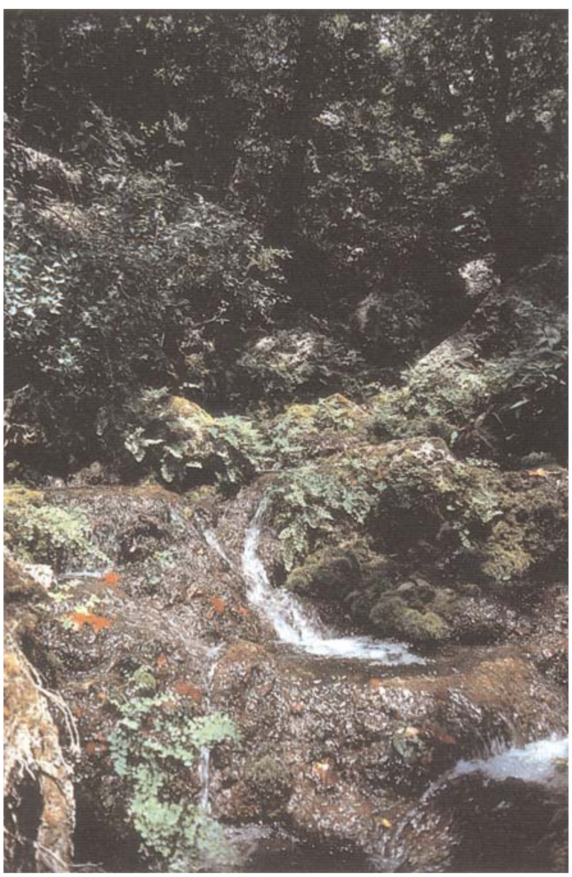
Female warbler with insect
© TPWD Dean Keddy-Hector

Warbler at a nest
© TPWD Dean Keddy-Hector

Golden-cheeked Warbler habitat
© TPWD David Riskind

Closed canopy habitat
© Carol Beardmore

Juniper with peeling bark
© TPWD D. Keddy-Hector



Creek bottom habitat
© TPWD Glen Mills

impact of cowbird parasitism on warbler productivity is not fully understood. Cowbirds lay their eggs in other birds' nests, leaving the host bird to raise the cowbird young. Golden-cheeked Warblers apparently will either abandon parasitized nests, or raise young cowbirds in addition to or in place of their own young. Warblers that abandon parasitized nests may renest later in the season. However, abandonment of first clutches, or raising cowbird young in addition to their own, decreases the total number and survivability of Golden-cheeked warbler young produced.

Habitat fragmentation reduces the quality and quantity of warbler habitat. In small woodland patches, the increased proportion of habitat edge to interior area may increase rates of brood parasitism and predation, so that the surviving populations cannot maintain themselves. Also, increased distances between patches may make recolonization of vacated habitat more difficult.

In Texas, Mexico and Central America, habitat management and protection, responsible land stewardship, and incentives for landowners to maintain and develop habitat, are keys to the survival and recovery of the Golden-cheeked Warbler. The diverse mix of hardwoods and junipers in canyons, and on slopes and adjacent hilltops, provide ideal habitat for the warbler. Numerous beautiful and interesting native plants and animals are also found in these canyons.

Recovery Efforts

Research is underway to better understand the life history, habitat requirements, limiting factors, and land management practices affecting the Golden-cheeked Warbler. Population surveys during the breeding season are being conducted in known and potential habitat areas. Efforts to provide information and educational opportunities to landowners and the public regarding life history and habitat requirements of the warbler are also a vital part of the recovery effort. Major recovery efforts are being conducted on Department of Defense's Fort Hood and Camp Bullis, Travis County and the City of Austin's Balcones Canyonlands Preserve, the U.S. Fish and Wildlife Services' Balcones Canyonlands National Wildlife Refuge, and many properties owned and/or managed by the Nature Conservancy. Additionally, Environmental Defense through their Safe Harbor Agreement with the U.S. Fish and Wildlife Service is assisting many landowners to manage and/or create habitat for the benefit of the warbler. Voluntary cowbird trapping is being conducted by more than 400 landowners in counties throughout the range of the warbler.

Recently, a consortium of researchers in governmental and non-governmental agencies has proposed a multinational effort to better understand and coordinate approaches to managing and recovering the Golden-cheeked Warbler. Additional research in Mexico and Central America is planned to gather information concerning life history and habitat requirements on the wintering range. Studies are needed to assess the potential for income generating activities, such as selective harvest of juniper, which may be compatible with habitat protection.

Where To See the Golden-cheeked Warbler

A number of state lands, including Colorado Bend State Park (SP), Dinosaur Valley SP, Garner SP, Guadalupe River SP, Honey Creek State Natural Area (SNA), Hill Country SNA, Kerr Wildlife Management Area, Longhorn Cavern SP, Lost Maples SNA, Meridian SP, Pedernales Falls SP, and Possum Kingdom SP offer opportunities for people to see Golden-cheeked Warblers and their habitat. Other locations include the Balcones Canyonlands National Wildlife Refuge, Travis Audubon Sanctuary, Wild Basin Preserve, and Emma Long City Park in the Austin area; and Friedrich Wilderness Park near San Antonio. Once open to the public, Government Canyon State Natural Area, located northwest of San Antonio, will offer additional opportunities to see Golden-cheeked Warblers.

Because the Golden-cheeked Warbler is an endangered species, birders and other observers should carefully follow certain viewing ethics. Recorded calls of the Golden-cheeked Warbler or Screech Owl should not be used to attract birds and observers should be careful not to disturb or stress birds.

How You Can Help

You can help by providing encouragement and support for private landowners who are managing their land to protect natural diversity and endangered species habitat. Landowners are encouraged to learn the facts about the Golden-cheeked Warbler and its habitat needs, and to protect areas of habitat found on their property.

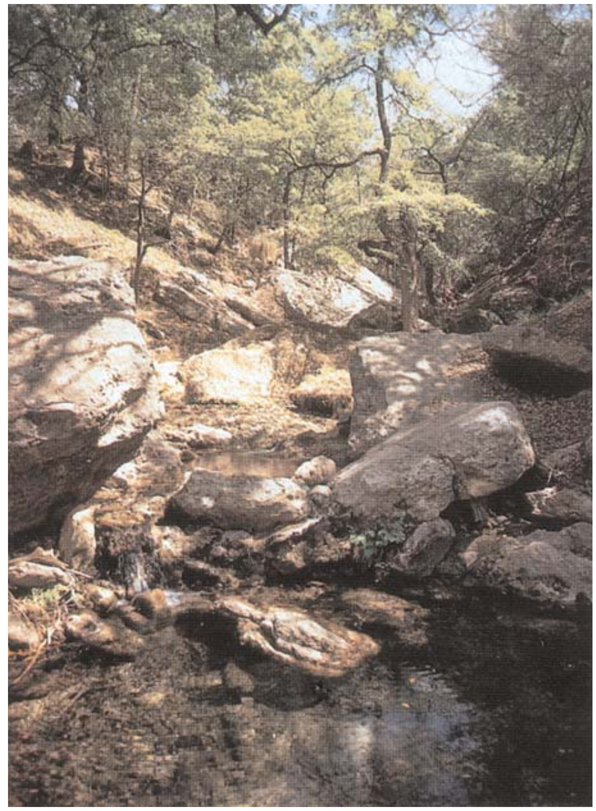
The Golden-cheeked Warbler is a beautiful songbird, and is much sought after among people who enjoy bird-watching and nature study. Possibilities exist for landowners to take advantage of the growing demand for natural history tours and vacations. Landowners interested in more information concerning nature tourism opportunities should contact the Nature Tourism Coordinator, Texas Parks and Wildlife Department, Austin (512) 389-4396; Environmental Defense, Austin (512) 478-5161; or the Nature Conservancy, San Antonio (210) 224-8774.

Finally, you can be involved in the conservation of Texas' nongame wildlife resources by supporting the Special Nongame and Endangered Species Conservation Fund. Special nongame stamps and decals are available at Texas Parks and Wildlife Department (TPWD) field offices, most state parks, and the License Branch of TPWD headquarters in Austin. Conservation organizations in Texas also welcome your participation and support.

For More Information Contact

Texas Parks and Wildlife Department
Wildlife Diversity Branch
4200 Smith School Road
Austin, Texas 78744
(512) 912-7011 or (800) 792-1112
or
U.S. Fish and Wildlife Service
Ecological Services Field Office
10711 Burnet Road, Suite 200
Austin, Texas 78758
(512) 490-0057

Management guidelines are available from the Texas Parks and Wildlife Department and U.S. Fish and Wildlife Service for landowners and managers wishing to maintain and improve habitat for the Golden-cheeked Warbler.



Golden-cheeked Warbler habitat
© TPWD Bill Reaves

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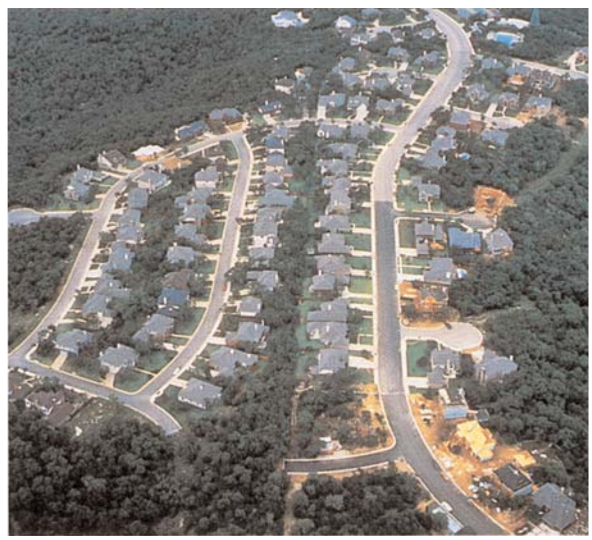

Urban expansion
© USFWS Wyman Meinzer

Warbler with identification band
© TPWD

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Management Guidelines for the Golden-cheeked Warbler in Rural Landscapes

The descriptions presented in this document are intended to help landowners determine if they have Golden-cheeked Warbler habitat on their property. Not all sites within the habitat types described will be used by Golden-cheeked Warblers. It is only where individuals of this species occupy the identified habitat types during the breeding season that special management considerations such as those provided in these guidelines need to be considered.

Private landowners have a tremendous opportunity to conserve and manage the fish and wildlife resources of Texas. The objective of these guidelines is to provide landowners with recommendations about how typically-used agricultural land management practices could be conducted so that it would be unlikely that Golden-cheeked Warblers would be adversely impacted. The guidelines will be updated periodically to make them more practical and useful to rural landowners. The guidelines are based on the best available information and current understanding about the biology of the warbler, but may be refined as more complete biological data are collected. TPWD biologists have prepared these guidelines in consultation with USFWS biologists to assure landowners who carry out agricultural land management practices within the guidelines that they would know, with the greatest certainty possible, that they would not be in violation of the Endangered Species Act.

This document also provides information on land management practices that are appropriate for protection and/or enhancement of habitat. The categories were chosen to represent commonly encountered vegetation types and to address common questions regarding the effect of management practices on Golden-cheeked Warblers. In addition, suggestions are offered that promote conservation of soil, water, plant, and wildlife resources.

Habitat Descriptions

Habitat Types Where Warblers Are Expected To Occur (Protection efforts should be focused in these habitat types)

Woodlands with mature Ashe juniper (cedar) in a natural mix with oaks, elms, and other hardwoods, in relatively moist (mesic) areas such as steep canyons and slopes, and adjacent uplands are considered habitat types that are highly likely to be used by warblers. Mature Ashe junipers are trees that are at least 15 feet in height with a trunk diameter of about five inches at four feet above the ground (dbh). These areas generally will have a nearly continuous canopy cover of trees with 50-100% canopy closure and an overall woodland canopy height of 20 feet or more. This habitat type is also important for deer, turkey, other songbirds, and a variety of other wildlife due to the diversity of vegetation and topography and, in many cases, proximity to water. Woodlands of this description should be retained wherever they occur, especially along creeks and draws, and on steep slopes and generally rough terrain. Landowners with woodlands that fit the above description should assume that warblers may be using the area and are advised to follow the management guidelines presented here. Additional information regarding habitat types and their potential to support Golden-cheeked Warblers is presented in Table 1.

Habitat Types That May Be Used By Warblers

It is relatively easy to recognize the above described high quality habitat types where Golden-cheeked Warblers are likely to occur. However, there are a number of other vegetation types that may also be used by warblers, depending on the location, size of tract, land use, adjacent landscape features, and vegetation structure. These habitat types are most often used by warblers when they are located adjacent to or near areas of high quality habitat.

The four habitat types discussed below can be associated with a variety of tree canopy covers, ranging from 35-100%. Also, all four habitat types can contain mature Ashe juniper. Although not representative of what is typically thought of as the "best" warbler habitat, these areas may support Golden-cheeked Warblers, especially fledglings (young birds that have left the nest). These habitats may be relatively more important to warblers nesting in the western and northern portions of the species' breeding range, or in areas where optimal habitat no longer exists. Although these habitat types may occupy a large geographic area within the Hill Country, little is known about warbler occupancy when the sites are not close to the optimal habitat types. Landowners are advised to treat the following vegetation types as occupied habitat until technical assistance is obtained or a survey done to determine whether or not specific areas support warblers:

1. Stands of mature Ashe juniper (trees with shredding bark), over 15 feet in height and dbh of about 5 inches, with scattered live oaks (at least 10% total canopy cover), where the total canopy cover of trees exceeds 35% and overall woodland canopy height is at least 20 feet.
2. Bottomlands along creeks and drainages which support at least a 35% canopy of deciduous trees (average canopy height of 20 feet), with mature Ashe juniper (at least 15 feet and 5 inches dbh) growing either in the bottom or on nearby slopes.
3. Mixed stands of post oak and/or blackjack oak (10-30% canopy cover), with scattered mature Ashe juniper (15 feet in height and 5 inches dbh), where the total canopy cover of trees exceeds 35% and

overall woodland canopy height is 20 feet.
4. Mixed stands of shin (scaly-bark) oak (10-30% canopy cover) with scattered mature Ashe juniper (15 feet in height and 5 inches dbh), where the total canopy cover of trees exceeds 35% and overall woodland canopy height is 20 feet. (See Table 1).

Areas Where Warblers Are Not Expected To Occur

The following types of areas are not typical warbler habitat and are unlikely to be used by warblers unless adjacent to warbler habitat areas. This is important because areas consisting of non-typical warbler habitat that are adjacent to occupied habitat may in fact be used for foraging. This is especially true for sparsely wooded grassland or low-impact agriculture, but much less so for industrial, commercial, and medium to high density residential areas (Coldren 1998). Further, although junipers occur abundantly over much of the Hill Country, a relatively small portion of them are actually a part of usable warbler habitat.

1. Stands of small Ashe juniper, averaging less than 15 feet in height and 5 inches dbh, are not habitat. This includes small juniper that invades open rangelands, previously cleared areas, or old fields. These areas are often dry and relatively flat, and lack oaks and other broad-leaved trees and shrubs. Generally, areas such as those described above that have been cleared within the last 20 years are not considered habitat.
2. Pure stands of larger (greater than 15 feet in height and 5 inches dbh) Ashe juniper, with few or no oaks or other hardwoods.
3. Open park-like woodlands or savannahs (even with old junipers) where canopy cover of trees is less than 35%. These areas often have scattered live oaks and other trees.
4. Small junipers and other trees coming up along existing fence lines.
5. Small junipers (less than 15 feet tall) coming up under larger hardwoods where junipers have been removed in the past 20 years.

Table 1. Ecological site types and Range Sites with plant communities that may provide habitat for Golden-cheeked Warblers. On flat or rolling uplands, warblers are most likely to occupy larger patches of woodlands adjacent to canyon systems. Most of the flat and rolling uplands within these Range Sites have other plant communities, like open savannahs, that do not support warblers. Sites that are not used by warblers are described in the Habitat Descriptions section of this leaflet.

Site Description	Range Site	Typical Plant Communities that may support Golden-cheeked Warblers	Potential for Golden-cheeked Warblers
Slopes and canyons, and associated creek bottoms	Adobe Clay Loam [1] Loamy Bottomland [1] Steep Adobe Steep Rocky	Continuous canopy woodland* of Ashe Juniper, Texas Oak, Live Oak, Lacey Oak, Chinkapin Oak, Cedar Elm, Escarpment Blackcherry, Texas Ash, Bigtooth Maple, Redbud, Hackberry, Pecan, and other deciduous trees	Highly likely to be used
Flat or rolling uplands with shallow, rocky soils of variable depth	Adobe Low Stony Hill Shallow Very Shallow	Continuous canopy woodland* of Live Oak, Blackjack Oak, Post Oak, Shin Oak, Lacey Oak, Texas Oak, Cedar Elm, Hackberry, Texas Madrone, and Ashe Juniper Patchy woodlands+ or interspersed mottes of mature Live Oak, Blackjack Oak, Post Oak, and Ashe Juniper	Highly likely to be used May be used
Flat or rolling uplands with reddish soils	Deep Redland [2] Gravelly Redland [2] Redland [2]	Continuous canopy woodland* of Live Oak, Blackjack Oak, Post Oak, Shin Oak, Lacey Oak, Texas Oak, Cedar Elm, Hackberry, Texas Madrone, and Ashe Juniper Patchy woodlands+ or interspersed mottes of mature Live Oak, Blackjack Oak, Post Oak, and Ashe Juniper	Highly likely to be used May be used
Flat or rolling uplands with shallow but more continuous rocky soils over limestone [3]	Low Stony Hill	Continuous canopy woodland* of Ashe Juniper, Live Oak, and Shin Oak Patchy woodlands+ or interspersed mottes of mature Live Oak, Ashe Juniper, Hackberry, Cedar Elm, and Mesquite	May be used May be used

* Defined as 50-100% canopy cover of trees at least 15 feet in height or greater.
+ Defined as 35-50% canopy cover of trees at least 15 feet in height or greater.
[1] Stream bottoms in and near canyon systems.
[2] Golden-cheeked Warblers may occur on Redland Range Sites adjacent to slope and canyon habitat. It is not known whether or not warblers occur on Redland Sites isolated from canyon systems.
[3] Common woody plants include Hackberry, Texas Persimmon, Texas Ash, Live Oak, Texas Oak, Ashe Juniper, Evergreen Sumac, Cedar Elm, and Mesquite

Controlling juniper on these areas by prescribed burning, hand cutting, or well-planned mechanical methods is often desirable to improve range condition and plant diversity, and is compatible with protection and conservation of adjacent Golden-cheeked Warbler habitat. Maintaining a minimum 300 feet wide buffer of woodland vegetation adjacent to and around Golden-cheeked Warbler habitat is beneficial to minimize predation. This recommendation stems for studies which suggest that avian predation is greatest within 300 feet of the edge of an occupied habitat patch than farther inward (Arnold et al. 1996). However, when brush management and maintenance activities near habitat are necessary, they should not occur during the March-August nesting season to avoid adverse impacts such as disturbance of nesting and feeding birds. Since brush management activities can affect habitat for the Black-capped Vireo as well as the Golden-cheeked Warbler, landowners are encouraged to learn about the habitat requirements of both endangered songbirds (see TPWD leaflet on the Black-capped Vireo).

It is important in wildlife management in general, and in endangered species management in particular, to consider the "big picture" with regard to how land types relate to one another. For example, when brush management practices are planned in non-habitat areas, one should consider the proximity of the area to habitat used by warblers. These guidelines encourage landowners to keep natural, mature woodland sites wooded while allowing for the restoration of former savannah and grassland habitats that have been invaded by small juniper (or other invasives).

Open savannah – not habitat
© Matt Wagner

Regrowth cedar - not habitat
© Matt Wagner

Agricultural Practices in Golden-cheeked Warbler Habitat

Disruption of the tree canopy should be avoided when planning ranch improvements or maintenance work in Golden-cheeked Warbler habitat. It is recommended that new fence lines and livestock watering facilities (pipelines, storage tanks, ponds, and troughs) be planned to avoid areas of habitat whenever possible. However, narrow linear openings, such as those needed for traditional agricultural management (fence lines, ranch roads, and livestock water pipelines) will not harm Golden-cheeked Warblers if openings (spaces between trunks or stems at breast height) are no greater than 16 feet in width. This width is large enough to allow for maintenance, while permitting the hardwood tree canopy to grow over the gap. Permanent electric fencing may enable landowners to cross fence areas of rough terrain with little or no disturbance to the tree canopy. Often, these power fences are the most cost effective way to cross fence areas of steep topography and shallow soils. Fencing and other ranch improvement work in Golden-cheeked Warbler habitat should only be done during the non-nesting period (September-February).

Dozing or hand cutting in habitat with closed tree canopy and steep slopes not only destroys warbler habitat, but mechanical disturbance also can create serious soil erosion problems. In addition, clearing these areas is generally not cost effective due to higher clearing costs; lower forage production potential, and grazing distribution problems associated with steep slopes. Selective removal of small juniper less than 15 feet in height and 5 inches dbh within habitat is not a problem as long as the tree canopy is not disturbed. Any selective removal of juniper within or adjacent to habitat should be done during the non-nesting period (September-February).

When mature juniper trees are abundant in the habitat, incidental removal of juniper for use as fence posts on the ranch will have little impact on warbler habitat. The number of trees cut depends on the density of Ashe juniper in the habitat. For example, more trees could be removed from an area with a high density of juniper compared with the density of hardwoods. The idea should always be to provide a mix of juniper and hardwoods. When posting is done, trees should be selected to avoid disturbance to the tree canopy. One way to do this is to select trees with a relatively small individual canopy and scatter your tree selections over the area. Posting should not occur in habitat during the nesting period (March-August).

In habitat areas and on rangelands immediately adjacent to habitat, it is important to manage grazing pressure by deer and livestock to prevent over browsing of broad-leaved shrubs and trees, and to maintain plant diversity and productivity. Controlling the number of browsing animals (deer, exotic animals, and livestock) is important to maintain hardwood seedlings and ensure eventual replacement of deciduous trees in the canopy. Range condition improvement in and adjacent to habitat areas, through proper grazing management and planned deferment, will likely prove beneficial to livestock and wildlife, including the Golden-cheeked Warbler.

Landowners with questions regarding how ranch improvements and management practices will affect habitat are advised to seek technical assistance from the Texas Parks and Wildlife Department, USDA Natural Resources Conservation Service, or U.S. Fish and Wildlife Service. For activities other than those described above, land managers should seek assistance from the U.S. Fish and Wildlife Service, since permits may be needed.

Other Management Suggestions

Reducing Impacts from Predation and Cowbird Parasitism

Reducing the impacts of predation and brood parasitism by Brown-headed Cowbirds may be important for successful reproduction in some populations of Golden-cheeked Warblers. This is particularly true where warblers nest near grazed land or grain crops

Planned grazing systems designed to rotate livestock away from known nesting areas during the breeding season (March-August) may be desirable to reduce cowbird impacts. Periodic rest also has important benefits for improving range condition and productivity. Since cowbirds are attracted to easily available food sources, spilling or scattering grain should be avoided. Supplemental feeding areas for livestock should be moved frequently, located away from nesting habitat, and kept free from accumulations of waste grain.

Maintaining woodland vegetation adjacent to Golden-cheeked Warbler habitat is often desirable to reduce predation and brood parasitism by Brown-headed Cowbirds. Woodland strips of 300 feet or more are preferable. These strips should be composed of both the physical structure (height and canopy cover) and species composition similar to warbler habitat (Arnold, et. al. 1996).

Finally, controlling cowbirds through trapping is effective in reducing warbler brood parasitism. Mounted mobile traps, placed near watering sites as livestock are rotated through pastures, have been used successfully to reduce cowbird numbers. Properly placed stationary traps have also proven effective in reducing cowbird numbers and parasitism in a local area. Other methods, such as shooting, can be used to supplement trapping efforts where needed. Persons trapping cowbirds need to be certified for the handling of non-target birds under the general trapping permit held by TPWD. Preventing mortality of non-target birds is of paramount concern, so traps must be carefully monitored and checked frequently. Contact Texas Parks and Wildlife Department for information and assistance in implementing a cowbird control program.

Habitat Restoration

The following suggestions are offered for landowners wishing to restore or create habitat for the Golden-cheeked Warbler in areas that currently do not support warblers. One type of restorable habitat is the relatively mesic (moist) area, with a diversity of deciduous trees, where junipers have been previously removed. Allowing the reestablishment of juniper on these sites would eventually result in the mature oak-juniper woodland preferred by Golden-cheeked Warblers.

Other situations where restoring habitat may be a possibility include relatively mesic areas dominated by juniper, where heavy browsing pressure by deer or livestock has prevented the establishment of hardwood seedlings. In these areas, control of deer numbers and planned deferment from livestock grazing would help promote reestablishment of broad-leaved shrubs and trees, eventually resulting in mature juniper-oak woodland.

In mesic areas where small junipers (15 ft. or less) are dominant, small junipers could be thinned to favor faster growth of remaining trees. Thinning would encourage hardwood regeneration, especially if some slash is left in place to provide protection for hardwood seedlings. If large junipers are dominant, several small openings per acre would encourage hardwood regeneration. These openings should be protected from browsing and left to regenerate naturally, or planted to native hardwoods. In each of these examples, the idea is to restore areas that may once have provided habitat to the natural oak-juniper woodland capable of growing on the site.

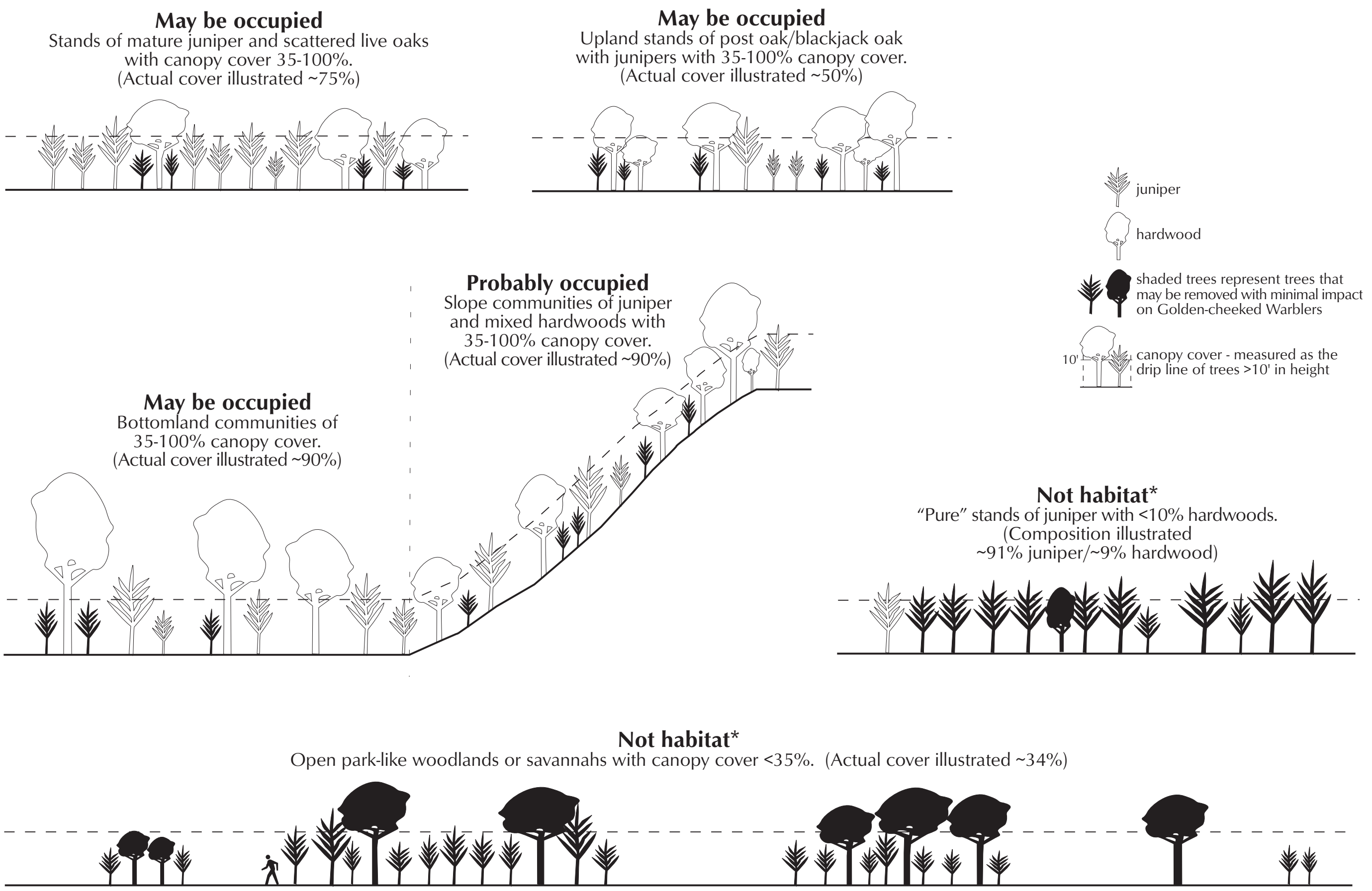
Further Guidance Concerning the ESA

Good range management practices such as proper stocking, rotational grazing, prescribed burning, periodic deferments, carefully planned brush control, and attention to plant and animal resource needs will help prevent loss of Golden-cheeked Warbler habitat. Habitat where Golden-cheeked Warblers are likely to occur should be protected from activities that alter the composition or structure of trees and shrubs, except as provided for in these guidelines. Likewise, management activities in areas that may be used by warblers should be carefully planned to avoid altering vegetation composition and structure and timed to avoid the breeding season until a survey is done to determine if warblers are using the area. Important habitat components such as the ratio of mature juniper to deciduous trees, and canopy structure and height, should be retained whenever possible to enable population recovery.

Landowners who are not sure whether or not they have suitable Golden-cheeked Warbler habitat, or whether a planned activity will affect these birds, may want to consult a biologist familiar with the species. An on-site visit by a biologist familiar with the warbler can determine if warbler habitat is present and whether the planned activity falls under the guidelines presented here. Also, a biologist who has a scientific permit from the U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department to do Golden-cheeked Warbler survey work will know how to conduct a breeding season survey to determine if warblers are present in the area for which a management activity is planned.

Technical Assistance

Technical assistance in range and wildlife management, including management for endangered species, is available to landowners and managers by contacting the Texas Parks and Wildlife Department, USDA Natural Resources Conservation Service, Texas Cooperative Extension, or U.S. Fish and Wildlife Service. Further guidance and specific questions concerning Golden-cheeked Warbler research, endangered species management and recovery, and landowner responsibilities under the Endangered Species Act, should be directed to the Texas Parks and Wildlife Department or U.S. Fish and Wildlife Service.

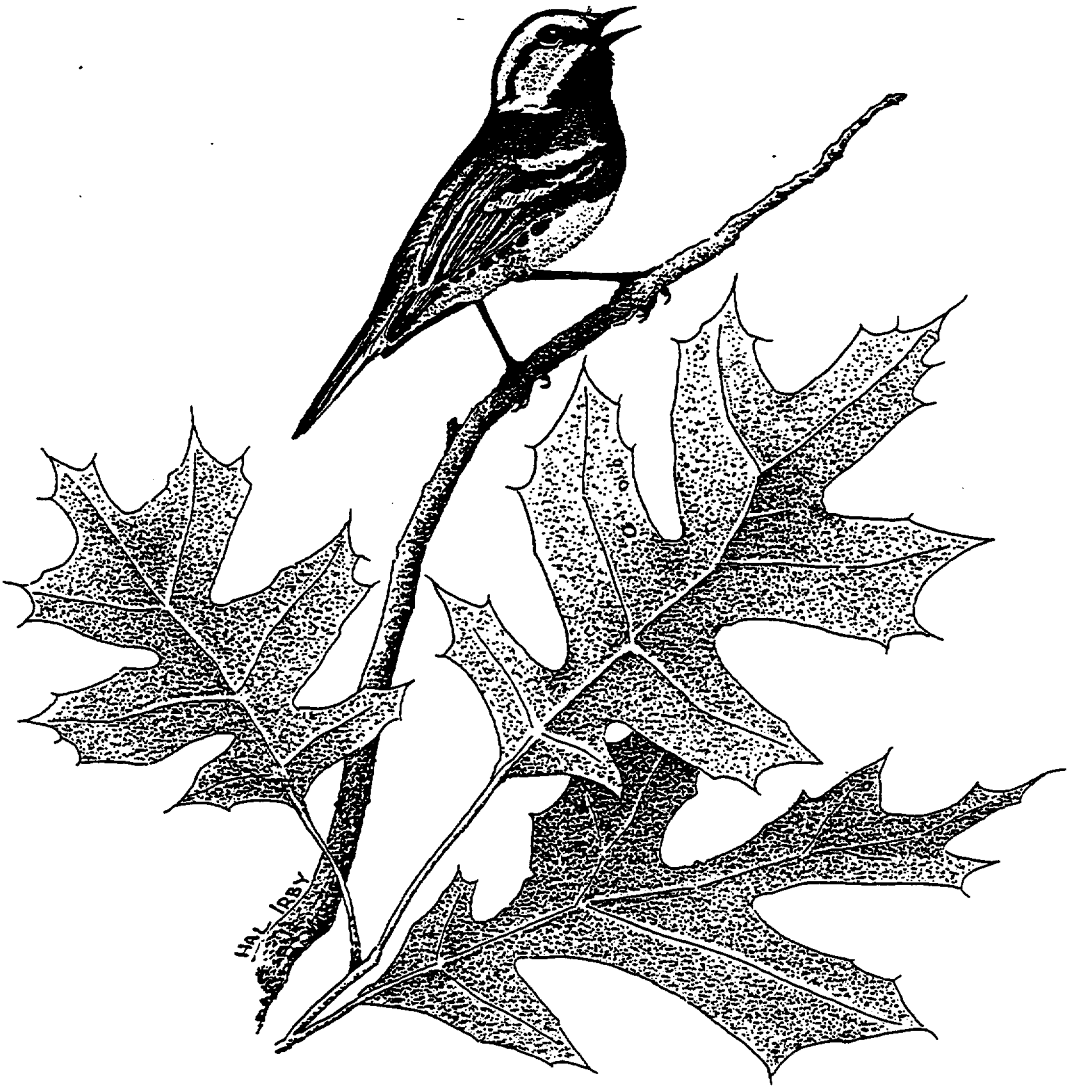


*As long as these areas are not in close (within 300 feet) proximity to "probably occupied" or "may be occupied" habitat, neither surveys nor permits are required for activities within these areas.

Funds for the production of this leaflet were provided by the U.S. Fish and Wildlife Service, under Section 6 of the Endangered Species Act.

GOLDEN-CHEEKED WARBLER

RECOVERY PLAN



U.S. FISH AND WILDLIFE SERVICE

REGION 2, ALBUQUERQUE, NEW MEXICO

1992

GOLDEN-CHEEKED WARBLER

(*Dendroica chrysoparia*)

RECOVERY PLAN

Prepared by

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Acting Regional Director, U.S. Fish and Wildlife Service

Date: SEP 30 1992

Disclaimer

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. Plans are published by the U. S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

Estimates of cost and task duration as listed in Part III have some uncertainty depending on the nature of the task. Duration of some research tasks are unknown because they are experimental in nature and it is difficult to predict the interval required to complete the task or to attain required data sets for statistical analysis. Costs of some tasks are uncertain when they involve activities for which there exists no previous cost experience and/or when they are dependent on earlier tasks.

Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species' status, and the completion of recovery tasks.

Literature Citations

Literature citations of this document should read as follows:

U.S. Fish and Wildlife Service. 1992. Golden-cheeked Warbler (Dendroica chrysoparia) Recovery Plan. Albuquerque, New Mexico. 88 pp.

Additional copies may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814

(301) 492-6403

or

1-800-582-3421

The fee for the Plan varies depending on the number of pages of the Plan.

Acknowledgments

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The illustration on the cover was drawn by and provided compliments of Hal Irby.

Executive Summary

Current Species Status: The golden-cheeked warbler is listed as endangered. Habitat destruction in the breeding range has accelerated (Wahl et al. 1990), since the initial surveys of Pulich (1976). Clearing of pine-oak woodlands in Mexico and Central America is eliminating habitat on the winter range and migration corridor.

Habitat Requirements and Limiting Factors: During the breeding season, golden-cheeked warblers inhabit woodlands containing Ashe juniper (*Juniperus ashei*) in combination with various deciduous trees such as Texas oak (*Quercus buckleyi*), scaley bark oak (*Q. sinuata* var. *breviloba*), and Plateau live oak (*Q. fusiformis*). The essential breeding season requirement is the presence of suitable nesting material in the form of bark strips from Ashe junipers. Other limiting factors may include availability of arthropod prey, a moderate to high degree of canopy cover, nest parasitism and predation, and proximity to water.

Recovery Objective: Delisting.

Recovery Criteria: The golden-cheeked warbler will be considered for delisting when (1) sufficient breeding habitat has been protected to ensure the continued existence of at least one viable, self-sustaining population in each of eight regions outlined in the plan, (2) the potential for gene flow exists across regions between demographically self-sustaining populations where needed for long-term viability; (3) sufficient and sustainable non-breeding habitat exists to support the breeding populations, (4) all existing golden-cheeked warbler populations on public lands are protected and managed to ensure their continued existence, and (5) all of these criteria have been met for 10 consecutive years.

Actions Needed:

1. Studies of golden-cheeked warbler population status and biology, ecology, habitat requirements, and threats on the breeding ground and in the winter range and along their migration corridor.
2. Protection of existing populations and habitat in the breeding range, wintering range, and along the migration corridor.
3. Increased voluntary protection of warbler habitat.
4. Enhancement and maintenance of the quality of warbler habitat on public and private lands.
5. Increased public awareness of the importance of the species and other endangered species.
6. Regulatory protection.

Total Estimated Cost of Recovery (Dollars x 1000):

Fiscal Year	Priority 1 Tasks	Priority 2 Tasks	Priority 3 Tasks	Total
1993	2,136	499	243	$ 2,878
1994	2,081	560	137	$ 2,778
1995	1,537	540	152	$ 2,229
1996	1,000	300	75	$ 1,375
1997	500	250	30	$ 780
1998	500	200	30	$ 730
1999	250	200	30	$ 480
2000-2008	100	200	30	$ 330
				$11,889

Date of Recovery: If the plan is implemented as outlined, the anticipated year that the delisting criteria should be met is 2008.

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List of Tables and Figures

I. INTRODUCTION AND BACKGROUND

The Golden-cheeked warbler (*Dendroica chrysoparia*) (GCW or warbler) breeds only in the mixed evergreen-deciduous woodlands of central Texas and winters in the highland pine-oak woodlands of southern Mexico and northern Central America. Human activities have eliminated much warbler habitat within parts of the warbler's range that existed at the time of Pulich's (1976) initial surveys in 1962. Recent surveys suggest that the rate of habitat loss is accelerating as suburban developments spread into prime warbler habitat along the Balcones Escarpment, especially in the growth corridor from Austin to San Antonio (Wahl *et al*. 1990).

A. LEGAL STATUS AND RECOVERY PRIORITY

The Golden-cheeked warbler was placed on the Endangered Species list on May 4, 1990 by means of an emergency rule (55 FR 18844). At the same time the emergency rule was published, a proposed rule to "permanently" list the species was published (55 FR 18846). The final rule listing the golden-cheeked warbler as endangered under the Endangered Species Act was published on December 27, 1990 (55 FR 53153). This species was added to the Texas Parks and Wildlife Department's list of endangered species on February 19, 1991 (Executive Order No. 91-001).

The GCW has a recovery priority of 2C. According to the Service's criteria, this indicates a species with a high degree of threats; in conflict with construction or development projects or other forms of economic activity; and, a high potential for recovery.

B. DESCRIPTION

Adult males in breeding plumage have yellow cheeks outlined in black with a thin black line through each eye and extending backwards from the eye. Upper breast and throat are black. Lower breast and belly are white with some lateral black spotting or streaking. The back is blackish. Wings are blackish with two white wingbars. Tail feathers are black, except that the outermost tail feather on each side is white with a black shaft line. Upper and lower mandibles are black. Legs and feet are black. Eyes are dark brown. The male is the only North American warbler with brilliant yellow cheeks completely outlined in black (Ridgway 1902, Bent 1953, Griscom and Sprunt 1957, Pulich 1965, Oberholser 1974, Pulich 1976).

Winter plumage of adult males is similar to the breeding plumage except that the black feathers of the throat are edged with yellow or cream.

Adult females are less strikingly marked than adult males. The back is dark olive-green with thin black streaks. The cheeks of females are yellowish but less brilliant than in males. The center of the throat is also yellowish, grading to pale buff or white on the abdomen. Sides of the throat are black with feathers tipped in white. Flanks are covered with black streaks (Oberholser 1974).

Juveniles are similar to adult females. Their backs are brownish olive. Wings are dark drab, wing-bars brownish, and cheeks are dull buff-colored. Throat, chest, and abdomen are drab or grayish white.

Pulich (1976) found average breeding weights were 10.2 g for 7 adult males, and 9.4 g for 11 adult females.

C. TAXONOMY

Early History: The golden-cheeked warbler was unknown to science until 1859 when Osbert Salvin collected two specimens near Tactic, Vera Paz, Guatemala on 4 November; it was later described by Sclater and Salvin (1860). D.C. Ogden collected the first United States specimen in 1864 near the confluence of the Medina and San Antonio Rivers in Bexar County, Texas (Dresser 1865). G. H. Ragsdale collected a second United States specimen in 1878 along the Brazos River in Bosque County, Texas (Purdie 1879). Werner found the first United States nest of the GCW in 1878 in Comal County (Brewster 1879, Bent 1953).

Evolutionary History: Mengel (1964) described a reasonable scenario for the derivation of the GCW, Townsend's warbler (*Dendroica townsendi*), hermit warbler (*D. occidentalis*), and black-throated gray warbler (*D. nigrescens*) from an ancestral form of the black-throated green warbler (*D. virens*). The GCW is the most recently derived of these species and is thought to have separated from the ancestral stock during one of the most recent Pleistocene interpluvial episodes about 20,000 years before the present. The validity of this scenario is supported by similarities in plumage, vocalizations, and habitat preferences of these species (Stein 1962, Mengel 1964), and Pleistocene vegetation distribution (Axelrod 1958, Van Devender 1986).

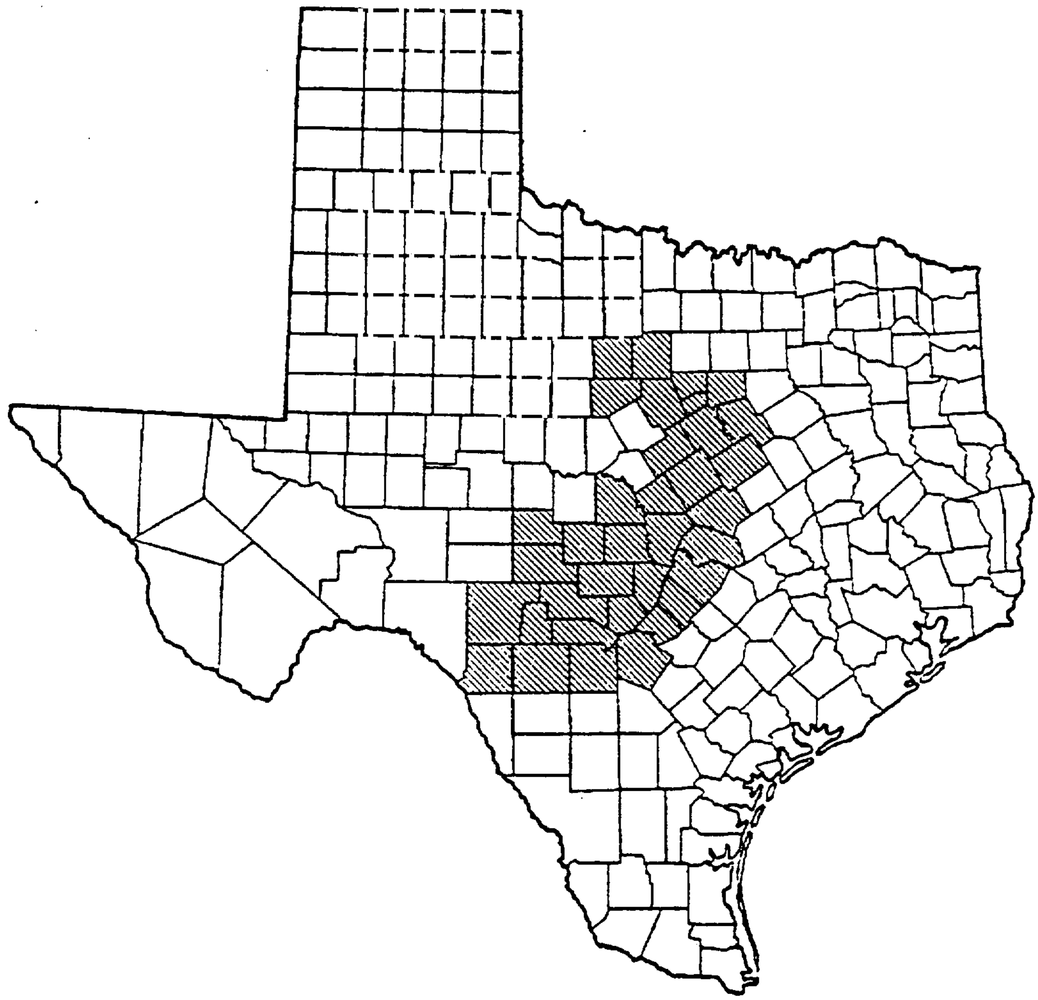
D. DISTRIBUTION

Breeding Range: GCWs nest on the Edwards Plateau, Lampasas Cut-Plain, and Llano Uplift regions of central Texas. The GCW has been reported as a breeding species from the following counties: Bandera, Bastrop, Bell, Bexar, Blanco, Bosque, Burnet, Comal, Concho, Coryell, Dallas, Eastland, Edwards, Erath, Gillespie, Hamilton, Hays, Hood, Johnson, Kendall, Kerr, Kimble, Kinney, Lampasas, Lee, Llano, McLennan, Medina, Palo Pinto, Real, San Saba, Somervell, Stephens, Tom Green, Travis, Uvalde, and Williamson (Figure 1) (see Pulich 1976 for supporting specimens and literature for each county).

The GCW may no longer nest in Tom Green, Concho, Dallas, Lee, McLennan, and Bastrop counties (Pulich 1976).

Winter Range and Migration Corridor: GCWs winter in the highlands of southern Mexico (Chiapas) and Central America (Figure 2). In the period July-October, GCWs migrate southward through the coniferous-oak woodlands of the Sierra Madre Oriental of Coahuila, Nuevo Leon, Tamaulipas, Queretaro, Veracruz, and Chiapas (Pulich 1976, Alvarez del Toro 1980, Lyons 1990, Perrigo et al. 1990). Records indicate GCWs winter at 1500-2600 m in the pine-oak woodlands of the Sierra Los Cuchumatanes and Sierra de las Minas of Guatemala, in the highlands of Honduras and northern Nicaragua, and in the Sierra Madre of Chiapas, Mexico (Sclater and Salvin 1860, Land 1962, Monroe 1968, Pulich 1976, Kroll 1980, Braun et al. 1986).

Figure 1. Breeding range of the golden-cheeked warbler (from Pulich 1976).*



* Cross-hatched counties indicate the current breeding range of the golden-cheeked warbler.

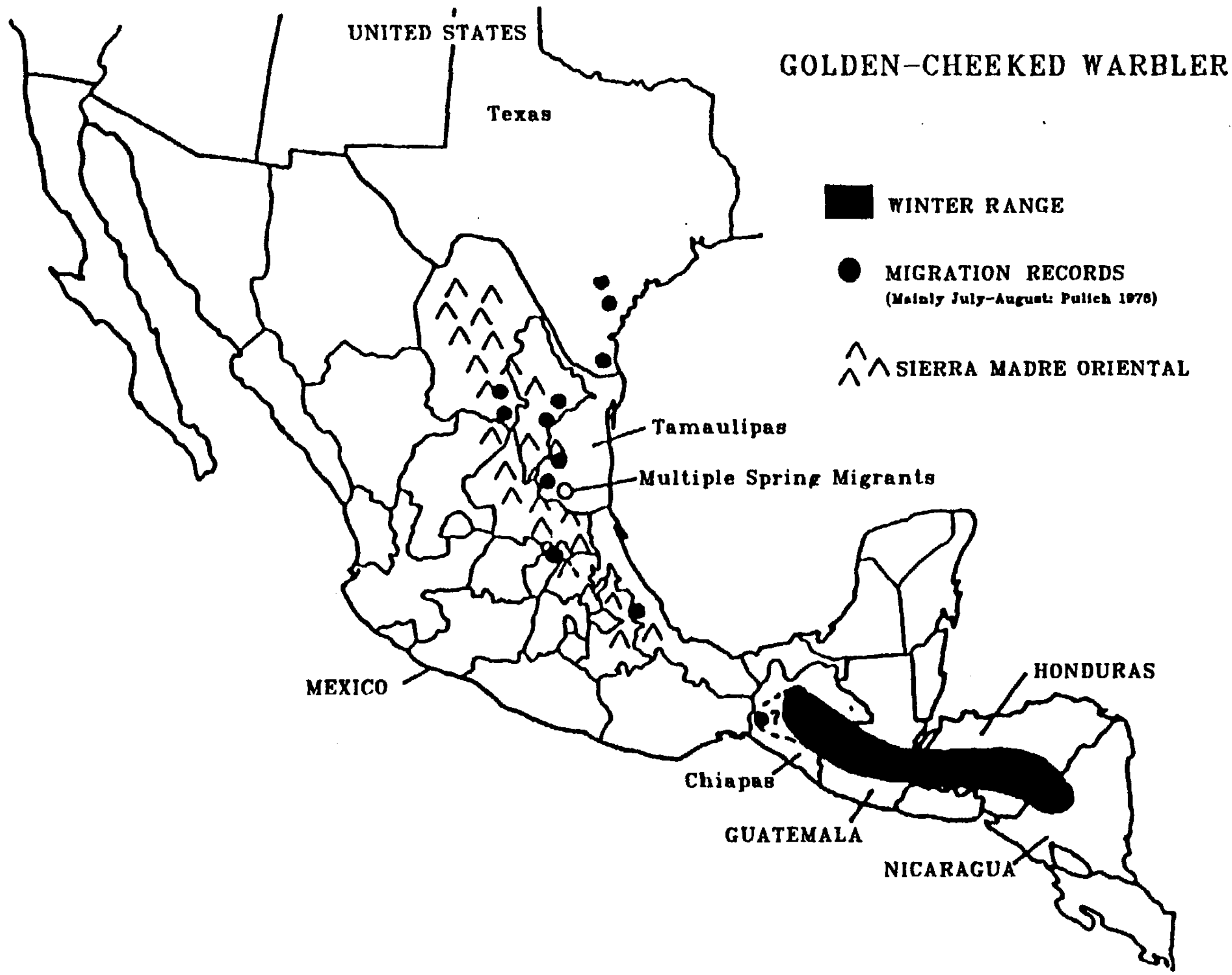


Figure 2. Winter range and migration records of the golden-cheeked warbler (from Perrigo et al. 1990).

E. HABITAT

Nesting Habitat - Tree Species Composition: On the breeding range, GCWs inhabit dense forests and woodlands (often locally called "brakes") containing Ashe juniper (*Juniperus ashei*) and a variety of other, mostly deciduous species including plateau live oak (*Quercus fusiformis*), Texas oak (*Q. buckleyi*), scaley bark oak (*Q. sinuata var. breviloba*), Lacey oak (*Q. glaucoides*), post oak (*Q. stellata*), black-jack oak (*Q. marilandica*), American elm (*Ulmus americana*), cedar elm (*U. crassifolia*), hackberry (*Celtis reticulata*), sugarberry (*C. laevigata*), little walnut (*Juglans microcarpa*), Arizona walnut (*J. major*), sycamore (*Platanus occidentalis*), Texas ash (*Fraxinus texana*), Mexican persimmon (*Diospyros texana*), coma (*Bumelia lanuginosa*), redbud (*Cercis canadensis*), evergreen sumac (*Rhus virens*), soapberry (*Sapindus drummondii*), deciduous holly (*Ilex decidua*), escarpment cherry (*Prunus serotina*), Mexican buckeye (*Ungnadia speciosa*), red mulberry (*Morus rubra*), big-tooth maple (*Acer grandidentatum*), and Texas mountain laurel (*Sophora secundiflora*) (Attwater in Chapman 1907, Johnston *et al*. 1952, Pulich 1976, Kroll 1980, Ladd 1985, Riskind and Diamond 1986, Wahl *et al*. 1990).

Although the species composition of woody vegetation varies greatly within suitable warbler breeding habitat, Ashe juniper is typically (often, but not always) the dominant species and occurs at all sites inhabited by nesting GCWs. Ladd (1985), for example, found that the most common trees at ten GCW sites (in order of frequency of occurrence or "relative dominance") were Ashe juniper, Texas oak, scaley bark oak, cedar elm, Plateau live oak, little walnut, hackberry, and Texas ash. Ashe juniper comprised 10% to 83% of total trees at 27 sites scattered throughout the breeding distribution of the GCW (Johnston *et al*. 1952, Pulich 1976, Kroll 1980, Ladd 1985, Wahl *et al*. 1990). At 14 sites measured by Wahl *et al*. (1990) the density of Ashe juniper ranged from 56 to 1,098 junipers per ha (sample mean = 422 junipers per ha).

Nesting Habitat - Structure: Wahl *et al*. (1990) characterized GCW habitat as "closed canopy Ashe juniper-oak woodland." This is true to the extent that GCWs prefer areas with a moderate to high density of trees and dense foliage usually at upper levels. For example, 15 sites inhabited by GCWs and measured by Kroll (1980), Wahl *et al*. (1990), and Beardmore (unpublished MS) contained on average 771 trees/ha (range 343 to 1562 trees/ha). In suitable habitat at Meridian State Park, Kroll (1980) found average tree densities of 988 stems per ha. Cover has been used to estimate foliage density in different height classes. Total cover at 14 GCW sites averaged 67% at 3 m (44%-117%), 73% at

5 m (21%-155%), and 68% above 5.5 m (12%-200%) (total cover can attain a figure of over 100% due to overlapping canopies) (Wahl et al. 1990).

Stepwise discriminant analysis applied to Kroll's measurements of woody vegetation suggested that presence of Q. sinuata and Ashe juniper, greater distances between trees, lower densities of Q. sinuata and Ashe juniper, and lower height of the stand were the most important variables associated with the presence of GCWs at Meridian State Park (Kroll 1980). A regression model created by Wahl et al. (1990) suggested that greater variability in tree heights, greater density of deciduous oaks, and greater average tree height were associated with higher densities of warblers.

Nesting Habitat - Availability of Nesting Material: GCWs construct nests from strips of bark found on Ashe junipers, consequently the presence of some junipers with shredding bark is a nesting habitat requirement for this species (Werner in Brewster 1879, Attwater in Chapman 1907, Pulich 1976). Ashe junipers begin shedding bark near ground level around 20 years of age (5 cm diameter at breast height (dbh)) (Kroll 1980). Shedding then progresses upward through the larger branches by the time the tree is 40 years old (10-15 cm dbh). These ages, however, may not be accurate because of differences in growth rates among junipers and because of the difficulty of accurately aging junipers by growth ring analysis (Pulich 1976). Female warblers have been observed obtaining bark strips for nest building from Ashe junipers with dbh's as small as 7.5 cm (C. Beardmore, USFWS, and L. O'Donnell, USFWS, personal communications).

Nesting Habitat - Availability of Water: An additional factor that may improve habitat quality is proximity to a watering/bathing site. Pulich (1976) and others (D. Lyter, Espey, Huston and Associates, and B. Armstrong, Texas Parks and Wildlife Department, personal communications) have noticed the tendency of GCWs to frequent springs and a watering trough outside of their territories. If proximity to free water is a limiting factor, then loss of springs and seeps may be a threat to GCWs.

Nesting Habitat - Importance of Canyon Slopes. Attwater (in Chapman 1907) and Ladd (1985) noticed that suitable warbler habitat coincided with steep slopes or rugged terrain. Although suitable GCW habitat is limited to canyon slopes in many areas, this habitat feature may not be a requirement for GCWs. Instead, GCWs may be associated with canyon slopes because of some combination of the following factors that influence habitat quality: (1) greater surface run-off and seepage, which favors luxuriant growth of deciduous trees and concomitantly greater arthropod availability, (2) greater protection against the effects of range fires, or (3) greater protection against clearing because of the high cost incurred in clearing steeper slopes.

It seems reasonable that moist canyon slopes should favor optimal conditions for warblers. It is also apparent, however, that warblers will occupy drier upland sites such as areas inhabited at Ft. Hood Military Reservation and Travis County Audubon Sanctuary (J. Cornelius and T. Hayden, DOD, and D. Lyter, P. Turner, Espey, Huston, and Associates, personal communications). Flat, riparian drainages with a cedar elm/live oak association such as those at Camp Bullis also are occupied by GCWs (S. Rust, Stewardship Services). David Steed (DLS Associates, personal communication) has described the intermittent occupancy by GCWs of drier, more open situations in Travis County. Unfortunately, the relative stability and productivity of GCW populations in these situations is not well known.

Nesting Habitat - Importance of Stand Age and Stature: Pulich (1976) described the oak-juniper associations preferred by GCWs as ". . . climax stands where trees have average heights of 20 feet [6.1 m] with some deciduous cover . . . ." Supporting this view are measurements made by Wahl et al. (1990), which show tree heights in suitable habitat (n=14 sites) average 6.5 m (range of mean values: 4.5-9.8 m). In addition, Kroll (1980) found that the oak-juniper associations occupied by warblers contained junipers averaging roughly twice the age and girth of junipers in unoccupied oak-juniper associations.

Interestingly, at Kroll's study site (Meridian State Park) occupied habitat contained shorter trees (mean = 3.4 m) than unoccupied habitat (mean = 6.1 m). This reaffirms the cautionary statements of Pulich (1976) regarding the difficulties of aging junipers based on stature. It also suggests that habitat suitability may be influenced more by stand age, habitat structure, tree species diversity, and/or other limiting factors than simply by height of the woody vegetation.

Older closed-canopy woods may be excellent habitat for GCWs because such associations maintain favorable conditions (abundant food, reduced wind shear, and elevated humidities) for warblers and their prey (Saunders et al. 1991), while simultaneously providing greater security against nest parasites and predators (Lovejoy et al. 1986, Wolf 1987). Ashe juniper contributes to the maintenance of such conditions because it is resilient, fast-growing, densely branched, and relatively long-lived.

Today, the great majority of woodlands inhabited by GCWs are not in the pristine condition implied by the term "old-growth". The juniper component of GCW habitat at Meridian State Park, Travis County Audubon Sanctuary, Ft. Hood Military Reservation, and some of the sites sampled by Wahl et al. (1990), has either been selectively cut or mostly cleared within the last 50 years. Scattered through these sites, however, are the requisite older junipers. The most important points in this regard are that (1) strict adherence to a definition of GCW habitat as "old-growth" woodland will likely exclude much suitable habitat that is certainly not old-growth, and (2) proper management of degraded GCW habitat in some cases may restore habitat quality within 2-4 decades.

Nesting Habitat - Importance of "Edge": Because of the cryptic nature of the female, relatively few GCW nests have been located. Therefore, the following discussion is based in part on locations of territories as determined by singing males. Pulich (1976) found the shape of each territory was determined by vegetation composition, as influenced by its ecological edge effect, rather than by the slope or terrain of habitat. Ladd (1985) observed several territories at Kerr Wildlife Management Area (KMA) that were bounded by an edge. Kroll (1980) found territories along trails, roadways, and grassland/woodland interfaces, described the GCW as an "edge species", and recommended improving GCW habitat by cutting extensive oak-juniper woodlands into narrow strips designed to mimic the alleged former distribution of juniper-dominated associations on canyon slopes. D. Lyter (personal communication) has found nests along trails and grassland/woodland interfaces but only in association with wooded canyonlands. Morse (1989) summarizing knowledge to date (citing Kroll 1980 and Ladd 1985) further proliferated the "edge-species view" of the GCW when he described it as a relictual denizen of woodland margins.

However, this point of view is at odds with the currently accepted view that GCWs do best in large blocks of unfragmented habitat (Biological Advisory Team 1990, Wahl et al. 1990, Pease and Gingerich, unpublished MS). The traditional definition of an edge species is one which is found along the interface between two habitat types such as grassland and woodland, and uses resources from both types to survive. GCWs forage and breed within the woodland matrix, and not in adjacent open areas. Although they seem tolerant of living in woodland habitat which is adjacent to an opening, there is no information on whether these birds are more reproductively successful than those in the interior. Hayes et al. (1987) described how GCW habitat at Meridian State Park was thinned and opened up in an effort to increase the amount of woodland edge habitat available for occupancy by GCWs. The result of this thinning has not been completely studied, however, it appears that the 24-28 territories found by Kroll (1980) have been reduced to 5 territories in 1991 (F. Gehlbach, Baylor University, personal communication).

Another problem with the "edge species" rationale is its dependence on a limited view of the vegetational history of the plateau. "Edge species" rationales depend on concepts of Edwards Plateau vegetation as predominantly grasslands and/or savannas interspersed with fragmented woodlands. An examination of plateau vegetation over the full evolutionary life span of the GCW does not necessarily support the "edge species" view of habitat requirements.

Since the origin of the GCW, Edwards Plateau vegetation has been dynamic. During the Pleistocene, conditions were more moist and the plateau was forested. Various woodland formations (both evergreen and deciduous) were widespread and at times even connected with woodlands of the Rocky Mountains, Gulf-Coastal plain, and Sierra Madre Oriental (Axelrod 1958, Mengel 1964, Lundelius 1986, Van Devender 1986).

At present, there is no quantitative evidence suggesting that warblers living along woodland "edges" are more abundant, more frequently paired with a female, or more productive along edges than in woodland interiors. Conversely, there is also no evidence that the species does best in woodland interior locations. Critical assessment of the problem is essential to the recovery of the GCW. Incorrect acceptance of the "edge-species" view with its implied requirement of high edge/interior ratio could lead to destruction of suitable woodland interior habitat and expose a greater portion of a population's nesting attempts to the heightened rates of nest predation and parasitism typical of forest margins (Gates and Gysel 1978, Brittingham and Temple 1983, Wilcove 1985). In the same way, incorrect acceptance of the "forest interior species" view would favor maintenance of woodland-interior habitat at the expense of high-quality woodland edge habitat.

Winter Habitat: There has been only one quantitative study of winter habitat use by GCWs (Kroll 1980). The elevation of Kroll's study site in Honduras was about 1500 m. Pines (*Pinus oocarpa*) dominated the overstory. Oaks, particularly *Quercus oleioides*, comprised 63%, and sweetgum (*Liquidambar styraciflua*) another 21% of total understory trees and shrubs at this site. Other collection localities and observation sites on the migration corridor and winter range have also been pine-oak woodlands (Land 1962, Alvarez del Toro 1980, Braun *et al.* 1986).

F. NESTING ECOLOGY

Establishment of Breeding Territories: GCWs return to central Texas from their wintering grounds by mid-March. Earliest arrival dates for males are in the first week of March (Attwater in Chapman 1907, Pulich 1976). Females usually arrive a few days to a week later. Males quickly select territories and begin displaying vocally from prominent perches. These territorial displays continue steadily and frequently until the young fledge, then essentially cease. Few territorial songs are heard after mid-July (Pulich 1976).

Nest Construction and Nesting Situations: Females begin building nests the first week of April (Pulich 1976). All known nests are comprised primarily of strips of juniper bark, 20-110 mm long, that are secured by cobwebs (Pulich 1976). The lining may be composed of bird feathers, grass, oak leaves, bits of moss, etc. (Werner in Brewster 1879, Attwater in Chapman 1907, Pulich 1976). Each completed nest is a compact cup-like structure averaging 80 mm outside diameter and 50 mm outside depth (n=13, Pulich 1976). GCWs apparently nest once a season unless the first attempt fails (Pulich 1976).

Attwater (in Chapman 1907) and Pulich (1976) indicate females usually place nests in the upper two-thirds of nest trees. Average nest height based on three studies of nests (n = 63) is 4.8 m (range 1.8-9.8 m) (Attwater in Chapman 1907, Quillen in Pulich 1976, Pulich 1976). Although Ashe juniper is the most common nest tree, GCWs also build nests in cedar elms, various oaks, walnuts, pecans, bald cypress, and presumably other species.

Incubation Period: Female warblers produce clutches of 3-4 (and rarely 5) creamy white eggs covered with scattered darker markings. The eggs average 17.7 mm by 13.7 mm (n = 50, Bent 1953).

Most complete sets of GCW eggs have been found during the period 3 April to 27 June (Pulich 1976). Clutches laid after the end of April probably are second renest attempts following failed or abandoned first attempts.

Incubation begins on the day before the last egg is laid and lasts 12 days (Pulich 1976). Females apparently perform all incubation duties in this and other *Dendroica* species (Mayfield 1960, Nolan 1978, Walkinshaw 1983). Pulich (1976) estimated that females spend at least 75% of daylight hours on the nest.

Care of Nestlings and Fledglings: Hatching success for 55 eggs laid in 33 GCW nests was 36.4% (or 20 eggs; Pulich 1976). Adult females brood recently-hatched nestlings and conduct most feedings. Males gradually participate in more feedings. Fledging occurs at about 9 days (Pulich 1976).

Fledgling success was 27% (15 fledglings from 55 eggs) for 33 nests studied by Pulich (1976). This was the lowest fledgling success of five other wood warblers summarized by Pulich (1976). Fledglings are dependent on their parents for at least 4 weeks. Often each adult feeds a portion of the brood and these single parent family groups may wander away from the original territory as the adult searches for food (Pulich 1976). Fledglings begin migrating south as soon as they gain their independence (Pulich 1976).

Migration: Although some GCWs stay in central Texas as late as August (Pulich 1976), most have left the breeding grounds by the end of July (Chapman 1907, Simmons 1924, Pulich 1976). The northward return is more synchronous, with most birds arriving during the second or third week in March (Pulich 1976).

Vocalizations: The territorial display songs of male GCWs and male black-throated green warblers (*Dendroica virens*) are very similar and have about the same quality as the song of the Bewick's wren (*Thryomanes bewickii*). GCW vocalizations tend to decline sometime during the nesting and fledgling period and continue to decline through the time when they migrate.

Males also produce incomplete or muffled versions of the standard territorial song. In other warblers such calls are often given after territorial disputes or when a male is close to the nest or the female (Ficken and Ficken 1962). Several workers have noticed subtle differences between the songs of GCWs in different populations (C. Sexton, City of Austin, Dept. of Environmental and Conservation Services; C. Beardmore, personal communications) and even the same male GCW may sing different song varieties (C. Beardmore, personal communication).

Adult male, female, and fledgling GCWs also produce high-pitched single "chips" or so-called "double-chip" notes. These sounds may function as contact notes or alarm calls (Morse 1967). Detection of this call is the best means for locating the female and offspring (Pulich 1976).

Predators: Pulich (1976) reported one instance of a rat snake (*Elaphe obseleta*) eating a brood of nestling GCWs. He also observed a coachwhip (*Masticophis flagellum*) in the vicinity of another nest. Blue jays (*Cyanocitta cristata*) may have a considerable effect on GCWs to the point of excluding GCWs from areas of apparently suitable habitat in urban areas (Tom Engels, unpubl. data; C. Pease, University of Texas, and C. Sexton, personal communications). Scrub jays (Aphelocoma coerulescens), great-tailed grackles (Quiscalus mexicanus), opossums (Didelphis virginianus), and fox squirrels (Sciurus niger) are other likely predators of eggs and young warblers. Fire ants affect other bird species by eating hatchlings, causing adults to abandon nests, and possibly reducing the invertebrate prey base. However, their effect on GCWs has not been determined.

Nest Parasitism: Pulich (1976) summarizes information on brown-headed cowbird (Molothrus ater) parasitism of GCW nests. In his Kendall County study area, 28 nests were studied to conclusion. Of those, 19 nests were parasitized. Out of those 19 nests, 3 golden-cheeked warblers and 9 cowbirds fledged. The 9 unparasitized nests produced 12 GCW fledglings. In a summary of all nests Pulich (1976) looked at, both in his study and museum specimens (n=61), he found 39% were parasitized. Cowbird eggs hatch two days before the eggs of GCWs (Pulich 1976) giving them an advantage over GCW hatchlings. In three years of study, Pulich (1976) found 9 cowbirds fledged out of 23 cowbird eggs laid. GCWs apparently will either abandon parasitized nests or raise young cowbirds in addition to their own young. The recent arrival of the shiny cowbird (Molothrus bonariensis) in Texas (one was caught in a trap on Fort Hood Military Reservation in May 1990) may present an additional threat to GCWs. This species of cowbird has recently expanded its range from South America to the United States. The threat of cowbird parasitism to GCWs is discussed later in the section "Reasons for listing and current threats".

G. DIET AND FEEDING BEHAVIOR

Analysis of stomach contents of 21 collected GCWs showed that out of 75 prey items identified, beetles (32%), caterpillars (17%), homoptera (17%), hemiptera (13%), and spiders (11%) were the most common prey of GCWs (Pulich 1976). Pulich (1976) also observed warblers feeding on spiders, caterpillars, lacewings, small cicadas, katydids, walking sticks, deer flies, crane flies, adult moths, and adult butterflies. Most prey items taken by GCWs at Meridian State Park (Bosque County) were lepidopteran larvae (54%, n = 82) or various orthoptera (13%, n = 20) (Kroll 1980). GCWs seem to avoid feeding on various spiny moth larvae such as tent caterpillars (Pulich 1976).

Although Simmons (1924) and Smith (1916) described GCWs making aerial sallies after volent insect prey, most foraging time is spent on foot moving from branch to branch gleaning small insects from the foliage (Pulich 1976).

Pulich (1976) observed that GCWs forage ". . .in the upper two-third level of its habitat." Sexton (1987) found that GCWs spent relatively more time foraging in the 1.5-9.1 m zone, and relatively less time foraging below this level. Beardmore (unpublished MS) found that male GCWs forage 60.9% of the time in the 5 m and greater zone before young fledge and 16.8% of the time in the 5 m and greater zone after fledging.

Pulich (1976) pointed out the close relation between the breeding time of GCWs and the appearance of numerous soft-bodied lepidopteran larvae in deciduous trees such as Q. *buckleyi* and Q. *sinuata*. The existence of this relationship is supported by the observations of Kroll (1980), Sexton (1987), and Beardmore (unpublished MS) that GCWs spend disproportionately more time in oaks (compared to the relative abundance of oaks) than in junipers. Beardmore (unpublished MS), however, also determined that GCWs did not show this strong preference for oaks later in the breeding season, but split their foraging time between oaks and junipers. Sexton's unpublished data have preliminarily indicated differences in the abundance and composition of potential warbler food items through the warbler nesting season and among key tree species.

H. POPULATION SIZE

Territory Size: Estimates of territory size ranged from 1.3-2.4 ha/territory (mean = 1.7 ha/territory, n = 14 territories) on one 28 ha study area examined by Pulich (1976). These values were based on intensive focal animal sampling and therefore are likely to represent accurate spatial requirements of territorial males. Kroll (1980) estimated 4.5-8.5 ha/pair (n = 10 territories); these values were also derived from focal animal sampling, but it is not clear whether they represent the space covered by individual displaying males.

Little is known about the area covered by females, non-displaying males, and family groups. Pulich (1976) believed that adults of both sexes would leave territories to visit watering/bathing areas. He also believed, however, that females generally limited most of their movements to a portion of the male's territory.

Population Density: Several authorities have attempted to determine total numbers of GCW "pairs" in limited areas studied intensively. Lacey (in Cooke 1923) found an average of 3.8 pairs (2-6 pairs, n = 5 years) per year on one 16 ha woodlot. Johnston et al. (1952 and 1953) and Webster Jr. (1954) found an average of 6.2 pairs (5.5-6.5 pairs, n = 3 years) on 15 ha. In a one year survey, Pulich (1976) found 14 pairs on 28 ha. A summary of these studies produces densities of 9.5-20 pairs/40 ha (100 ac).

Population Size: Pulich (1976) noted that estimates of territory size or population densities of displaying males should not be used to extrapolate GCW population sizes over extensive areas of oak-juniper woodland. Such extrapolation is inappropriate because (1) GCWs and other wood warblers do not always saturate extensive expanses of suitable habitat (Ficken and Ficken 1968, Pulich 1976, Sealy 1979, Ryel 1979, Gill 1980), (2) a large portion of displaying males in a given population may be unpaired (Gibbs and Faaborg 1990), and (3) non-displaying, non-territorial individuals may comprise a large portion of a given songbird population (Smith and Arcese 1984).

To allow for the presence of some unoccupied areas within expanses of occupied, suitable habitat, Pulich (1976) used 8 ha/pair in "good" habitat, 20 ha/pair in "average" habitat, and 33 ha/pair in "marginal" habitat to calculate total GCW population size for range-wide expanses of oak-juniper woodland. Pulich (1976) then applied these values to his own and to Soil Conservation Service (SCS) estimates of available "Virgin juniper" habitat (Table 1) to calculate potential numbers of paired GCWs. The SCS estimates of habitat availability when multiplied by Pulich's density estimate in average habitat, at 20 ha/pair, gave a value of 18,486 pairs in 1962 and 14,750 pairs in 1974, a 20% loss in 12 years (1.6% per year). In contrast, using Pulich's (1976) estimates of habitat availability, with habitat graded into the three levels of habitat quality, gave values of 7,815 pairs in 1962, and 7,475 pairs in 1974, an 8% loss in 12 years.

Comparing the earlier (1962 and 1974) estimates with the recent survey attempt of Wahl et al. (1990) is complicated by differences in methodologies. Wahl et al. (1990) used LANDSAT MSS (Multi-spectral scanner) imagery in combination with scattered ground surveys of vegetation and warbler abundance. Unfortunately, the satellite imagery did not cover all portions of the GCW breeding distribution, plus the LANDSAT imagery came from three distinct periods -- 1974, 1979, and 1981.

Obviously, the asynchronous timing of the remote sensing imagery creates difficulties in determining the year to which habitat availability estimates should be linked. The lag between the creation of the remote sensing imagery and subsequent field surveys has also likely increased the frequency of habitat classification errors. Despite these problems, remote-sensing coupled with thorough ground surveys should be the most comprehensive of the methods discussed thus far.

Wahl et al. (1990) did attempt to correct for the changes in vegetation that had taken place between the dates of the satellite imagery by ground truthing a portion of the study. In doing so, they produced the following estimates of total available habitat: (1) 338,035 ha of total habitat uncorrected for changes since dates of satellite imagery, (2) 237,163 ha of total habitat corrected for changes since dates of satellite imagery, and (3) 32,149-106,776 ha of total habitat in patches greater than 50 ha. They then calculated a potential population size of 4,822-16,016 "pairs" (at 15 "males"/100 ha or 6.7 ha/"male").

These estimates can be modified in two ways for purposes of comparison with the population estimates of Pulich (1976). First, the density values of Pulich (1976) should be substituted for the one used by Wahl et al. (1990). This occurs because Wahl et al. (1990) derived the value, 6.7 ha/pair (or "male"), using a modified form of the Emlen Transect method (Ramsey and Scott 1981), while Pulich (1976) derived his population estimates from spot-mapping data gathered from a marked population. DeSante (1981),

Table 1. Historical changes in amounts of golden-cheeked warbler breeding habitat.

	Available Habitat (ha)	Percent Habitat Loss
SCS ESTIMATES OF VIRGIN JUNIPER* HABITAT (Pulich 1976)		
1962	367,705	
1974	295,858	20%
STATUS REPORT ESTIMATES OF GCW HABITAT (Wahl et al. 1990)		
1974-1981 Habitat Detected by LANDSAT Imagery	338,035**	
LANDSAT Imagery corrected by 1989 ground truthing	237,163	30%
Potential total loss of habitat from 1962 to 1990	130,542	35%

* Virgin Ashe juniper was 33.5% of all cedar brakes estimated by the SCS in 1962. Likewise, virgin Ashe juniper comprised 24.6% of cedar brakes in 1974. This amounts to a 21% decrease in virgin Ashe juniper between 1962 and 1974, and a 9% increase in cedar brakes.

** Status report was in error. This is the corrected value.

Tilghman and Rusch (1981), Jolly (1981), and van Riper(1981) have pointed out the unreliability of transect methods (in comparison with spot-mapping) for estimating absolute densities of terrestrial birds. Furthermore, Ramsey and Scott (1981) have suggested that in work with sensitive species, derivation of density estimates from transect counts should be done conservatively to reduce the risk of overestimating population size. In this regard, if 8 ha/pair is assumed to be an accurate maximum density for GCWs in large expanses of "good" habitat, then uniform application of the density value of 6.7 ha/territory would overestimate the number of GCW territories by 19% (2,425 territories per 100,000 ha).

Second, patches 50 ha and smaller should be retained in the total of habitat assumed to contain some GCWs. Thirty-four percent (36/107) of patches of habitat smaller than 50 ha were inhabited by GCWs (Benson 1990).

An additional correction, which allows for more uniform comparison, is to assume that proportions of "good" (@ 8 ha/territory), "average" (@ 20 ha/territory), and "marginal" habitat (@ 33 ha/territory) were the same in the Pulich (1976), as in the Wahl et al. (1990) study (23%, 31%, and 46%, respectively). Using these corrections, the resulting 1990 population estimate then becomes 13,800 territories or a decline of 25% (4,686 territories) in the 28 years since the 1962 estimate.

I. REASONS FOR LISTING AND CURRENT THREATS

Habitat Loss: Loss of habitat is the most important threat to the existence of the GCW. In particular, on-going and imminent habitat destruction was used to justify the emergency listing of the GCW in 1990 (55 FR 18844). Habitat loss was from urbanization and clearing associated with agricultural practices. When a species has such limited and definable habitat requirements, habitat loss most likely results in a population reduction.

Effects of secondary factors such as declining oak regeneration, cowbird parasitism, habitat fragmentation, and proximity to urbanized areas have not been well-studied. Consequently, long-term impacts of these secondary factors on GCWs and their habitat must be either projected from current trends or inferred from studies with other species and communities.

Regarding the rate of loss of suitable nesting habitat, SCS estimates (Pulich 1976) and the estimates of Wahl et al. (1990) suggest there has been a loss of 130,542 ha (326,355 ac) or 35% of the habitat available since 1962 (Table 1). The data of Wahl et al. (1990) indicate that the rate of decline of habitat has actually accelerated in recent years. There appears to have been a 30% loss of habitat in the 9-16 years since the original LANDSAT imagery was collected.

Previously, the main reason for steady loss of habitat was the clearing of juniper to improve pasture conditions for cattle grazing (Pulich 1976). Other reasons for loss of juniper woodlands included cutting of junipers for fence posts, furniture wood, and cedar oil. Most recent losses in nesting habitat have occurred in counties such as Travis, Williamson, and Bexar, in which rapid suburban development has spread into oak-juniper woodlands. Wahl et al. (1990), for example, found that 80,829 ha (80%) out of a total of 101,286 ha of recent habitat losses had taken place in 12 counties undergoing significant urban expansion or recreational lake and second home development (Table 2).

Creation of impoundments for flood control and livestock has destroyed additional habitat for the GCW. Such losses occurred because oak-juniper communities often survive only along canyon slopes adjacent to springs and streams, which have been dammed. Pulich (1976) recounts the destruction of warbler populations by reservoirs such as Canyon Dam (Comal County) and Lake Whitney (Bosque and Hill counties). Larger reservoirs have inundated about 67,000 ha within the distribution of the GCW (C. Loeffler, Texas Parks and Wildlife Department, unpublished data; Dowell and Petty 1974). Smaller impoundments (11.25 ha or smaller) may have

Table 2. Counties containing at least 1,000 ha of golden-cheeked warbler habitat in 1988 (counties denoted by an asterisk are undergoing urbanization or recreational lake and second home development; adapted from Wahl et al. 1990).

COUNTY	SIZE OF COUNTY (ha)	AVAILABLE HABITAT (ha)
TRAVIS*	265,010	43,098
REAL	180,262	26,782
COMAL*	149,344	24,796
BANDERA	212,265	21,631
HAYS*	176,076	20,495
BURNET*	263,721	18,845
KERR*	276,869	18,163
EDWARDS	543,291	17,189
UVALDE*	405,247	16,541
WILLIAMSON*	293,183	14,989
KENDALL*	171,885	13,295
KIMBLE	323,886	12,765
MASON	240,658	10,832
BLANCO*	183,681	9,831
BEXAR*	325,010	8,778
CORYELL	273,634	8,294
BELL	278,929	8,270
GILLESPIE*	275,935	8,175
LLANO	249,368	7,429
BOSQUE	257,093	6,389
MEDINA*	345,294	4,878
KINNEY	351,440	2,455
MENARD	234,947	2,030
McLENNNAN	276,189	2,030
SOMERVELL	48,712	1,909
JOHNSON	189,408	1,644
TOTAL	6,791,343	329,503

inundated an additional 112,000 ha (Clarke 1985). Proposed large reservoirs would further inundate about 8,288 ha within the nesting range (Frye and Curtis 1990, Dowell and Petty 1974).

These values are pertinent because the coincidence of former warbler habitat and existing reservoir sites suggests that a large portion of presently flooded terrain once supported GCW populations. Construction of large reservoirs has also led to destruction of much adjacent GCW habitat due to rapid development of land surrounding lake-side communities.

Loss of Winter and Migration Habitat: Most wood warblers spend the major portion of each year away from the breeding range (Schwartz 1980, Morse 1989). This is also true of the GCW, which are either in-transit along the migration corridor or on the winter range for at least 7 months each year. This fact emphasizes the critical importance of GCW habitat in Mexico and Central America.

A recent report by Lyons (1990) summarized the threats facing GCW habitat in Guatemala. Foremost among these is logging and clearing of pine-oak woodlands for commercial lumber, wood pulp, charcoal, firewood, marble quarrying, and farmland (Leonard 1984, Universidad Rafael Landivar 1984). One source estimated that the Guatemalan highlands will be completely logged over in 25-40 years if measures are not taken to halt or reverse the present course (Universidad Rafael Landivar 1984).

Destruction of Oaks: An additional factor that may reduce habitat quality for GCWs is the loss of oaks to various fungal infections (Johnson and Appel 1984). Of primary concern are the effects of the "Oak Wilt" fungus (*Ceratocystis fagacearum*). All oak species may be infected by this fungus, but red oaks, particularly live oaks, Texas oaks, and blackjack oaks are especially susceptible. White oaks, such as post oak and shin oak, appear to be more resistant to oak wilt (USDA 1990).

Oak wilt is rapidly transmitted in live oaks via interconnected root systems. Such local spread of the infection can radiate from sites of initial infection at rates of up to 40 m/year (Appel *et al*. 1989). Some infected patches already cover 80 ha and contain hundreds of dead or dying oaks (Appel and Maggio 1984). Unlike in live oaks, the oak wilt fungus forms mats beneath the bark of Texas and blackjack oaks. Sap-feeding beetles are attracted to these fungal mats and may transmit fungal spores over long distances by feeding on fresh wounds of other oaks. Fungal mats may develop on live or dead (i.e., fire wood) trees and branches (USDA 1990).

The effects of this disease on GCWs should be most pronounced where Texas oak and live oak are major components of warbler habitat and where the importance of other deciduous canopy species is low. Oak wilt may have contributed to the decline of warblers at the Kerrville State Recreation Area (Wahl et al. 1990).

In many parts of central Texas, over-browsing by white-tailed deer (Odocoileus virginianus), goats, and various exotic ungulates has adversely impacted recruitment (i.e., young organisms attaining adulthood, reproducing, and thus replenishing the population) of deciduous trees (Wahl et al. 1990). Overbrowsing, coupled with the broadening impact of oak wilt, suggests that the species composition of oak-juniper woodlands is changing toward greater dominance of juniper. Although GCWs show great tolerance for variability in relative dominance of juniper, the tendency of GCWs to avoid juniper monocultures suggests that the combined influence of overbrowsing and oak wilt could lead to a reduction in the carrying capacity of warbler habitat.

Nest Parasitism: Some wood warblers such as Kirtland's warbler (Dendroica kirtlandii) are undoubtedly threatened by cowbird parasitism. Prior to initiation of an intensive cowbird removal program, up to 75% of all nests of this species were parasitized (Walkinshaw 1983). Kirtland's warbler lacks defenses (such as rejection of cowbird eggs or abandonment of parasitized nests) that can reduce the impact of nest parasitism (Mayfield 1960). Furthermore, habitat degradation on the breeding and/or winter grounds may have depressed the total population of this species to only about 200 pairs (Ryel 1981). Obviously, at this population size, any deleterious effect of recruitment represents a serious threat to the survival of the species.

Pulich (1976) found eggs of cowbirds in 19 of 33 (58%) GCW nests. However, the effect of cowbird parasitism on GCW populations is unknown because (1) GCWs will abandon parasitized clutches and re-nest later in the season when the intensity of parasitism declines (Payne 1973, 1976; Pulich 1976; Nolan 1978); and (2) adult GCWs can successfully rear their own young plus young cowbirds (Pulich 1976, Wahl et al. 1990). This may indicate a partial adaptation to cowbird parasitism that may suggest some contact with cowbirds through the evolutionary history of the warbler.

However, several anthropogenic (human caused) factors, including urbanization and certain agricultural practices have greatly increased the density and access of cowbirds to a variety of habitats. Cowbirds historically occupied short-grass prairies of the Great Plains west of the Mississippi River, and followed migrating buffalo herds. With the clearing of forested lands, the cowbird's range has greatly expanded (Friedman 1929, Mayfield 1965). Current livestock practices tend to concentrate cowbirds in a given area through the cowbird's reproductive season, greatly increasing the rate and length of exposure of host nests to parasitism events. Other agricultural practices have also led to increased cowbird populations by decreasing winter mortality, such as leaving waste grains in harvested fields and in feed lots, on which flocks of cowbirds and other blackbirds congregate to feed (Brittingham and Temple 1983). In addition, the abandonment of first nests due to cowbirds, or the raising of cowbird young in addition to their own, decreases the total number of GCW young produced by GCW females and the survivability of their young.

An additional complication is that concentrations of livestock may elevate rates of nest parasitism (Rothstein et al. 1987, Gryzbowski 1988) in concert with habitat fragmentation in more exposed (Nice 1937) or edge nest sites (Brittingham and Temple 1983, Wolf 1987). The localized increase in nest parasitism in exposed or edge areas, where researchers and casual observers are more likely to find nests, makes it difficult to draw conclusions about the overall significance of nest parasitism. Finally, cowbird parasitism may interact synergistically or antagonistically with factors such as nest predation (Nolan 1978). These considerations emphasize the difficulties inherent in correctly assessing the effect of cowbird parasitism or effectiveness of cowbird control programs by using only simple measures such as nest parasitism rates or numbers of cowbirds destroyed.

Although the degree of impact of cowbird parasitism on GCW productivity is not determinable at this time and research to determine whether cowbirds are a threat to warbler recovery should be done, current information indicates that it may be prudent to design management strategies that would reduce the chance that nests are parasitized by cowbirds. In this regard, obvious procedures for reducing the impact of nest parasitism on GCW populations would include the following: (1) restoration of fragmented oak-juniper communities so that the open areas preferred by cowbirds become less available and of smaller size close to GCW nesting habitat; (2) elimination of cowbird feeding areas near GCW habitat; and (3) some localized trapping of cowbird females and juveniles may be necessary at management sites with highly fragmented habitat. However, trapping is not recommended unless data collected over a 2-year period indicate a given warbler population is unable to sustain itself without human intervention or unless cowbird parasitism is extreme the first year.

Complicating these management procedures is the ability of cowbirds to traverse great distances (up to 13 km) between feeding and nesting areas (Smith 1981; Rothstein et al. 1984, 1987). If cowbirds can traverse great distances while maintaining high reproductive output, then removal of livestock and livestock feeding areas from GCW management areas may be ineffective unless these management areas are very large, and livestock are uncommon in surrounding lands.

Rothstein et al. (1987) came to the same conclusion in reference to effectiveness of cowbird trapping stations. In their study, cowbird trapping at a "pack station" in the Sierra Nevada had little impact on numbers of adult resident females in surrounding areas. The interpretation of Rothstein et al. (1987) was that the removal program failed locally because the abundance of free-ranging cattle in the area diminished the tendency of local resident adults to use the trap-site feeding station.

The type, extent, and cost of cowbird control measures should be carefully considered before initiation to justify the appropriateness. For example, although localized trapping of cowbirds may be justifiable as a short-term means to boost GCW productivity in highly fragmented sites, too little is known about effects of cowbird parasitism on GCWs to justify intensive investment in large-scale cowbird removal programs.

Initial cowbird trapping efforts conducted at the Ft. Hood Military Reservation were ineffective in reducing the incidence of parasitism on black-capped vireos (*Vireo atricapillus*), and these same efforts may have actually increased parasitism rates by attracting cowbirds to localized vireo populations (Tazik and Cornelius 1990). More recent data, however, suggest that greatly intensified trapping efforts and reduction of livestock numbers on Ft. Hood have significantly decreased parasitism rates and increased vireo productivity (Hayden, personal communication).

Habitat Fragmentation: Fragmentation of habitat reduces habitat quality for woodland songbirds in the following ways: (1) small patch size and thus small population size make extant populations more susceptible to random extinction or effects of inbreeding; (2) increased distance between patches reduces gene flow between populations and makes recolonization of vacant patches more difficult; and,

(3) increased proportion of habitat edge in small patches may so alter patterns of insect abundance, vegetation structure, and songbird foraging activity (due to changes in the microclimate) (Brett 1989, Klein 1989, Parker 1989, Reville et al. 1990, Saunders et al. 1991), or so heighten rates of nest parasitism and nest predation that the surviving songbird populations cannot maintain themselves (Lovejoy et al. 1986, Wilcove et al. 1986).

Proximity to urban areas may compound the problem of fragmentation by exposing edge habitats to high densities of certain nest predators such as blue jays (*Cyanocitta cristata*). Additional research is needed to determine impacts associated with jay predation. Wilcove (1985), for example, also found that small suburban fragments experienced higher predation rates than nests in small rural fragments.

Wood warblers typically produce only one rather small brood of young per year and usually construct open nests (Chapman 1907, Bent 1953, Griscom and Sprunt, Jr. 1957), thus we would expect wood warbler species to be sensitive to any factor such as habitat fragmentation that reduces foraging efficiency and increases nest predation (Morse 1989). Despite this generalization, wood warblers vary in their sensitivity to habitat fragmentation. Some species, such as black-and-white warblers (*Mniotilta varia*) and ovenbirds (*Seiurus aurocapillus*), quickly disappear when otherwise suitable habitat is chopped into small patches. Other species such as yellowthroats (*Geothlypis trichas*) and Kentucky warblers (*Oporornis formosus*) seem to be at least superficially tolerant of fragmentation effects (Whitcomb et al. 1977, 1981; Gibbs and Faaborg 1990).

Pulich (1976), Kroll (1980) and Ladd (1985) have pointed out that GCWs will inhabit territories in woodlands along habitat edges. However, the nature of those territories (i.e., whether occupied by unmated males, mated pairs, or successfully reproducing pairs) is unknown.

Effects of isolation on GCWs depend in part on the dispersal ability of the species. Although GCWs travel great distances on migration, site fidelity may restrict breeding season dispersal movements. As patches become more isolated, local populations of warblers become isolated and more subject to the deleterious effects of inbreeding. Furthermore, rates of juvenile returns to birth sites in many passerine species are low despite high winter survivorship (Morse 1989). As nesting populations become more isolated, the ability of returning juveniles to locate suitable habitat and mating opportunities declines, thus nullifying programs such as cowbird trapping that try to elevate the reproductive success of host species (Mayfield 1983). In addition, the further isolated an area is, the harder it is for a given area to be recolonized if the population is extirpated.

J. CONSERVATION MEASURES

Current Research: A number of studies of various aspects of GCW ecology are currently in progress. C. Beardmore's examination of GCW behavior (MS in preparation), for example, will augment those of Kroll (1980) and Sexton (1987) by providing detailed information on sexual differences in GCW foraging behavior and foraging substrate preferences.

Population monitoring projects currently in progress include studies at the following sites: (1) Camp Bullis Military Reservation and Friedrich Wilderness Park, Bexar County (Susan Rust, personal communication); (2) Travis County Audubon Sanctuary (David Lyter, and Paul Turner, TPWD, personal communication); (3) Hamilton Pool Natural Area (Terri Seigenthaler, Austin Parks and Recreation Department, personal communication); (4) Ft. Hood Military Reservation (John Cornelius and Tim Hayden, personal communication); (5) Kerr Wildlife Management Area (Tim Schumann, U.S. Fish and Wildlife Service, and Verajean Hatfield, Hatfield Consultations, personal communications), (6) Lower Colorado River Authority, Wheless and McGregor Tracts (Sherri Kuhl, LCRA, personal communication); (7) Cypress Creek Watershed, Travis County, Texas Department of Transportation (Bill Hood, Texas DOT); and (8) Bull Creek Watershed and 3M Austin Center (DLS Associates, 1990, 1991, 1992). In addition, the Balcones Canyonlands National Wildlife Refuge (BCNWR), which is being established to protect endangered species habitat and serve in an interpretive/educational role, began monitoring GCWs in 1992 on about 3,000 acres and will continue and expand this in the future.

John Cornelius and Tim Hayden are conducting intensive studies of GCW population biology at the Ft. Hood Military Reservation. In 1991 and 1992, this work resulted in the banding of about 300 GCWs and will set the stage for the first thorough examination of this species' population biology. In addition, a Section 6 project was started at the Kerr Wildlife Management Area that proposes to determine the territory size and return rate of GCWs and the relationship of GCW occupation of habitat to forest edge and interior situations.

The Nature Conservancy of Texas and Texas Parks and Wildlife Department in cooperation with the U.S. Fish and Wildlife Service have begun a detailed remote sensing study of the distribution of GCW nesting habitat. Results of this project should be valuable in monitoring patterns in habitat availability. A similar study is needed over the entire migration corridor and wintering range.

Other Conservation Measures: The U.S. Fish and Wildlife Service has formed a GCW Recovery Team. This recovery team will provide advice to the U.S. Fish and Wildlife Service on conservation of the GCW.

The Balcones Canyonlands Conservation Plan (BCCP) is a conservation plan (as defined in Section 10(a) of the Endangered Species Act) that is being developed in Travis County. The BCCP would set up a system of preserves for the GCW and other endangered and candidate species along with other conservation measures. The BCCP is still developing and has not yet been submitted to the U.S. Fish and Wildlife Service for approval.

Another protection effort under way in Travis, Burnet, and Williamson counties is the establishment of the Balcones Canyonlands National Wildlife Refuge by the U.S. Fish and Wildlife Service. It is hoped that, in conjunction with the BCCP and surrounding areas, the Refuge can support a significant population of GCWs. The refuge has already purchased 3,500 acres and proposes to be at least 41,000 acres when completed.

Many private landowners in Central Texas have contacted the U.S. Fish and Wildlife Service for assistance in determining whether or not GCW habitat occurs on their properties and what conservation measures are necessary to protect the warbler. Several of these individuals are voluntarily managing their lands to preserve, enhance, and voluntarily restore GCW breeding habitat.

Prospects for habitat preservation in southern Mexico and Central America are not well known. In Chiapas, Mexico, the Lagunas de Montebello National Park may preserve some pine-oak woods along the Guatemalan border. The Guatemalan Congress has recently been considering declaring much of the Sierra de las Minas as a protected area. In addition, the Guatemalan Audubon Society is presently negotiating for the acquisition of an 896 ha preserve in the same mountain range and an additional preserve near Chelem-ha (Lyons 1990).

K. EXISTING PUBLIC LANDS WITH GCW HABITAT

A number of public parks, recreation areas, wilderness areas, and military reservations already protect some GCW habitat within the breeding distribution (Figure 3, Table 3). Of particular importance are existing public lands that already protect large blocks of GCW habitat.

Foremost among the public lands with large GCW populations is the 87,800 ha U.S. Army reservation at Ft. Hood (Coryell and Bell counties). This military base contains at least 2,786 ha of warbler habitat and represents the single largest existing habitat area in one ownership. The 11,152 ha Camp Bullis military reservation (Bexar County) also contains GCW habitat.

Unfortunately, the amount of GCW habitat present on most publicly held sites is not well known. Studies to determine the amount and occupancy rate of GCW habitat need to be done. This amount of habitat may be only a small portion of the total of existing GCW habitat, but it might be increased through efforts to improve the quality and quantity of warbler habitat on state and other public lands. This approach may also provide a significant future public

Figure 3. Distribution of some public lands within the breeding range of the Golden-cheeked Warbler (underlining indicates "GCWs present": (1) Possum Kingdom SP, (2) Lake Mineral Wells SP, (3) Dinosaur Valley SP, (4) Meridian SP, (5) Lake Whitney SP, (6) Naval Industrial Reservation Ordnance Park, (7) Ft. Hood Military Reservation, (8) Colorado Bend SP, (9) Inks Lake and Longhorn Caverns SPs, (10) Lake Georgetown, (11) Buck WMA, (12) Enchanted Rock SNA, (13) Balcones Canyonlands NWR, (14) LBJ SP and National Park, (15) Pedernales Falls SP, (16) Hamilton Pool and Westcave preserves, (17) Kerr WMA, (18) Guadalupe SP and Honey Creek Ranch SNA, (19) Lost Maples SNA, (20) Garner SP, (21) Hill Country SNA, (22) Camp Bullis Military Reservation/Friedrich Wilderness Area, (23) Kickapoo Caverns SP, (24) Lake Whitney SRA, (25) Mother Neff State Park.

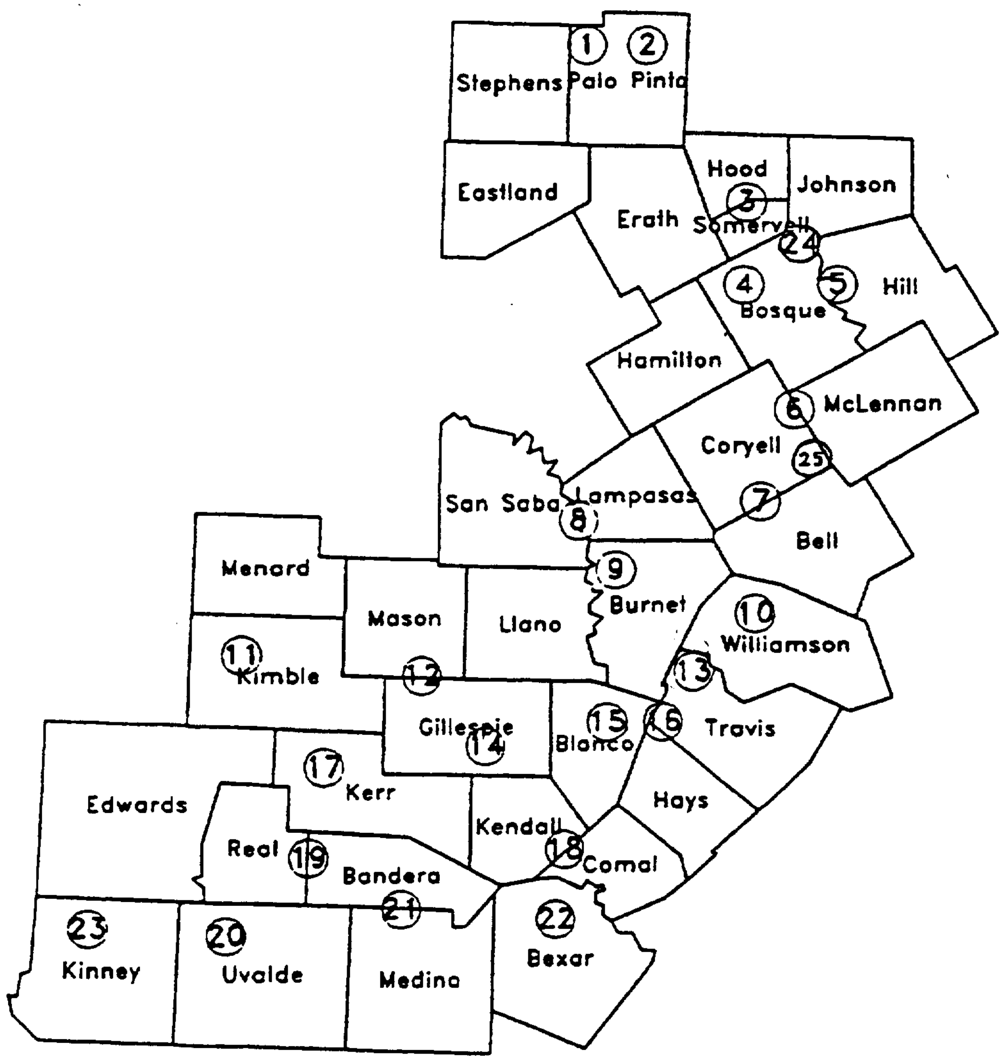


Table 3. Total hectares of some state and federal lands within the breeding distribution of the golden-cheeked warbler.

NAME	COUNTY	TOTAL HECTARES
STATE LANDS		
HILL COUNTRY SNA	BANDERA/MEDINA	2,148*
LOST MAPLES SNA	BANDERA	870*
BLANCO SRA	BLANCO	42
PEDERNALES FALLS SP	BLANCO	1,944*
MERIDIAN SRA	BOSQUE	201*
LAKE WHITNEY SRA	BOSQUE/JOHNSON/SOMERVELL	382
INKS LAKE SP	BURNET	481
LONGHORN CAVERN SP	BURNET	256*
GUADALUPE RIVER SP	COMAL/KENDALL	775*
HONEY CREEK RANCH SNA	COMAL	917*
MOTHER NEFF SP	CORYELL	104
CEDAR HILL	DALLAS	731
ENCHANTED ROCK SNA	GILLESPIE/LLANO	657
LBJ STATE HISTORIC PARK	GILLESPIE	293
CLEBURNE SRA	JOHNSON	212
KERR WMA	KERR	2,597*
KERRVILLE SRA	KERR	207
BUCK WMA	KIMBLE	849
COLORADO BEND SP	LAMPASAS	2,131*
POSSUM KINGDOM SRA	PALO PINTO	612*
LAKE MINERAL WELLS SP	PARKER	1,162
DEVIL'S SINKHOLE SNA	REAL	716
DINOSAUR VALLEY SP	SOMERVELL	510*
EAGLE MOUNTAIN SRA	TARRANT	160
GARNER SP	UVALDE	568*
SUBTOTAL		20,300
FEDERAL LANDS		
FT. HOOD MR	CORYELL/BELL	86,800*
CAMP BULLIS MR	BEXAR	11,152*
LAKE GEORGETOWN	WILLIAMSON	5,000*
BALCONES CANYONLAND NWR	TRAVIS/BURNET/ WILLIAMSON	3,500*
SUBTOTAL		106,452
TOTAL		126,752

* denotes those sites known to have GCWs

relations benefit by reducing pressure on the private landowner to maintain GCW habitat.

The largest state properties that contain occupied GCW habitat include Hill Country State Natural Area (Bandera and Medina counties), Pedernales Falls State Park (Blanco County), Kerr Wildlife Management Area (Kerr County), and Colorado Bend State Park (Lampasas County). Numerous smaller public properties managed by Texas Parks and Wildlife Department, Lower Colorado River Authority, and various federal, state, county, and municipal lands also contain some GCW habitat.

L. RECOVERY STRATEGY

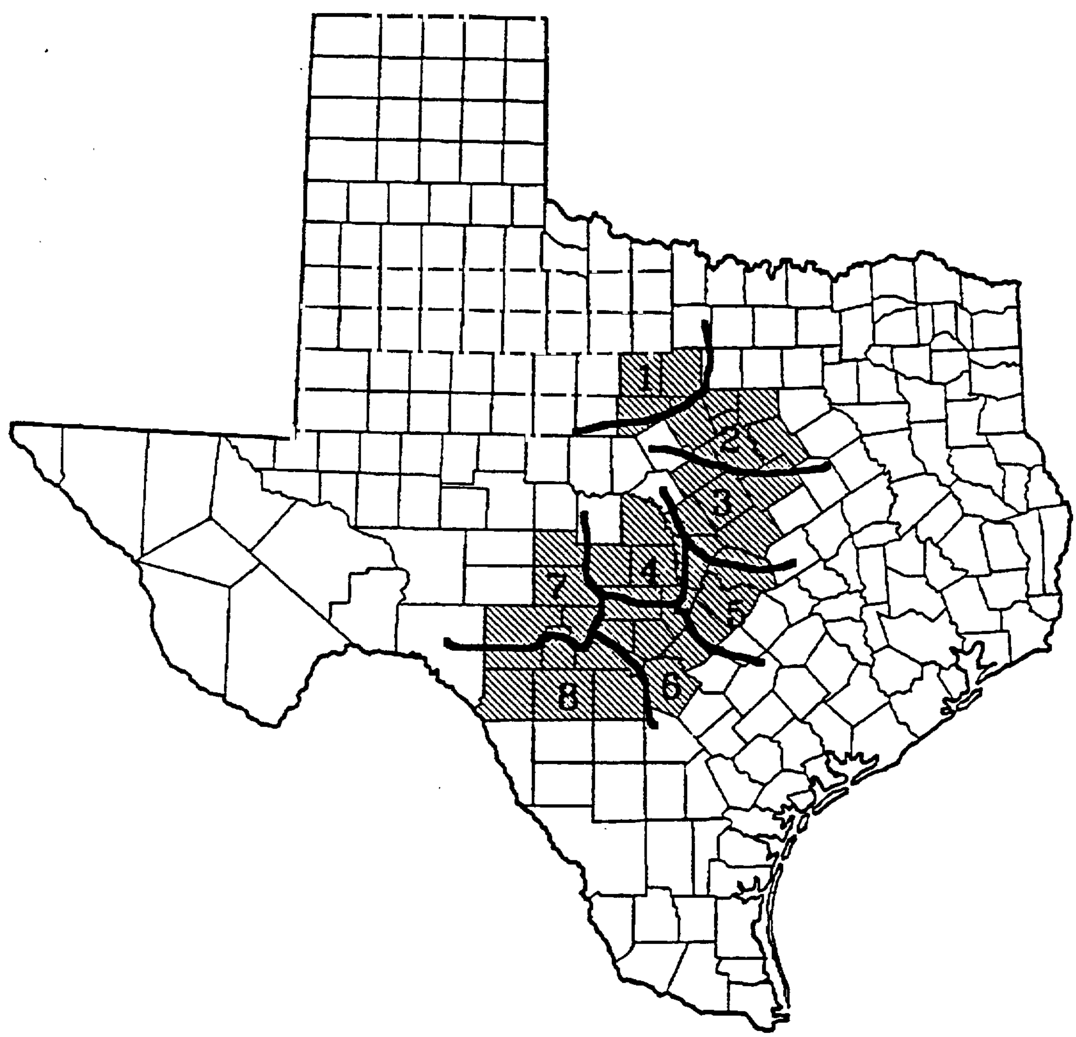
Before discussing recovery strategy, some terminology used throughout the remainder of the recovery plan that is necessary to understand the recovery strategy and recovery criteria is defined below.

> A <u>population</u> is a set of organisms belonging to a species that is geographically delimited and capable of freely interbreeding with one another under natural conditions (Wilson 1975).
>
> A <u>viable population</u> is a population that "maintains its vigor and its potential for evolutionary adaptation" (Soulé 1987) and that "is self-sustaining with minimal demographic or genetic intervention over the long term" (Wilcox 1986).
>
> <u>Focal area</u> is used to mean areas targeted for meeting the recovery criteria. These areas may consist of a single population or one or more populations that are in more or less isolated patches but are interconnected with other populations through gene flow (that is, a metapopulation).

This recovery plan assumes that attainment of the recovery criteria presented in Section II will provide for long-term maintenance of this species. These criteria include the following:

(1) Sufficient breeding habitat should be protected to ensure the continued existence in each of eight regions, outlined in Figure 4, of at least one self-sustaining population that is either viable on its own or through its connection to other populations. The eight regions were delineated based on such considerations as geologic, vegetational, or watershed boundaries. These regions were also delineated to cover the entire breeding distribution of the GCW. The population sizes and arrangements necessary to attain and maintain viability need to be defined as part of recovery. Ideally, this criteria should be accomplished by targeting focal areas that coincide with public lands to the maximum extent practicable and by building voluntary relationships with private landowners to protect additional habitat needed to assure viability.

Figure 4. Regions 1-8 for golden-cheeked warbler populations.



(2) If no population in a given region is a viable population by itself, then there should be at least one population in the region that is (a) large enough to be demographically self-sustaining (though it can be dependent on its connection to other populations to be genetically viable) and (b) has the potential for gene flow to be maintained between the population and at least one other self-sustaining population so that genetic viability is provided for.

(3) Sufficient wintering habitat and migration corridor habitat for this species should be protected south of the breeding range. The success of this part of the plan will depend largely on cooperative efforts among many public and private entities over several international boundaries.

(4) Until information is obtained that will determine the size and arrangement of the populations and habitat needed for recovery, all existing occupied GCW habitat on public areas should be protected.

(5) All of the above conditions should be maintained for at least 10 consecutive years, so that a high degree of confidence in the perpetuation of the conditions is assured.

It is not known if gene flow occurs or could occur throughout the entire breeding range of the warbler, or whether gene flow is geographically restricted in certain areas. For example, GCW's may be so site tenacious behaviorally to certain watersheds or other portions of the breeding range that they would not likely select a territory in any other part of the breeding range and are, therefore, geographically limited.

Accurate models for predicting viable population sizes for specific species are not yet available (Grumbine 1990). Lande and Barrowclough (1987) suggested that 500 individuals may at least be the correct order of magnitude for maintenance of a population. Modeling efforts of Pease and Gingerich (unpublished MS) indicate that a viable population for generalized small songbird populations needs to be at least 500-1000 pairs. A stochastic modeling approach used by Dennis _et al_. (1991), however, demonstrates sensitivity of the extinction process to species-specific demographic attributes. Soulé (1987) summarized recommendations by the contributors to his book, _Viable Populations for Conservation_, and suggested a viable population size in the low thousands for most vertebrates. Although these estimates for viable populations are relatively similar, it demonstrates the difference of opinion on the subject. Viability of the GCW populations will be determined by research tasks recommended in the recovery outline.

The purpose of recovery is to ensure that the species can maintain itself for an extended period of time without intervention. In this regard, the approach should be cautious; in other words, it would be better to target a few more pairs than is estimated for recovery than too few pairs and have the species dwindle to the point of extinction. This plan recommends against allowing a reduction of potentially healthy GCW groups to dwindle to a threshold level where sustainability and viability have a low probability.

Fundamental to the recovery strategy is the creation of a system of protected populations scattered over the present breeding distribution. In some cases, interconnectivity of populations is necessary to protect populations against effects of inbreeding and to provide for recolonization of sites if local populations are extirpated. Essentially nothing is known about the dispersal abilities of GCWs. Consequently, the only way to assure that managed populations are interconnected is to encourage maintenance of abundant and scattered patches of habitat outside of the focal areas. This strategy of identification and establishment of viable, self-sustaining populations should include, among other things: (1) research tasks such as the remote sensing/GIS survey work and ground truthing to locate existing large patches of habitat; (2) improved public relations, incentives, assistance, and/or educational programs designed to increase voluntary protection of warbler habitat; and (3) methods for establishing and maintaining public and private management areas in Mexico and Central America to assure preservation of adequate habitat along the migration corridor and in the winter range.

There are several approaches that could lead to the attainment of the populations and associated habitats. The approach most likely to succeed is to increase protection of habitat through enhanced public relations/public education, incentives, assistance, and cooperative arrangements with landowners. Coupled with this approach should be intensified protection and management for the GCW on existing public lands. Habitat acquisition is an approach that is available in limited instances, such as in the case of the Balcones Canyonlands National Wildlife Refuge. However, direct acquisition of enough habitat to recover this species is not probable and cannot be viewed, by itself, as a means of recovering the species. Although it is likely that a combination of these two approaches will be employed, full recovery will be dependent in large part on the cooperative efforts of private landowners and public entities, and an effort should be made to emphasize creative alternatives at every opportunity.

Research aimed at elucidating various aspects of the ecology and population biology of the GCW will be critical to accomplishing the objective of this plan. In particular, the results of carefully-designed studies must be available for designing management techniques and detailed strategies and evaluating (1) the effectiveness of management techniques, (2) the appropriateness of the recovery criteria, and (3) the progress of recovery. Definitive studies will require more than a single field season. Collaboration among the various parties conducting research can maximize the efficiency associated with conducting the needed GCW research.

Federal agencies have a responsibility to comply with Section 7 of the Endangered Species Act. Specifically, the Act says "all other Federal agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species." Several Federal agencies have programs that can contribute to the conservation of the GCW.

The U.S. Fish and Wildlife Service will coordinate the implementation of this recovery plan with other recovery plans and efforts that overlap the range of the GCW both in Texas and in Mexico and Central America.

II. RECOVERY

A. OBJECTIVE AND CRITERIA

Objective: The objective of this recovery plan is to outline steps necessary to recover the golden-cheeked warbler to the point that it can be removed from the Endangered and Threatened Species List.

Criteria: The golden-cheeked warbler will be considered for delisting (removal from the List) when:

(1) sufficient breeding habitat has been protected to ensure the continued existence of at least one viable, self-sustaining population in each of eight regions outlined in Figure 4;

(2) if no population in a given region is viable by itself, then there should be at least one population in the region that (a) is large enough to be demographically self-sustaining and (b) has the potential for gene flow to be maintained between the population and at least one other self-sustaining population so that genetic viability is provided for;

(3) sufficient and sustainable non-breeding habitat exists to support the breeding populations in #1 above;

(4) all existing GCW populations on public lands are protected and managed to ensure their continued existence, at least until the optimum and spatial arrangement of populations needed for long-term maintenance of the species (viability) is determined;

(5) all of the above have been maintained for at least 10 consecutive years.

These reclassification criteria are preliminary and may be revised on the basis of new information (including research specified by this recovery plan). The size and location of the populations within the eight regions will be determined as a result of completion of some of the tasks in the recovery outline. The estimated date for attaining the objective of this plan (delisting) is 2008.

B. RECOVERY OUTLINE

The following is an outline of recovery tasks needed to attain the objective of this plan. The following section (C.) includes more detailed information on the tasks.

1.0 Research Needs

1.1 Population Biology

1.11 Determine survivorship, dispersal, reproductive success, and other population parameters.
1.12 Determine population sizes, etc., necessary to attain and maintain viability.
1.13 Determine whether gene flow is provided for among populations.

1.2 Ecology and Behavior

1.21 Study foraging behavior and prey species.
1.22 Study the movements within populations and during the post-breeding period.
1.23 Study distribution in relation to productivity.
1.24 Study the relationship of various predators to GCW reproductive success.
1.25 Determine the rate and extent of cowbird parasitism and whether it is a threat to recovery.
1.26 Study the biology and behavior of wintering and migrating GCWs.

1.3 Habitat Requirements and Availability

1.31 Determine habitat requirements and habitat selection patterns in the breeding range.
1.32 Study habitat patch size requirements and determine the effects of disturbance on reproductive success.
1.33 Determine the effects of urbanization and other land use practices on patch size requirements.
1.34 Study the dynamics of hardwood regeneration in older mixed deciduous-juniper associations.
1.35 Study habitat requirements of GCWs during migration and on their wintering grounds.
1.36 Determine current distribution of existing habitat on private and public land in the breeding range.

1.37 Determine locations of the focal areas and associated habitat.
1.38 Determine size of buffer zones needed to reduce impacts of urbanization and agricultural activities.
1.39 Study the effects of management options in Task 3.0.
1.310 Determine current distribution and availability of habitat in the winter range and migration corridor.
1.311 Determine the optimum distribution of areas to be protected in the winter range and migration corridor.

1.4 Monitoring

1.41 Monitor target populations.
1.42 Monitor the effects of management tasks in 3.0.
1.43 Develop a post-recovery monitoring plan.
1.44 Monitor habitat and populations in Mexico and Central America.

2.0 Habitat Needs

2.1 Establish a system of focal areas, and interconnecting habitat where necessary, within the eight regions in the breeding range.
2.11 Protect populations on public land.
2.12 Protect populations on private land.
2.121 Locate landowners interested in voluntarily protecting GCW habitat.
2.122 Encourage voluntary protection and improve incentives for voluntary protection of GCW habitat.

2.2 Protect habitat in the winter range and along the migration corridor.
2.21 Identify currently protected areas within potential GCW winter and migratory habitat.
2.22 Make contacts, encourage and assist, where possible, with efforts by governmental and conservation organizations and individuals in these countries.
2.23 Identify and encourage funding of conservation efforts.
2.24 Investigate and encourage options to protect habitat.

3.0 Management Needs

3.1 Enhance and maintain quality of GCW habitat on public and private lands.
3.2 Maintain hardwood regeneration within GCW management sites.
3.3 Promote the regeneration of oak-juniper woodlands in certain areas previously cleared, thinned, or burned.
3.4 Develop management options for formation of GCW habitat.
3.5 Adopt management strategies that reduce the impact of cowbird parasitism and nest predation on GCW populations.
3.6 Minimize the extent to which GCWs are affected by agriculture and urbanization.
3.7 Develop management guidelines and provide technical assistance to landowners.
3.8 Investigate and encourage sustainable development options for GCW habitat in Mexico and Central America.

4.0 Public Information and Education

4.1 Increase public awareness of the importance of the GCW and natural ecosystems.
4.2 Develop curriculum/media for childhood and adult natural history/endangered species education.
4.3 Develop and disseminate informative brochures and pamphlets on GCW management and natural history.
4.4 Develop and provide information and educational materials for Mexico and Central America.
4.5 Develop demonstration ranches and public areas.

5.0 Regulatory

C. NARRATIVE OUTLINE FOR RECOVERY ACTIONS

1.0 Research needs

Because female GCWs are difficult to observe, typical habitat is very dense, and nests are extremely cryptic, many details of the species' life history have not been adequately studied. It is also often difficult to obtain access to census populations on habitats in private ownership.

1.1 Population biology

1.11 Determine survivorship, dispersal, reproductive success, and other population parameters. Determine rates of population turn-over, rates of return to the same area year after year, rates of nesting productivity, the proportion of mated pairs and unmated individuals within populations, and rates and distances of interpopulational movements of adults and returning juveniles, by means of a mark-recapture study. This information will be used in developing viability models (1.12), determining when viable population targets for delisting have been met, and assisting with determining whether gene flow among populations is provided.

1.12 Determine population sizes, etc., necessary to attain and maintain viability. Use the information from 1.11 to develop viability models and determine population sizes, amount of area, and necessary distribution of habitat and populations (including corridors) needed to assure viable populations in each of the eight regions.

1.13 Determine whether gene flow is provided for among populations. Use the information from 1.11 and 1.12 or gather other genetic information to determine whether gene flow is provided for where needed. Gene flow is closely tied to viability (Task 1.12) and determining the locations of focal areas (Task 1.37). A consideration in determining the locations of target populations (focal areas) is the potential for gene flow and enhancement of adaptive genetic variation. The positioning of the populations should be evaluated from a theoretical perspective, but the proposed populations and associated habitat need to be designed with existing populations and habitat in mind. Area selection should be influenced by the distance to and location of other viable or self-sustaining populations.

1.2 Ecology and Behavior

1.21 Study foraging behavior and prey species. Further study of foraging behavior as it relates to various ecological and physical aspects of the habitat is needed, particularly post-breeding foraging behavior. Other studies are also needed, such as determining the types and abundances of prey species as they relate to vegetation species composition and other ecological and physical variables that may influence prey abundance.

1.22 Study movements within populations and during the post-breeding period. This information is particularly important in relation to habitat types and quality and will be applied to further defining the habitat requirements of the species. This task could be done in conjunction with Tasks 1.11 and/or 1.23.

1.23 Study distribution in relation to productivity. This study would document the productivity of GCWs in relation to the habitat used. It would address questions such as: (1) are there unmated individuals, what habitats are they using, and are they essential for recovery, and (2) is there a habitat type that is more productive than others, so that protection efforts can focus on more productive habitat. This study should be done in conjunction with fragmentation studies (Tasks 1.32 and 1.33).

1.24 Study the relationship of various predators to GCW reproductive success. Various predators may have a significant impact on the reproductive success of GCWs. This study would document predation rates in relation to fragmentation and land use practices.

1.25 Determine the rate and extent of cowbird parasitism and whether it is a threat to recovery. Cowbird abundances, rates of cowbird nest parasitism, and the effects on GCW productivity should be identified at several experimental sites. Then, various livestock densities and rotational schemes and other variables should be manipulated at those sites to determine if there is an effect on cowbird concentrations, rates of nest parasitism, and GCW productivity. In addition, the effects of fragmentation should be studied to determine if rates of cowbird parasitism and GCW productivity are affected. Adequate evaluation of these impacts may require several years of study.

1.26 Study the biology and behavior of wintering and migrating GCWs. Studies are needed of warbler distribution and movements, and foraging behavior in their winter range and migration corridor. Banding stations should be established at wintering and migrating sites. Studies should be coordinated with Mexican and Central American programs, as well as other programs such as Partners in Flight, U.S. Forest Service's Sister Forest Program, and Smithsonian research programs.

1.3 Habitat requirements and availability

1.31 Determine habitat requirements and habitat selection patterns in the breeding range. A definitive study of the habitat requirements and habitat selection patterns of GCWs is needed. Previous work has focused on vegetative structure in suitable habitat or on foraging substrate preferences without attempting to examine potential underlying causal relationships.

This study of the breeding habitat should include measurements of vegetation structure/form, warbler foraging behavior (Task 1.21), warbler movements (Task 1.22), patterns of warbler abundance (Task 1.23), and examination of factors influencing abundance of warbler prey (Task 1.21), GCW predators (Task 1.24), and nest parasites (Task 1.25). The importance of water to the quality of GCW nesting territories needs to be clarified. Habitat selection studies could focus around nest site selection studies.

1.32 Study habitat patch size requirements and determine the effects of patch size on reproductive success. Expand the research that has already been done on patch size requirements. Map locations of territorial males and, if possible, distributions of mated pairs and productive pairs in relation to size and location within the patches of habitat. This task could be done in conjunction with Task 1.33.

1.33 Determine the effects of urbanization and other land use practices on GCW abundance. The effects of urbanization and other land use practices are difficult to treat separately, however, some of the variables that might be investigated include: trails, roads, fence lines, rights-of-way in urban versus rural situations, low and high density housing, recreational activities and developments, commercial and business development, brush clearing, increased predators, increased nest parasitism, noise, and lighting. This task could be done in conjunction with Task 1.32, especially to determine effects of land use practices on reproductive success and the interaction of these effects with patch size.

1.34 Study the dynamics of hardwood regeneration in older mixed deciduous-juniper associations. Long-term monitoring studies are needed that will provide information on the plant population biology and the dynamics of plant succession in central Texas woodlands. In particular, focus is needed on the effects of oak wilt and overbrowsing on hardwood regeneration and resulting plant population dynamics and community composition. This study should also determine browsing levels that would be compatible with GCW habitat regeneration. Browsing studies should include the effects of deer and exotic and domestic animals.

1.35 Study the habitat requirements of GCWs during migration and on their wintering grounds. Describe the vegetation species composition and structure of migration stop-over points and winter range. This work will require coordination of field surveys with remote sensing work designed to locate extant patches of winter habitat (Task 1.310).

1.36 Determine current distribution of existing habitat on private and public land in the breeding range. The ongoing remote sensing study of GCW habitat distribution in central Texas should be completed. The study should provide maps indicating the distribution and total area of suitable habitat on public and private lands in all counties within the breeding distribution of the GCW. This study should also search the periphery of the range in an effort to detect any habitat where GCW populations might be surviving in counties where the species is thought to have been extirpated. This study should also include a measure of habitat quality and relative density of GCWs by habitat type.

1.37 Determine the availability and placement of the focal areas and associated habitat. These focal areas should be selected in such a way as to include habitat that would meet delisting criteria for at least one viable, self-sustaining population for each region. Information should also be used from research conducted under Task 1.0 to determine the size and distribution of the focal areas and the interconnecting habitat. Preservation of the distribution of the GCW including the extremities of the breeding range is part of the recovery strategy. Focal areas should coincide with public land to the maximum extent practicable. A more complete survey of public lands for GCWs is needed. Ultimately, there should be well distributed patches of protected habitat on public and private lands throughout the present breeding distribution of the species. Distribution of dispersal habitat should also be considered.

1.38 Determine size of buffer zones needed to reduce impacts of urbanization and agricultural activities. The size of the area needed to support target populations should consider the need for buffer zones in some areas to reduce the impacts of urbanization and agricultural activities. Information obtained in Tasks 1.1, 1.2 and 1.3 should be used to determine the size of buffers.

1.39 Study the effects of management options in Task 3.0. Study the effects of management options in Task 3.0. Before comprehensive management guidelines are disseminated, management options should be tested for success in both producing GCW habitat and recolonization by GCWs.

1.310 Determine the current distribution and availability of habitat in the winter range and migration corridor. Relatively few records exist for wintering and migratory GCW. A thorough exploration of the known habitat types and other areas of similar habitat is needed. A remote sensing study and associated GIS that can be used to monitor the distribution and rate of change of suitable winter habitat for the GCW should be developed. The ground-truthing for this project should be coordinated with field survey activities called for in Task 1.35.

1.311 Determine the optimum distribution of areas to be protected in the winter range and migration corridor. Based on information collected in Tasks 1.35, 1.310, and 2.21, the locations of areas to be managed and protected should be determined. Where possible, target areas should coincide with currently protected areas. While positioning should be evaluated from a theoretical perspective, the practicability and ease of protection should also be considered.

1.4 Monitoring

1.41 Monitor target populations. Select and implement a censusing methodology to monitor target populations in focal areas, and in connecting habitat where necessary, to assist with determination of whether the delisting criteria have been met. Each population should be monitored to determine if they are viable. If possible, this task should be accomplished by field surveys of territories during the first part of the breeding season (mid-March through mid-May). Design of surveys must provide unbiased information on dispersion and density of territories and any other information necessary to determine if populations are viable.

1.42 Monitor the effects of management tasks in 3.0. Long-term results of managing GCW habitat, nest parasites, and nest predators (Task 3.0) should be monitored. Ideally, reproductive success and overall survival of GCWs subjected to the management scheme should be the gauge to determine if a management scheme is benefitting the species.

1.43 Develop a post-recovery monitoring plan. The Endangered Species Act requires implementation of a plan in cooperation with the States to monitor effectively for not less than 5 years the status of all species that have recovered and have been removed from the Endangered and Threatened Species List. The post-recovery monitoring plan should be developed before the species is delisted.

1.44 Monitor habitat and populations in Mexico and Central America. Select and implement a surveying methodology to monitor populations in the wintering and migrating areas.

2.0 Habitat Needs

2.1 Establish a system of focal areas and interconnecting habitat, where necessary, within the eight regions in the breeding range. It is intended that the focal areas, where feasible, will be on existing public lands. In many instances, however, the amount of habitat available on public lands will be insufficient to meet the delisting criteria. In this case, other methods of providing for the habitat needs of the species should be explored, such as conservation agreements, conservation easements, or land acquisition from willing sellers. Creation of the Balcones Canyonlands National Wildlife Refuge (16,400 ha or 41,000 ac; USFWS 1991) in conjunction with implementation of the Balcones Canyonlands Conservation Plan (8,400 ha or 21,000 ac; Butler/EH&A Team 1991) is an example of a potential focal area that would coincide largely with public lands.

2.11 Protect populations on public land. This task (one of the delisting criteria) requires protection of GCW habitat (identified as part of Task 1.37) now located on public lands (Figure 3, Table 3). This protection should be provided at least until sufficient information is available to delineate the focal areas and associated habitat necessary for long-term maintenance of the species, determined under Task 1.37.

2.12 Protect populations on private land.

2.121 Locate landowners interested in voluntarily protecting GCW habitat. Landowners within the distribution of GCWs should be canvassed to determine who has an interest in voluntarily managing their property in a way that is consistent with maintaining viable populations of GCWs. Landowners within the focal areas should be given priority; however, habitat outside focal areas may still be important in maintaining interconnectivity through dispersal behavior.

2.122 Encourage voluntary protection and improve incentives for voluntary protection of GCW habitat. Interested individuals and agencies should be assisted

in their efforts to protect habitat.
Efforts should be accelerated for providing landowners with incentives for preserving GCW habitat and for investigating and expanding the options private landowners can use to protect and manage GCW habitat. Incentives could be in the form of technical guidance and assistance, private lands/landowner assistance programs, conservation easements, or state wildlife management tax exemptions. This effort should be linked with the development of educational curricula and endangered species habitat management guidelines so concerned landowners can be kept as involved in the recovery effort as possible (Task 4.3).

2.2 <u>Protect habitat in the winter range and along the migration corridor.</u> Encourage and assist with habitat protection efforts in cooperation with the governments and conservation organizations of Mexico, Honduras, Guatemala, and Nicaragua. The methods used need to be tailored to those most appropriate for each country. Focus should be on areas identified in Task 1.311.

2.21 <u>Identify currently protected areas within potential GCW winter and migratory habitat.</u> Identify and offer support to ongoing efforts to protect GCW winter and migratory habitat. Encourage studies to identify potential habitat in other protected areas. Information from such studies may also be useful in determining the optimum distribution of areas to be protected in the nonbreeding range (Task 1.311).

2.22 <u>Make contacts, encourage and assist, where possible, with efforts by governmental and conservation organizations and individuals in these countries.</u> Various organizations and individuals are already working on issues related to recovery of the GCW. It would be more efficient to identify those programs and facilitate protection and research through established projects.

2.23 Identify and encourage funding of conservation efforts. Funding possibilities through programs such as World Bank, Assistance for International Development, and the North American Free Trade Agreement (NAFTA) should be explored. Funding could be facilitated through contacts made in Task 2.22.

2.24 Investigate and encourage options to protect habitat. Creative and sustainable ways to protect habitat at the private, local, state, and/or national level should be encouraged.

3.0 Management

3.1 Enhance and maintain quality of GCW habitat on public and private lands. Focal areas and associated habitat should be managed to enhance and maintain the quality of GCW habitat. Factors such as oak wilt, overbrowsing, and cowbird parasitism may progressively reduce habitat quality and population viability in focal areas unless appropriate habitat management procedures are applied. Appropriate habitat management procedures should be developed and monitored (Task 1.42) to identify their benefit to the species.

3.2 Maintain hardwood regeneration within GCW management sites. GCW populations should be protected against the effects of oak wilt and overbrowsing. Activities, such as moving infected firewood from place to place, that make oaks more susceptible to oak wilt should be avoided. Populations of white-tailed deer, goats, exotic ungulates, and other browsing animals within GCW target populations may need to be managed to ensure hardwood regeneration. The response of GCWs to these practices should be researched and monitored, as indicated in Tasks 1.39 and 1.42.

3.3 Promote the regeneration of oak-juniper woodlands in certain areas previously cleared, thinned, or burned. In some areas targeted for GCW populations, enhancement of habitat for GCWs may be desirable. In those areas, where secondary succession of pure junipers occurs and GCWs are not present, scattered younger juniper may be thinned and replaced with hardwood seedlings. This process should be monitored to see if GCWs will colonize such managed stands. Conversely, juniper could also be encouraged in areas where they have been cut out and where mature hardwoods remain.

3.4 Develop management guidelines for formation of GCW habitat. Depending on the results of Task 1.32 and 1.33, it may be advisable to allow adjacent patches of GCW habitat to coalesce into a single continuous expanse of habitat or to create edge. Woodland/grassland interfaces that are irregular may need to regrow so that the resulting interface is relatively smooth. Additional fragmentation of blocks of habitat with trails, roads, fenceline rights-of-way, or any other type of right-of-way may need to be avoided.

3.5 Adopt management strategies that reduce the impact of cowbird parasitism and nest predation on GCW populations. If the results of Tasks 1.24 and 1.25 indicate that cowbird parasitism or predation is a threat to the recovery of the GCW, then methods to reduce the number or productivity of female cowbirds and potential warbler predators in the vicinity of GCW populations, or otherwise reduce population-wide rates of nest parasitism and predation, may be necessary. Experimental nest predator and nest parasite removal programs may be appropriate. This approach may be the only feasible way to maintain productivity of some GCW populations, although it is considered a short-term solution. Localized threats may have to be addressed at some sites where they are seriously impacting the warbler population. These determinations can be made on a site-by-site basis. If predator control is contemplated, careful consideration should be given to determining its necessity and ecological impact prior to implementation.

3.6 Minimize the extent to which GCWs are affected by agriculture and urbanization. In the interim, until information is gained from research called for in Tasks 1.33 and 1.38, the extent to which GCW populations are affected by urban and agricultural activities that might increase rates of predation, nest parasitism, and disturbance of GCWs should be limited.

3.7 Develop management guidelines and provide technical assistance to landowners. Interim guidelines should be formulated to provide management options a landowner or manager could adopt that would benefit the species. Especially included should be how to integrate warbler needs into existing land management programs. This could be developed through existing networks such as the Texas Agricultural Extension Service, the Soil Conservation Service, Texas Parks and Wildlife Department, or other state, local, and federal technical guidance programs that reach private landowners.

3.8 Investigate and encourage sustainable development options for GCW habitat in Mexico and Central America. Various uses such as selective extraction of medicinal plants may be compatible with GCW habitat protection. Sustainable development should be encouraged with the voluntary cooperation of these countries.

4.0 Public education and information

4.1 Increase public awareness of the importance of the GCW and natural ecosystems. To accomplish this task, informative and exciting natural history programs should be developed for all age groups. Such programs should acquaint the audience with typical regional ecosystems. In particular, the audience should become acquainted with the basic appearance and natural history of the more common, more dramatic, and more sensitive local organisms, including the GCW.

4.2 Develop curriculum/media for childhood and adult natural history/endangered species education. Consult with science and natural history education specialists to determine the most effective formats for curriculum packages. Develop multi-age group curricula. Use existing photographic material, such as Adams and Adams (1976), to increase public familiarity with the natural history and plight of GCWs. Distribute curricula as appropriate to public and private schools, college-level programs, and public media outlets. This effort should be coordinated with other existing environmental education programs such as Project WILD.

4.3 Develop and disseminate informative brochures and pamphlets on GCW management and natural history. Information developed in Task 3.7 should be provided to landowners. Information may also be given in workshop format.

4.4 Develop and provide information and educational materials for Mexico and Central America. Information identified in Task 3.8 and others should be provided to the public, agencies, and organizations.

4.5 Develop demonstration ranches and public areas. Using the guidelines developed in Task 3.7, demonstration areas should be managed where landowners can observe recovery efforts. Candidates for such demonstration areas on public lands might be the Kerr Wildlife Management Area and the Balcones Canyonlands NWR. Some private lands may also serve as demonstration areas.

5.0 Regulatory

Habitat should be protected through available regulatory measures, with particular emphasis placed on areas likely to be within the focal areas. Large expanses of oak-juniper woodland judged suitable for GCWs should be protected. Section 9 of the Endangered Species Act specifically prohibits the take of an endangered species without a permit. Section 7 of the Act requires that Federal agencies consult with the Service on any action they authorize, fund, or carry out that may affect listed endangered or threatened species. Several other Federal, state, and local regulations (such as the Lacey Act, the Migratory Bird Treaty Act, Texas Parks and Wildlife regulations, and the City of Austin Endangered Species Survey Ordinance) have been implemented specifically for protecting endangered species.

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III. RECOVERY PLAN IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated costs for the recovery program. It is a guide for meeting the objective discussed in Part II of this Plan. This schedule indicates tasks, task priorities, the responsible agencies, and lastly, estimated costs. These actions, when accomplished, should bring about the recovery of the species and protect its habitat. It should be noted that the estimated monetary needs for all parties involved in recovery are identified for only a 3 year period and, therefore, Part III does not reflect the total estimated financial requirements for the recovery of this species.

Priorities in column one of the following implementation schedule are assigned using the following guidelines:

Priority 1 - An action that <u>must</u> be taken to prevent extinction or to prevent the species from declining irreversibly in the <u>foreseeable</u> future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objectives.

<u>Key to Acronyms used in Implementation Schedule</u>

- APRD - Austin Parks and Recreation Department
- BCCP - Balcones Canyonlands Conservation Plan
- DOD - Department of Defense
- FWS - U.S. Fish and Wildlife Service
  - ES - Ecological Services
  - IA - International Affairs
  - LE - Law Enforcement
  - Refuge - Refuges
  - PA - Public Affairs
  - Res - Research
  - MBMO - Migratory Bird Management Office
- Guat - Guatemala
- Hond - Honduras
- LCRA - Lower Colorado River Authority
- Mex - Mexico
- Nica - Nicaragua
- SCS - Soil Conservation Service
- TAEX - Texas Agricultural Extension Service

TFS - Texas Forest Service
TNC - The Nature Conservancy or the Texas Nature Conservancy
TPWD - Texas Parks and Wildlife Department
SA - City of San Antonio Parks Department

GOLDEN-CHEEKED WARBLER RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY: FWS REGION	RESPONSIBLE PARTY: FWS PROGRAM	RESPONSIBLE PARTY: OTHER	COST ESTIMATES ($000): YEAR 1	COST ESTIMATES ($000): YEAR 2	COST ESTIMATES ($000): YEAR 3	COMMENTS
1	1.11	Determine survivorship, dispersal, reproductive success, etc.	8	2 2 8	ES Refuge Res	TPWD DOD	30 10 1 10 20	30 10 1 10 20	30 10 1 10 20	This information is needed for task 1.12 and may also need to be collected later to determine if delisting criteria are met.
1	1.35	Study habitat requirements in Mexico and Central America.	3	2 9 9	ES IA MBMO	TNC Mex Guat Nica Hond	1 10 20 20 20 20	1 10 20 20 20 20	1 10 20 20 20 20	
1	1.36	Determine current distribution of habitat in breeding range.	2	2	ES	TPWD TNC	20 15 15	5 10 10		
1	1.37	Determine location of focal areas.	2	2	ES		5	5		In coordination with Recovery Team
1	1.310	Determine distribution of habitat on the winter range and migration corridor.	3	2 9 9	ES IA MBMO	TNC Mex Guat Hond Nica	2 15 1 15 10 10 10 10	2 15 1 5 5 5 5 5	2 15 1 5 5 5 5 5	
1	1.311	Determine optimum distribution of areas to be protected in the winter range and migration corridor.	2	2 9 9	ES IA MBMO	TNC Mex Guat Hond Nica			2 5 1 2 2 2 2 2	
1	2.11	Protect populations on public land.	ongoing	2 2	ES Refuges	TPWD DOD SA APRD LCRA	500 3 16 1 1 3	500 3 16 1 1 3	500 3 16 1 1 3	Cost estimates for refuges include land acquisition costs for BCNWR. Cost estimates for acquiring land for the BCCP are provided in the Black-capped Vireo Recovery Plan and are not duplicated here.

GOLDEN-CHEEKED WARBLER RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY FWS REGION	RESPONSIBLE PARTY FWS PROGRAM	RESPONSIBLE PARTY OTHER	COST ESTIMATES ($000) YEAR 1	COST ESTIMATES ($000) YEAR 2	COST ESTIMATES ($000) YEAR 3	COMMENTS
3	1.22	Study movements of GCWs.	2	2	ES		9	6		May be done in conjunction with task 1.11 or 1.23.
				2	Refuge		3	2		
						TPWD	3	2		
						DOD	3	2		
3	1.26	Study ecology of wintering and migrating GCWs.	3	2	ES		10	5	5	
				9	IA		10	5	5	
				9	MBMO		10	5	5	
						TNC	5			
						Mex	10	5	5	
						Hond	10	5	5	
						Guat	10	5	5	
						Nica	10	5	5	
3	1.43	Develop post-recovery monitoring.	2	2	ES					Develop prior to delisting
						TPWD				
3	4.1	Increase public awareness.	ongoing	2	ES		15	5	5	
				2	Refuge		25	20	15	
				2	PA		15	5	5	
						TPWD	10	5	5	
						SCS	5	5	5	
						DOD	5	5	5	
						TNC	5	5	5	
						TAEX	10	5	5	
						BCCP	5	5	5	
3	4.2	Develop curriculum/media on endangered species.	3	2	ES		30	15	5	
				2	Refuge		10	10	5	
						TPWD	15	5	5	

GOLDEN-CHEEKED WARBLER R[illegible]RY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY: FWS REGION	RESPONSIBLE PARTY: FWS PROGRAM	RESPONSIBLE PARTY: OTHER	COST ESTIMATES ($000): YEAR 1	YEAR 2	YEAR 3	COMMENTS
1	2.121	Locate landowners interested in voluntarily protecting GCW habitat.	5	2	ES		5	5	5	
						TPWD	5	5	5	
						SCS	5	5	5	
						TNC	5	5	5	
1	2.122	Encourage voluntary protection and improve incentives for voluntary protection of GCW habitat.	ongoing	2	ES		100	100	100	Cost estimates represent salaries or partial salaries of staff conducting technical assistance.
						TPWD	100	100	100	
						SCS	100	100	100	
						TNC	100	100	100	
						TAEX	50	50	50	
1	2.22	Make contacts, encourage and assist with ongoing conservation efforts in Mexico and Central America.	3	2	ES		5	5	5	
				9	IA		30	30	30	
				9	MBMO		1	1	1	
						TNC	5	5	5	
						Mex	5	5	5	
						Guat	5	5	5	
						Hond	5	5	5	
						Nica	5	5	5	
1	2.23	Identify and facilitate funding in Mexico and Central America.	ongoing	2	ES		2	2	2	
				9	IA		5	5	5	
				9	MBMO		1	1	1	
						TNC	5	5	5	
						Mex	2	2	2	
						Guat	2	2	2	
						Hond	2	2	2	
						Nica	2	2	2	
1	3.7	Development guidelines and provide assistance for landowners.	ongoing	2	ES		20	20	10	
				2	Refuge		5	5	1	
						TPWD	50	50	40	
						DOD	5	5	1	
						SCS	50	50	40	
						TAEX	50	50	40	
2	1.12	Determine population sizes and arangements necessary to attain and maintain viability.	2	2	ES				30	Collect data in 1.11 first.
				8	Res				2	
						TPWD			10	
2	1.21	Study foraging and prey species.	2	2	ES		15	15		
						TPWD	5	5		
						DOD	5	5		
2	1.23	Study distribution in relation to productivity.	3	2	ES		15	15	15	
				8	Res		1	1	1	
						TPWD	5	5	5	

GOLDEN-CHEEKED WARBLER RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY: FWS REGION	RESPONSIBLE PARTY: FWS PROGRAM	RESPONSIBLE PARTY: OTHER	COST ESTIMATES ($000) YEAR 1	COST ESTIMATES ($000) YEAR 2	COST ESTIMATES ($000) YEAR 3	COMMENTS
2	1.24	Study relationship of predators.	3	2 8	ES Res	 TPWD	9 1 3	9 1 3	9 1 3	
2	1.25	Determine rate of cowbird parasitism.	3	2	ES	 TPWD DOD	9 3 5	9 3 5	9 3 5	
2	1.31	Determine habitat requirements in breeding range.	5	2 2	ES Refuge	 TPWD DOD	5 3 2 2	5 3 2 2		Task should be done concurrently with Tasks 1.21-1.25.
2	1.32	Study patch size requirements and effects of disturbance.	3	2 8	ES Res	 TPWD LCRA	1 1 5 2	1 1 5 2	1 1 1 1	
2	1.33	Determine effects of land use practices.	3	2	ES	 TPWD DOD	12 4 5	12 4 5	12 4 5	
2	1.34	Study hardwood regeneration	2	2	ES	 TPWD TFS		5 1 9	5 1 9	
2	1.38	Determine buffer zones.	2	2	ES	 TPWD DOD	5 1 3	5 1 3		
2	1.39	Study effects of management options in Task 3.0.	3	2 2	ES Refuge	 TPWD DOD		9 10 3 5	9 10 3 5	
2	1.41	Monitor target populations.	ongoing	2 2	ES Refuge	 TPWD DOD	2 1 5 5	2 1 5 5	2	
2	1.42	Monitor the effects of management tasks.	ongoing	2 2 8	ES Refuge Res	 TPWD DOD	1 1 1 5 3	1 1 1 5 3	1 1 1 5 3	

GOLDEN-CHEEKED WARBLER RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY: FWS REGION	RESPONSIBLE PARTY: FWS PROGRAM	RESPONSIBLE PARTY: OTHER	COST ESTIMATES ($000): YEAR 1	COST ESTIMATES ($000): YEAR 2	COST ESTIMATES ($000): YEAR 3	COMMENTS
2	1.44	Monitor habitat in Mexico and Central America.	ongoing	2	ES			1	1	
				8	Res			5	5	
						Mex		5	5	
						Guat		5	5	
						Hond		5	5	
						Nica		5	5	
2	2.21	Identify currently protected areas within potential GCW winter & migratory habitat.	2	2	ES		1	1		
				9	IA		2	2		
				9	MBMO		1	1		
						TNC	2	2		
						Mex	2	2		
						Guat	2	2		
						Hond	2	2		
						Nica	2	2		
2	2.24	Investigate options to protect habitat.	ongoing	2	ES		1	1	1	
				9	IA		50	50	50	
				9	MBMO		1	1	1	
						TNC	50	50	50	
						Mex	100	100	100	
						Guat	100	100	100	
						Hond	100	100	100	
						Nica	100	100	100	
2	3.1	Enhance and maintain GCW habitat.	ongoing	2	ES		30	20	20	
				2	Refuge		20	20	20	
						TPWD	50	50	50	
						DOD	25	25	25	
						SCS	20	30	30	
2	3.2	Maintain hardwood regeneration.	ongoing	2	ES		5	2	1	
				2	Refuge		5	2	2	
						TPWD	10	5	5	
						DOD	5	2	2	
						TFS	10	5	5	
						SCS	10	5	5	
2	3.3	Promote regeneration of habitat.	ongoing	2	ES		15	10	5	
				2	Refuge		2	1	1	
						TPWD	15	10	5	
						SCS	10	5	2	
						DOD	2	1	1	
2	3.4	Develop management options for formation of GCW habitat.	ongoing	2	ES					
				2	Refuge		1	1	1	
						TPWD	5	5	3	
						SCS	2	2	1	
						DOD	1	1	1	

GOLDEN-CHEEKED WARBLE[illegible]COVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY: FWS REGION	RESPONSIBLE PARTY: FWS PROGRAM	RESPONSIBLE PARTY: OTHER	COST ESTIMATES ($000): YEAR 1	YEAR 2	YEAR 3	COMMENTS
2	3.5	Reduce cowbird parasitism and predation, if warranted.	ongoing	2	ES		5	3	2	
				2	Refuge		1	1	1	
						TPWD	10	5	3	
						SCS	5	5	3	
						DOD	5	2	1	
2	3.6	Minimize effect of urbanization & agriculture.	ongoing	2	ES		20	20	20	
				2	Refuge		1	1	1	
						TPWD	1	1	1	
						SCS	1	1	1	
						BCCP	5	5	5	
2	3.8	Investigate sustainable development options for GCW habitat in Mexico and Central America.	ongoing	2	ES		1	1	5	
				9	IA		5	5	5	
						TPWD	1	1	1	
						TNC	1	1	10	
						Mex	5	5	10	
						Hond	5	5	10	
						Guat	5	5	10	
						Nica	5	5	10	
2	4.3	Develop and disseminate brochures.	ongoing	2	ES		3	10	5	Two years to develop; Second year costs also reflect printing costs
						TPWD	5	10	5	
						SCS	5	5	5	
						TAEX	5	5	5	
2	4.4	Develop information materials for Mexico and Central America.	3	2	ES			1	1	
				9	IA			5	5	
						Mex		5	5	
						Hond		5	5	
						Guat		5	5	
						Nica		5	5	
2	4.5	Develop demonstration areas.	3	2	ES			2	2	
				2	Refuge		1	2	2	
						TPWD	3	5	5	
						TNC	1	2	2	
2	5.0	Regulatory	ongoing	2	ES		30	30	30	
				2	LE		30	30	30	
				2	Refuge		1	1	1	
3	1.13	Determine if gene flow is provided for.	3	2	ES				30	Collect data in 1.11 first.
				8	Res				10	
						TPWD			7	

IV. Appendix

INDIVIDUALS AND AGENCIES PROVIDING COMMENTS ON THE DRAFT GOLDEN-CHEEKED WARBLER RECOVERY PLAN

ANDERSON, ROLAND AND THELMA, private property owners

ARNOLD, KEITH A., Professor, Texas A&M University, Department of Wildlife and Fisheries Sciences

ARROYO, BRYAN, Wildlife Biologist, U.S. Fish and Wildlife Service

BALTHROPE, WILLIAM D., rancher

BARLOW, JON C., Curator, Department of Ornithology, Royal Ontario Museum

BERRY, JOHN M., landowner

BESSENT, CHRISTINE, member National Bluebird Society, participant Bird Atlas of Texas project

BRUNS, DUSTY, Land Manager, Camp Bullis Training Site, Department of the Army

BUSHONG, LUTHER C. AND LOIS, private landowners

CAVIN, E.D. AND CLAUDIA, Ph.D's

CLARKE, DON, Gulf Coast Research Group, Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service

CORNELIUS, JOHN, D.E.H., Fish and Wildlife Branch, HQ III, Corps of Engineers

CRENWELGE, DENNIS D., Ph.D., Managing Partner, Crenwelge Livestock Company

DAVIS, JONATHAN R., Attorney

DENISON, CHARLES A., rancher

DIERKS, WILLARD and ALICE, landowners and ranchers

GAFFORD, BILL, Concan Sales & Service

GIPSON, LILLIAN, private property owner

HAM, MARSHALL A., Acting Chief, Office of Migratory Bird Management, U.S. Fish and Wildlife Service

HAYDEN, TIM, Wildlife Biologist, U.S. Army CERL

HOLLE, DEBORAH, Refuge Manager, Balcones Canyonlands National Wildlife Refuge, U.S. Fish and Wildlife Service

HOOVER, BILLY, rural landowner

JOHNSON, R. ROY, Senior Ecologist, Johnson and Haight

KUHL, SHERRI, Environmental Protection, Lower Colorado River Authority

KYLE, WESLEY, private citizen

LADD, CLIFTON, Senior Staff Ecologist, Espey, Huston & Associates, Inc.

McCLURE, DONALD, rural landowner and rancher

McMULLAN, DEBBIE, rancher

McTEE, CHARLY, General Manager, Texas Wildlife Association

MICHELS, STEPHANIE, landowner

MILLS, G. SCOTT, SWCA Environmental Consultants

MINNICH, DON W., Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service

NAGEL, ARTHUR W., President, Riverside and Landowners Protection Coalition

NORRIS, DWAYNE, landowner and rancher

NORRIS, MALDON, landowner and rancher

O'DONNELL, LISA, Wildlife Biologist, U.S. Fish and Wildlife Service

ONETH, HARRY W., State Conservationist, Soil Conservation Service, U.S. Department of Agriculture

PERNER, GINGER and PAUL, rural landowners

POERNER, COL. HOMER W., Camp Buck Ranch, ranch owner and manager

ROGERS, FRIEDA R., landowner

RUST, SUSAN P., Consulting Ecologist, Stewardship Services

SCHEELE, GARY, private landowner

SEXTON, CHARLES, Environmental Specialist, City of Austin, Environmental and Conservation Services Department

STEVENS, CHRISTI, Earth First! Austin

TURNBO, ANN, rancher

TURNBO, HARDY, rancher

WARREN, HENRY J., President, San Saba County Property Owners Association

WITTS, DAVID A., attorney

WOMACK, JESS Y., private landowner

WOOD, WENDELL, property owner

THE FOLLOWING INDIVIDUALS' OR AGENCIES' COMMENTS WERE RECEIVED AFTER THE AUGUST 31, 1992 DEADLINE AND WERE CONSIDERED BUT ARE NOT FORMALLY ADDRESSED IN THIS APPENDIX

ARMSTRONG, BILL, Biologist, Kerr Wildlife Management Area, Texas Parks and Wildlife Department

BALLEW, HELEN, Project Director, Hill Country Foundation

BUREAU OF RECLAMATION, Department of the Interior

GRZYBOWSKI, JOSEPH A., Ph.D.

HOHMANN, MR. AND MRS. LEONARD, landowners

KROLL, JAMES C., Ph.D., Stephen F. Austin State University

LANCASTER, W.A., Director of Highway Design, Texas Department of Transportation

MARSHALL, BARBARA, landowner, Marshall Cattle Company

PEAVY, DAN C., D.D.S., landowner

STEED, DAVID L., Ph.D., DLS Associates

WILCOVE, DAVID, Ph.D., Senior Ecologist, Environmental Defense Fund

PRINCIPAL COMMENTS RECEIVED ON THE GOLDEN-CHEEKED WARBLER DRAFT RECOVERY PLAN

This recovery plan was available for technical/public review in July of 1992. The public comment period ended August 31, 1992. The Service distributed almost 300 copies of the draft plan, as well as notifying 144 county managers, agencies, and individuals by letter that the plan was available for public review and comment. Comments from 75 individuals or agencies were received by the August 31, 1992, deadline. All comments were considered when developing the final plan. The Service appreciates the time that each of the commenters took to review the draft and to submit their comments.

The comments discussed below represent a composite of those received. Comments of a similar nature are grouped together. Substantive comments that question approach, methodology, or financial needs called for in the draft plan, or suggest changes to the plan are discussed here. Comments received that relate to the original listing decision, general comments about the Endangered Species Act that did not relate to the golden-cheeked warbler, or comments regarding simple editorial changes, are not discussed here. Many favorable, supportive comments were also received but are not discussed below.

All comments received are retained as a part of the Administrative Record of recovery plan development in the Austin, Texas, Ecological Services office.

Comment: How many birds were there in 1973 and how many are there now?

Service Response: Historical and current population levels are discussed in the Introduction and Background (Population Size section) of the recovery plan.

Comment: The government plans to dictate to farmers and ranchers how they can use their land.

Service Response: The recovery strategy section of the plan stresses the need to work cooperatively and creatively with landowners to recover the species. The recovery tasks outline voluntary protection on the part of private landowners. In addition, the recovery plan is a planning document, it does not promulgate any rules or regulations.

Comment: The government is planning to eliminate goats, cows, etc.

Service Response: The recovery plan discusses the possible impact of goats, cows, and other hoofed species on recruitment of the hardwood component of golden-cheeked warbler habitat and on cowbird populations. In the recovery section, research on the impact of these species on recruitment and cowbird populations is proposed. The recovery plan does not propose to eliminate these animals.

Comment: Please provide the people of the involved counties practical information for preserving this species. The USFWS should work with landowners on this project.

Service Response: The recovery strategy calls for "enhanced public relations/public education". The Service agrees that informing landowners and managers is an important point and has added a task that specifically addresses the development and dissemination of informative brochures and workshops on management for golden-cheeked warblers. Tasks 2.121 and 2.122 refer to encouraging voluntary protection by private landowners. The Service would like to be contacted by landowners who are interested in protecting habitat, so that suggestions can be made and compatible uses can be discussed.

Comment: The Service should recognize that many landowners do preserve habitat for warblers and other wildlife.

Service Response: The Service recognizes this fact. However, it was inadvertently left out of the Conservation Measures section in the draft plan. A new paragraph was inserted in the final plan discussing this matter.

Comment: The reference to an "intensified enforcement effort" should be dropped.

Service Response: The wording of Task 5.0 Regulatory was changed.

Comment: Habitat must be preserved on public lands as well.

Service Response: This is part of the delisting criteria. The focal areas should use public lands to the maximum extent practicable. GCW populations on public land may count toward the viable, self-sustaining populations called for in the recovery criteria.

Comment: Whether this particular plan succeeds or not will eventually depend on the preservation of migration routes and wintering grounds.

Service Response: In designing the recovery tasks, the Service tried to treat the migration and wintering habitat, and the breeding habitat with equal importance. For every major type of task on the breeding ground, a similar or complementary task for the migration and wintering habitat was included. To strengthen this concern, the Service added tasks under monitoring, management, and public information and education to be carried out in Mexico and Central America. In addition, an effort will be made to coordinate with other ongoing conservation programs in Mexico and Central America and to facilitate funding, training, equipping, and communicating with Mexican and Central American biologists.

Comment: A male golden-cheeked warbler was reportedly observed by a qualified ornithologist in the mountains of Queretaro, Mexico in early January 1972. A more thorough examination of the wintering range is needed.

Service Response: This sighting is unknown to the drafter of the plan and to the Service. We are contacting the commenter for more information. Task 1.310 was augmented to include determining the current wintering and migrating distribution and examining other potential habitat areas.

Comment: Determining what kind of disturbance the golden-cheeked warbler can tolerate, particularly in regard to the edge vs. interior debate, is the most important point in establishing management policies for the GCW.

Service Response: The Service recognizes that this is an important point and tasks 1.23, 1.31, 1.32, 1.33, and 1.38 address this issue.

Comment: With territories averaging 2-4.2 ha/pair on tracts, extrapolations to state-wide estimates become highly suspect.

Service Response: The size of an average territory is not used to determine the range-wide population estimate. Instead, an estimate of density (usually pairs or males per 100 ha) is used, which is often derived from a transect line or point count. The reason density estimates are used is that territories are not usually contiguous or continuous and a certain amount of unoccupied habitat is included in the density estimate. Likewise, estimates of potentially suitable habitat for the golden-cheek include habitat that is not occupied.

Comment: We do not have information to justify brown-headed cowbird management.

Service Response: No other summary or study of the impact of brown-headed cowbird parasitism on golden-cheeked warblers has been done since Pulich's work. In his Kendall County study area, 28 nests were studied to conclusion. Of those, 19 nests were parasitized. Out of those 19 nests, 3 golden-cheeked warblers and nine cowbirds fledged. The 9 unparasitized nests produced 12 GCW fledglings. In a summary of all nests Pulich looked at both in his study and museum specimens (n=61), he found 39% were parasitized. Pulich (1976) also points out that the success rate of GCW nests (27%) is the lowest of all the other wood warblers he investigated. The above information suggests that GCWs are impacted by cowbirds. To what degree this affects the productivity of GCWs is not known. Recovery task 1.25 addresses this research need. Other recovery efforts, particularly management efforts, should incorporate consideration of the results of the cowbird research.

Comment: The recovery plan did not identify the focal areas.

Service Response: The Service does not believe that we have all the information necessary on which to base that decision. Therefore, gathering that information was made one of the recovery tasks.

Comments: The amounts of money and the agencies responsible mentioned in the implementation schedule probably will not or can not commit to these projects or amounts.

Service Response: The implementation schedule is a planning tool. It does not commit any agency or any agency's money to a task. It can be used to prioritize tasks, estimate costs, and serve as a basis for requesting endangered species appropriations. The tasks or ideas put forward in recovery plans are implemented as time and money is available.

Comment: Research focused on developing prescriptions for restoring a "natural landscape" reflective of some past time would seem to be the most efficient direction to take in addressing the needs of this bird and the rest of the biota dependent on the same ecosystem.

Service Response: Although species specific, several of the tasks in both the research and management sections may provide information applicable to restoring "natural landscapes". The Service is also interested in landscape-level biodiversity.

Comment: Are the tasks prioritized? Research on habitat needs and management are far more important than on single species biology.

Service Response: The tasks are prioritized as 1, 2, or 3 as defined in the introduction to the implementation schedule. Research on habitat and management are important, but some life history information is usually needed to determine what is recommended to protect or manage a species.

Comment: The recovery plan treats all counties within the range of the golden-cheeked warbler the same. Rapid urbanization does not apply to several of the counties within the range.

Service Response: Habitat loss due to urbanization and certain agricultural practices is the primary threat to the existence of the warbler. Urbanization along the Waco-Austin-San Antonio corridor is an immediate threat. However, Pulich (1976) and Wahl et al. (1990) documented the loss of habitat in rural settings also. For purposes of recovery, the threat from urbanization is often considered more serious than agricultural activities because habitat is permanently removed and is usually replaced by structures of some sort. Also the secondary impacts of noise, lighting, expanded infrastructure, urban predators, etc. in urban areas may have an additional negative impact on GCWs and their habitat. In agricultural areas, cleared habitat may be able to be restored and secondary impacts are usually not increased over what is already existing.

Comment: The plan proposes to encourage the growth of juniper.

Service Response: The plan proposes to encourage the protection and growth of GCW habitat which is an oak-juniper woodland in areas needed for recovery. The plan proposes to encourage the growth of juniper in limited areas that have the hardwood vegetation species composition and structure similar to what warblers use as a demonstration to see if warbler habitat can be restored and used by the species. The plan does not propose to encourage the growth of monoculture juniper or the conversion of open pastureland to GCW habitat.

Comment: Habitat preservation for GCWs should be demonstrated on public lands and ranches.

Service Response: A task that would develop public and private demonstration areas was added to the Public Information and Education Section of the recovery outline.

Comment: Notify only persons with potential habitat on their property -- not a massive distribution to unaffected people.

Service Response: Through the tasks listed under Public Information and Education, the Service proposes to develop and disseminate information on how to recognize golden-cheeked warbler habitat, what management activities a landowner can use to enhance and/or protect habitat, and what activities are compatible with GCWs. This information may be distributed through brochures, workshops and/or contacts with technical assistance programs of involved agencies. The primary audiences will be those that have potential habitat or opportunities to promote conservation of GCWs.

Comment: The plan should be based on a thorough knowledge of the biology of the species.

Service Response: Recovery plans outline what is needed to recover a species. Rarely do we know enough about a species during the initial development of a recovery plan to definitively state what strategies are needed to recover a species. It is not unusual for research to be the primary need for recovery in the early stages of conservation work, and its importance in devising effective management techniques should not be underestimated. Recovery planning is a continuous process, and plans are amended and revised as necessary to incorporate research results and include more site specific, management-oriented tasks as they are devised.

Comment: The recovery plan offers no guidance or priority for the management of the species.

Service Response: Development of management guidelines for the species were recommended in the Management Needs tasks of the draft Recovery Plan; however, in the final plan the Service has made this a separate task and put additional emphasis on management guidelines by also including dissemination of this information in the Public Information and Education tasks.

Comment: If the estimate of warblers is as the plan suggests, 13,800 territories, and if recovery is requiring only 7,500 breeding pairs, then it appears that thousands of warblers could be killed and we would still achieve recovery.

Service Response: The 13,800 territories is an estimate based on density estimates in certain specific localities and then extrapolated over the estimated habitat acreage projected by ground-truthed Landsat imagery. Territories may or may not be occupied by mated males, and mated males may or may not actually breed and produce young. Additionally, there are difficulties associated with making population estimates as discussed on page 17. After much consideration, the figure of 7,500 breeding pairs was dropped from the recovery criteria, as well as, the 15 populations. Instead the plan now uses at least one viable, self-sustaining population per eight regions in place of the above two former recovery criteria. The eight regions were delineated based on geology, vegetation, and watershed boundaries. This strategy preserves the current distribution of the species. The numbers and spatial arrangement of populations needed to assure viability of the populations and the ability of the populations to sustain themselves has yet to be determined and is a recovery task. In addition, warblers cannot be taken under the provisions of the Endangered Species Act as long as they are listed. Before the species is delisted the Service should have a more specific idea of the numbers needed to maintain the species for the long-term. In addition, the other delisting criteria should also be met to achieve recovery.

Comment: Pulich's 1962 estimate of 18,385 pairs of GCWs should be the minimum recovery goal.

Service Response: The recovery criteria have been changed. The number of warblers and other factors needed to provide self-sustaining, viable populations will be determined after completion of several tasks in the plan.

Comment: Not enough emphasis has been placed on bringing other branches of the federal government into compliance with the Endangered Species Act. The Army has been helpful in their efforts, but other agencies such as the Soil Conservation Service, the Army Corps of Engineers, and U.S. Dept. of Agriculture are likely agents of GCW habitat destruction.

Service Response: Federal agencies under Section 7 of the ESA must consult if their action "may affect" an endangered species. This is a legislated responsibility. Federal agencies are also responsible for utilizing "their authorities in furtherance of the purposes of [the] Act by carrying out programs for the conservation of endangered species...". Federal agencies are identified in the Implementation Schedule where they can assist with various research, management, and education tasks.

Comment: Some discrepancies or confusion exists in Table 3 and the discussion of Pulich's population estimates.

Service Response: We have added extra clarification on these two points in the final plan.

Comment: The goal of showing the 15 populations to be genetically interconnected is unlikely to occur.

Service Response: This was changed in the final plan. The plan now indicates that if populations are not viable without genetic interconnectedness then the "potential for gene flow" should be maintained. What is necessary to provide that potential will be determined through tasks in the Recovery Plan.

Comment: The birds have been around for 125 years, they should be smart enough to find other places to nest.

Service Response: Golden-cheeked warblers are habitat specialists and are found only in only about 31 counties in Texas. Studies have shown that most small songbirds inhabit all habitat that is suitable for their life requirements.

The elimination of one territory within that habitat results in the affected pair moving to another already occupied territory or to less suitable habitat where they fail to reproduce. If the displaced pair goes to already occupied habitat then they either out compete the pair in residence or fail to reproduce. If the pair in residence is moved out then they try to out compete a third pair or fail to reproduce. The net result is the loss of one pair. In other words there are limited places to nest successfully. Golden-cheeked warblers were first described from Texas in 1865. The species was first described by science in 1860 from a specimen taken in Guatemala in 1859. As described in the text of the plan the golden-cheeked warbler probably had its origin during the Wisconsin glacial period, about 20,000 years before the present.

Comment: A major part of this recovery plan should target monies and research to improve the overall range conditions and thereby improve the quality of GCW habitat. The SCS could and should handle this kind of program.

Service Response: The goal of recovery plans are to conserve particular species in their ecosystems. Resources for carrying out these plans are limited, and therefore a major part of the recovery plan is focussed on actions that will directly benefit the species. However, the Service believes that improving the overall range conditions of the Edwards Plateau is an admirable goal and would benefit many species; and while this covers a broader goal than the GCW recovery plan, implementation of this recovery plan may contribute to the broader goal. The Service would be glad to work through the SCS or any other entity to benefit species and ecosystems of concern and has identified the SCS as a responsible party in several tasks in the implementation schedule.

Comment: Is a single continuous expanse of habitat (read juniper) necessary?

Service Response: No. A continuous expanse of all juniper is not golden-cheeked warbler habitat. It must also have the other elements described in the Background section. A single, continuous expanse of habitat is not intended for recovery. Instead, what the recovery plan says is that the larger expanses of habitat should be given priority for protection efforts.

Comment: Captive breeding was not considered.

Service Response: Captive breeding has an important role in recovery of some endangered species, but we do not currently believe it is necessary or justified for the recovery of the golden-cheeked warbler. It was not considered because the habitat for the golden-cheeked warbler is still present. The species is not to the point where captive breeding is needed to augment the natural populations. Captive breeding is also an extremely costly endeavor. If in the future captive breeding does seem to be necessary then the Service will consider including it in the recovery efforts.

Comment: Prior to the implementation of the recovery plan there should be a social, economic, and environmental study made and approved through the public hearing process.

Service Response: Recovery plans are excluded from the National Environmental Policy Act (NEPA) process. However, implementation of tasks in a recovery plan is subject to the NEPA process. Public hearings may be held if an Environmental Impact Statement is required to implement various parts of this recovery plan.

Comment: Would a property owner lose the rights to use his property forever if they are granted a conservation easement?

Service Response: There are many different levels of protection and conditions associated with conservation easements. Each one is tailored to habitat protection needs and concerns of the landowner.

Comment: Would access to and the use of public lands and parks be denied in an effort to protect potential habitat?

Service Response: There are compatible uses associated with GCW habitat. Camping, hiking, bird watching, and fishing in established public areas are not likely to affect GCWs. However, there are some exceptions to this general statement, such as bird watchers repeatedly playing GCW song tapes to elicit GCW responses, which may adversely impact the birds.

Great Trinity Forest Management Plan

Threatened and Endangered Species

Interior Least Tern

(Sterna antillarum athalassos)

Interior Least Tern

Scientific Name: *Sterna antillarum athalassos*

Federal Status: Endangered, 6/27/85 • State Status: Endangered

Description

Least Terns are the smallest North American terns. Adults average 8 to 10 inches in length, with a 20 inch wingspan. Their narrow, pointed wings make them streamlined flyers. Males and females are similar in appearance. Breeding adults are gray above and white below, with a black cap, black nape and eye stripe, white forehead, yellow bill with a black or brown tip, and yellow to orange legs. Hatchlings are about the size of ping-pong balls and are yellow and buff with brown mottling. Fledglings (young birds that have left the nest) are grayish brown and buff colored, with white heads, dark bills and eye stripes, and stubby tails. Young terns acquire adult plumage after their first molt at about 1 year, but do not breed until they are 2 to 3 years old. The Least Tern's call has been described as a high pitched "kit," "zeep," or "zreep."

Interior Least Tern on nest
© Leroy Williamson

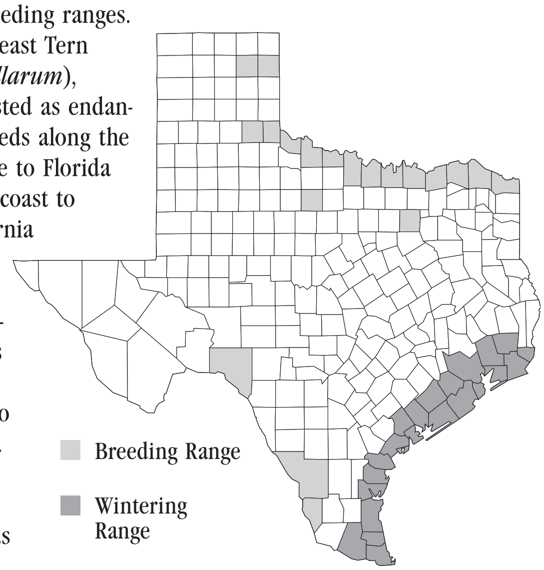
Least Tern and chick
© TPWD Glen Mills

Distribution and Habitat

There are three subspecies of the Least Tern recognized in the United States. The subspecies are identical in appearance and are segregated on the basis of separate breeding ranges. The Eastern or Coastal Least Tern (*Sterna antillarum antillarum*), which is not federally listed as endangered or threatened, breeds along the Atlantic coast from Maine to Florida and west along the Gulf coast to south Texas. The California Least Tern (*Sterna antillarum browni*), federally listed as endangered since 1970, breeds along the Pacific coast from central California to southern Baja California. The endangered Interior Least Tern (*Sterna antillarum athalassos*) breeds inland along the Missouri, Mississippi, Colorado, Arkansas, Red, and Rio Grande River systems. Although these subspecies are generally recognized, recent evidence indicates that terns hatched on the Texas coast sometimes breed inland. Some biologists speculate that the interchange between coastal and river populations is greater than once thought.

The Interior Least Tern is migratory, breeding along inland river systems in the United States and wintering along the Central American coast and the northern coast of South America from Venezuela to northeastern Brazil. Historically, the birds bred on sandbars on the Canadian, Red, and Rio Grande River systems in Texas, and on the Arkansas, Missouri, Mississippi, Ohio and Platte River systems in other states. The breeding range extended from Texas to Montana and from eastern Colorado and New Mexico to southern Indiana. It included the braided rivers of Oklahoma and southern Kansas, salt flats of northwest Oklahoma, and alkali flats near the Pecos River in southeast New Mexico.

Today, the Interior Least Tern continues to breed in most of the major river systems, but its distribution is generally restricted to the less altered and more natural or little disturbed river segments. In Texas, Interior Least Terns are found at three



reservoirs along the Rio Grande River, on the Canadian River in the northern Panhandle, on the Prairie Dog Town Fork of the Red River in the eastern Panhandle, and along the Red River (Texas/Oklahoma boundary) into Arkansas.

Nesting habitat of the Interior Least Tern includes bare or sparsely vegetated sand, shell, and gravel beaches, sandbars, islands, and salt flats associated with rivers and reservoirs. The birds prefer open habitat, and tend to avoid thick vegetation and narrow beaches. Sand and gravel bars within a wide unobstructed river channel, or open flats along shorelines of lakes and reservoirs, provide favorable nesting habitat. Nesting locations are often at the higher elevations away from the water's edge, since nesting usually starts when river levels are high and relatively small amounts of sand are exposed. The size of nesting areas depends on water levels and the extent of associated sandbars and beaches. Highly adapted to nesting in disturbed sites, terns may move colony sites annually, depending on landscape disturbance and vegetation growth at established colonies.

For feeding, Interior Least Terns need shallow water with an abundance of small fish. Shallow water areas of lakes, ponds, and rivers located close to nesting areas are preferred.

As natural nesting sites have become scarce, the birds have used sand and gravel pits, ash disposal areas of power plants, reservoir shorelines, and other manmade sites.

Life History

Interior Least Terns arrive at breeding areas from early April to early June, and spend 3 to 5 months on the breeding grounds. Upon arrival, adult terns usually spend 2 to 3 weeks in noisy courtship. This includes finding a mate, selecting a nest site, and strengthening the pair bond. Courtship often includes the "fish flight," an aerial display involving aerobatics and pursuit, ending in a fish transfer on the ground between two displaying birds. Courtship behaviors also include nest preparation and a variety of postures and vocalizations.

Least Terns nest in colonies, where nests can be as close as 10 feet but are often 30 feet or more apart. The nest is a shallow depression in an open, sandy area, gravelly patch, or exposed flat. Small twigs, pieces of wood, small stones or other debris usually occur near the nest.

Egg-laying begins in late May, with the female laying 2 to 3 eggs over a period of 3 to 5 days. The eggs are pale to olive buff and speckled or streaked with dark purplish-brown, chocolate, or blue-gray markings. Both parents incubate the eggs, with incubation lasting about 20 to 22 days. The chicks hatch within one day of each other and remain in the nest for about a week. As they mature, they begin to wander from the nest, seeking shade and shelter in clumped vegetation and debris. Chicks are capable of flight within 3 weeks, but the parents continue to feed them until fall migration. Least Terns will renest until late July if clutches or broods are lost.

Activities of the Interior Least Tern during the breeding season are limited to the portion of river near the nesting site. Nesting adults defend an area surrounding the nest (territory) against intruders, and terns within a colony will defend any nest within that colony. When defending a territory, the incubating bird will fly up giving an alarm call, and then dive repeatedly at the intruder.

The breeding season is usually complete by late August. Prior to migration, the terns gather at staging areas with high fish concentrations. They gather to rest and eat prior to the long flight to southern wintering grounds. Low, wet sand or gravel bars at the mouths of tributary streams and floodplain wetlands are important staging areas. Interior Least Terns often return to the same breeding site, or one nearby, year after year.

Nesting success of terns at a particular location varies greatly from year to year. Because water levels fluctuate and nesting habitats such as sandbars and shorelines change over time, the terns are susceptible to habitat loss and frequent nest and chick loss.

The Interior Least Tern is primarily a fish-eater, feeding in shallow waters of rivers, streams, and lakes. The birds are opportunistic and tend to select any small fish within a certain size range. Feeding behavior involves hovering and diving for small fish and aquatic crustaceans, and occasionally skimming the water surface for insects.

In portions of the range, shorebirds such as the Piping and Snowy plovers often nest in close proximity. The Piping Plover is listed as Threatened by the U.S. Fish and Wildlife Service.

Threats and Reasons for Decline

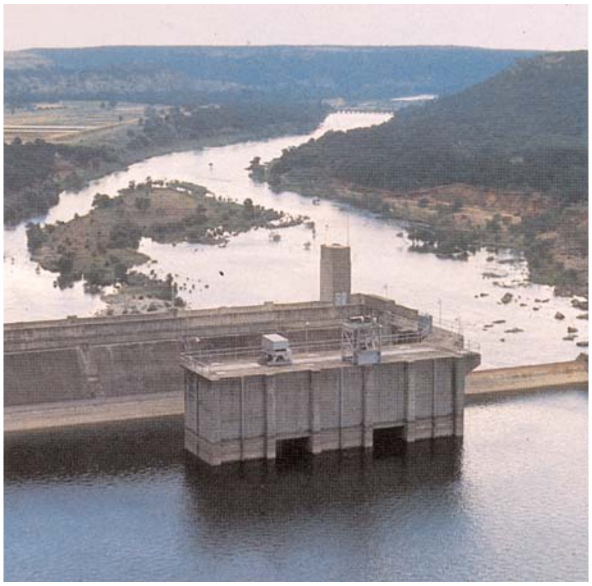
Channelization, irrigation, and the construction of reservoirs and pools have contributed to the elimination of much of the tern's natural nesting habitat in the major river systems of the Midwest. Discharges from dams built along these river systems pose additional problems for the birds nesting in the remaining habitat. Before rivers were altered, summer flow patterns were more predictable. The nesting habits of the Least Tern evolved to coincide with natural declines in river flows. Today, flow regimes in many rivers differ greatly from historic regimes. High flow periods may now extend into the normal nesting period, thereby reducing the availability of quality nest sites and forcing terns to nest in less than optimum locations. Extreme fluctuations can inundate potential nesting areas, flood existing nests, and dry out feeding areas.

Historical flood regimes scoured areas of vegetation, providing additional nesting habitat. However, diversion of river flows into reservoirs has resulted in encroachment of vegetation and reduced channel width along many rivers, thereby reducing sandbar habitat. Reservoirs also trap much of the sediment load, limiting formation of suitable sandbar habitat.

In Texas and elsewhere, rivers are often the focus of recreational

Least Tern chicks
© TPWD Glen Mills

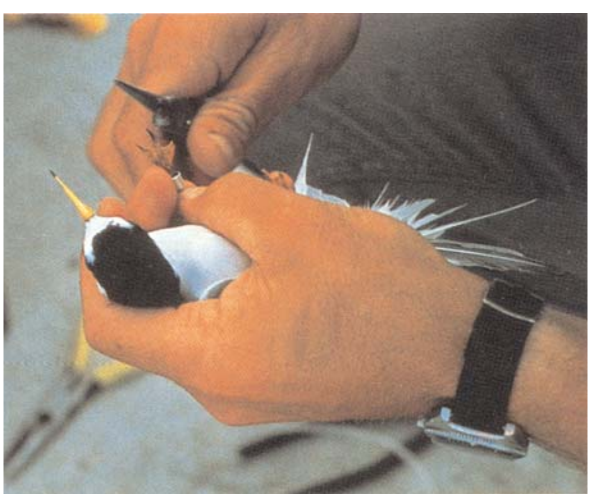
Nesting area and foraging site on the Canadian River
© Bruce C. Thompson



Dam on the Brazos River
© TPWD

activities. For inland residents, sandbars are the recreational counterpart of coastal beaches. Activities such as fishing, camping, and ATV use on and near sandbar habitat are potential threats to nesting terns. Even sand and gravel pits, reservoirs, and other artificial nesting sites receive a high level of human use. Studies have shown that human presence reduces reproductive success, and human disturbance remains a threat throughout the bird's range.

Water pollution from pesticides and irrigation runoff is another potential threat. Pollutants entering rivers upstream and within breeding areas can adversely affect water quality and fish populations in tern feeding areas. Least Terns are known to accumulate contaminants that can affect reproduction and chick survival. Mercury, selenium, DDT derivatives, and PCBs have been found in Least Terns throughout their range at levels warranting concern, although reproductive difficulties have not been observed.



Banding Least Terns
© Bruce C. Thompson

Finally, too little water in some river channels may be a common problem that reduces the birds' food supply and increases access to nesting areas by humans and predatory mammals. Potential predators include coyotes, gray foxes, raccoons, domestic dogs and cats, raptors, American Crows, Great Egrets, and Great Blue Herons.

Recovery Efforts

State, federal, and private organizations throughout the United States are collaborating to census the birds, conduct research, curtail human disturbance, and provide habitat. Continued monitoring of confirmed and potential colony sites is underway to assess population status and reproductive success. Protective measures, including signs and fences, are being implemented to restrict access to sites most threatened by human disturbance. Vegetation control at occupied sites, chick shelter enhancement, predator control, pollution abatement, and habitat creation/restoration at unoccupied sites are management strategies used to benefit Interior Least Tern populations.

Biologists continue to assess habitat availability and quality throughout the bird's range in Texas, and identify essential habitat for management and protection. Recently, in a cooperative effort between the Texas Parks and Wildlife Department, National Park Service, International Boundary and Water Commission, Comision Internacional de Limites y Aguas, Oficina de Ecologia Estado de Coahuila, and City of Del Rio, warning signs in both Spanish and English were erected to inform visitors about the effects of human disturbance on the terns. Also, the National Park Service recently initiated annual status surveys for Interior Least Terns at Amistad NRA. Finally, public information campaigns concerning Least Tern conservation are a vital part of the recovery process.

Where To See Interior Least Terns

Falcon State Park near Falcon Heights in Zapata County (956) 848-5327, Amistad National Recreation Area near Del Rio in Val Verde County (830) 775-7491, and Gene Howe Wildlife Management Area near Canadian in Hemphill County (806) 323-8642 offer visitors the opportunity to see and learn more about the Interior Least Tern. Often, the best opportunity to see the birds is by boat. Please remember that human disturbance during the nesting season reduces reproductive success and threatens survival. The terns should be viewed from a distance with binoculars or spotting scope.

How You Can Help

Interior Least Terns and other colonial nesting shore and water birds (plovers, herons, egrets, spoonbills, ibis, gulls, and skimmers) often nest on sandbars and islands. These areas offer protection from predators, but the birds are still vulnerable to human disturbance. Since the hot sun can quickly kill small chicks and unhatched eggs if the adults are flushed from the nest, you can help by staying off sandbars and islands and away from flats and shorelines where birds are nesting. Also, when adults are flushed from the nest, the eggs or young are more vulnerable to predation. Nesting areas maintained as bird sanctuaries are identified by official signs. If you want to observe the birds, bring binoculars and stay a safe distance away so you don't disturb the birds. Pets and livestock should also be kept off these areas while the terns are nesting. Remember that state and federal laws protect migratory and endangered birds, and harassing them at any time is illegal.

You can be involved in the conservation of Texas' nongame wildlife resources by supporting the Special Nongame and Endangered Species Conservation Fund. Special nongame stamps and decals are available at Texas Parks and Wildlife Department (TPWD) Field Offices, most State Parks, and the License Branch of TPWD headquarters in Austin. Conservation Passports, available from Texas Parks and Wildlife, are valid for one year and allow unlimited access to most State Parks, State Natural Areas, and Wildlife Management Areas. Some of the proceeds from the sale of these items are used to protect habitat and to provide public information concerning endangered species conservation. Conservation organizations in Texas welcome your participation and support.

For More Information Contact

Texas Parks and Wildlife Department
Wildlife Diversity Branch
4200 Smith School Road
Austin, Texas 78744
(512) 912-7011 or (800) 792-1112
or
U.S. Fish and Wildlife Service
Ecological Services Field Office
10711 Burnet Road, Suite 200
Austin, Texas 78758
(512) 490-0057

Bilingual "Do not Disturb" sign

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Designing an Island Habitat for the Interior Least Tern

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Designing an Island Habitat for the Interior Least Tern

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M. R. Crawford (December, 2003)
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S. E. Schneider (May, 2003)

Submission date: May 15, 2003

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Date	Date	Date

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Date	Date

ABSTRACT

The purpose of this project was to develop a design that will create an island environment for the nesting habitation of the Interior Least Tern, an endangered species. The U.S. Army Corps of Engineers (USACE) and the bird's habitat and nesting requirements set forth the following design criteria for the team:

- Island surface area about 0.8 to 1.2 ha (2 to 3 acres)
- Concentrated in the center of the channel
- Island should have gently sloping, sandy beaches
- Less than 10% vegetation
- Withstand high flows

Diverting and manipulating flow by implementing a structure or structures to promote sediment deposition within the center of the Arkansas River near Jenks, Oklahoma was investigated. Both physical and computer modeling were used to explore the development of these hydraulic structures. Each experimental method has its own strengths and weaknesses and the utilization of more than one method provided verification of the overall feasibility of the designs. Based on the data and results gathered during the testing phase, a rectangular riprap structure followed by a chevron riprap structure open to the flow was selected as the final design. Recommendations for implementing the structure along with a cost analysis for the materials and labor required to construct the structure are reported herein. Because of the large expense involved in the implementation of the design structure, it is strongly recommended that a small prototype be built and tested in or near the straight reach of the Arkansas River adjacent to 121st Street south of Jenks, Oklahoma. This will allow for final design verification without affording the total expense of the project.

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Dr. Paul Weckler—design team advisor
Wayne Kiner—stream trailer physical model testing
Darrel Temple, Sherry Britton, and Kem Kadavy—physical scale model testing
Dr. Bill Barfield—computer model testing
Dr. Glenn Brown—design calculations

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INTRODUCTION

The purpose of this project was to develop a design that will create an island environment for the nesting and habitation of the Interior Least Tern. The creation of this island is expected to facilitate the recovery of this endangered species. The 2002-2003 Oklahoma State University Biosystems Engineering Senior Design Team was selected by the U.S. Army Corps of Engineers (USACE) Tulsa District to analyze and propose a solution to the problem.

The Interior Least Tern was listed as an endangered species in 1985, with a total population estimated at 5000. Channelization, irrigation, and construction of reservoirs and pools have drastically depleted the nesting habitats used by the Least Terns. The U.S. Army Corp of Engineers has done various studies on the habitation and breeding styles of the least tern species in the Arkansas River area in order to devise a plan to stabilize the species in that area.

Analysis into the possibility of implementing a structure or structures in the river to divert and manipulate flow to promote sediment deposition within the center of the channel was conducted by the team. The analysis was accomplished through several testing methods to determine a possible design structure that creates an island habitat for the birds. The structures that best served in the manipulation of the river mechanics for island creation are discussed in detail herein.

STATEMENT OF PROBLEM

A solution to problem must conform to a variety of specifications determined both by the habitation preferences of the Least Tern and by the U.S. Army Corps of Engineers. These criterion include location, flow conditions, island design specifications, and cost limitations.

Location

The island habitat should adhere to the following location criterion. The location boundaries are the Arkansas River natural channel from Keystone Dam to Muskogee, Oklahoma. An ideal location is one that is not be too close to the dam, where excess scouring can occur, and not too far downstream, where excess sediment can deposit.

Flow Conditions

The design of the island habitat should be such that the listed conditions should occur at the following flow rates:

- The average flow conditions to maintain proper scour around the island and prevent land bridging are 710 m^3/s (25,000 cfs).

- The minimum flow conditions to maintain proper scour around the island and prevent land bridging are 57 m^3/s (2,000 cfs).
- The maximum flow conditions to scour vegetation from the top of the island are 1130 m^3/s (40,000 cfs). Investigation of the feasibility of scouring the island will be done to determine if it will be a reasonable maintenance procedure, or if it will degrade the remaining structure of the island beyond reasonable expectations.
- The island design should be able to withstand a flood event of 1700 m^3/s (60,000 cfs).

Island Design Considerations

The design of the island habitat should conform to the following criteria. The surface area of the island should be 0.8 to1.2 ha (2 to 3 acres) and should be concentrated in the center of the channel. The island should have gently sloping sandy beaches, less than ten percent vegetation, and should withstand high flow conditions.

Cost Limitations

No specified cost limitation was provided by the USACE as a guideline for the project. However, the proposed solution should fall within reasonable limits, resulting in a feasible and practical design for implementation.

BACKGROUND INFORMATION ON LEAST TERNS

As previously mentioned, the least tern is currently on the endangered species list. An intensive literature review was conducted to determine the specific characteristics of the terns in order to gain knowledge to successfully recover the species.

Habitat Requirements

The Interior Least Tern is migratory and breeds primarily on sandbars, sandbar islands, and lake and reservoir shorelines in lower and mid-American rivers and lakes. The breeding season in these areas ranges from arrival in late May through the end of August (Sidle, 1990). They usually nest on elevated areas away from the edge of the water. Least terns prefer habitations with very little or no vegetation; however, pieces of driftwood are often utilized for protection shelter on islands where it is available. The birds are colonial, and they often return to a particular site for consecutive breeding seasons (Keenlyne, 1986). Numbers of nests in a specific area vary from year to year and month to month due to river level fluctuations causing variations in island widths and heights. Least terns feed on forage fish of two to eight centimeters in length and may rely on distance from food sources for determining a suitable nesting habitat (Keenlyne, 1986).

Changes in Habitat Conditions

Use of artificial habitats such as sand and gravel pits and dredged islands has increased due to the reduction of islands caused by constructing dikes and other systems in many rivers (Sidle, 1990). Because of the nature of the tern's habitat requirements, careful consideration must be used in selecting an island design that will be environmentally stable over a long period of time, and it must also be a habitat that the birds will consistently use each season.

PREVIOUS ISLAND DESIGN CONSIDERATIONS

A literature review was conducted on the previous attempts for preserving island habitats to explore possible options to implement a successful design. The first investigation into literature consisted of searching for past ideas that would support a cost effective, long-term preservation of the design structure resulting in an island. However, this research proved that this type of preservation had not been previously performed. Previous attempts primarily consisted of labor intensive and expensive methods of preserving the habitats.

Missouri River Project

Several projects have been proposed and implemented in the Missouri River between the Niobrara River and Ponca, Nebraska by the Army Corp of Engineers Omaha Division. The 1993-1995 Plan for Habitat Improvement for the Interior Least Tern and Piping Plover was finalized in May 1993, and it consisted of a ten-year plan, in which suggested activities would be researched and implemented to improve breeding of these species.

Many of the projects analyzed by the Omaha Division involved the repair of previously used habitats. Twenty sites, ranging from 0.01 to 20 ha (1.3 to 49 acres), were selected to develop for habitats. These sites were chosen based on final elevations of 0.3 to 0.6 m (1 to 2 ftt) above the water surface elevation during high range flows of 1090 m^3/s (38,500 cfs) (Meuleners, 1994). The vegetation was mechanically leveled and the islands were capped with 0.6 m (2 ft) of sand. Shoreline Erosion Arrestor bags were used on the upstream and channel sides of the islands to prevent erosion. Biological as well as socioeconomic repercussions were evaluated for the habitation rehabilitations. Various alternatives were considered for different aspects of the project. Alternatives for mechanically controlling vegetation were chemical clearing, hand clearing, burning, and flow manipulations. Instead of bulldozing the islands for recapping, the expensive alternative of dredge capping was considered (Meuleners, 1994).

Additionally, the implementation of floating islands and bulldozing low-elevation islands were also considered (Meuleners, 1994). The success of floating islands for least tern habitation was not known at the time the document was written. These islands had been installed in two test areas before the 1993 breeding season, but the birds did not use them during that first season of their existence (Meuleners, 1994). No information was found listing the success or failure of the prescribed projects.

Arkansas, Canadian, and Red Rivers Study

The U.S. Army Corp of Engineers Tulsa District conducted a study in July 2002 resulting in the Management Guideline and Strategies for Interior Least Terns. Long-term strategies of the document were to develop and maintain islands with suitable nesting habitat by implementing various methods and to evaluate and monitor the project impacts (USACE-TD, 2002). In addition, short-term strategies were developed to initiate steps for achieving the long-term goals and to provide immediate relief to the birds. These strategies include releases of floodwater to scour islands for vegetation removal, dredging of current islands to replenish sand deposits, and providing appropriate water releases from reservoir dams when possible to ensure optimal nesting conditions for the terns (USACE-TD, 2002). Season pool plans will be executed for Keystone to allow for minimum flow requirements during the late part of the nesting season (USACE-TD, 2002). Plans have also been devised for water conservation and water operations regarding water supply, water quality, and hydropower.

Zink Island Habitat

Zink Island is a manmade island on the Arkansas River near the 21st Street bridge in Tulsa, Oklahoma. A photograph of the island showing least tern activity is shown in Figure 1.

Figure 1: Zink Island in 1995

The Tulsa Audubon Society has done an annual study for the last decade to determine patterns in fledged young and nests on the island. The survey extends from the middle of May through the middle of July, the majority of the breeding season for the species. The results show a dramatic decrease in the number of fledged young per nest from 1.44 in 1992 to 0.35 in 2002 (Harwood, 2002). The dramatic decrease in breeding rates is largely due to excessive vegetation growth on the island that discourages the birds from nesting and breeding at this location, yet the presence of Canadian geese and occasional flooding were also noted as possible threats that caused a decrease in the number of fledged young found. It is unknown whether or not the island would see increased use if the vegetation were greatly reduced.

ANALYSIS OF NESTING HABITAT CONDITIONS

The Tulsa Division provided the design group with an airboat inspection of the Arkansas River ranging from Jenks, Oklahoma to several miles past the bridge at Bixby, Oklahoma. The tour consisted of visiting different habitations frequently used by the least terns during the 2002 breeding season. Various reasons for frequent use included sparse vegetation, gently sloping banks, surface areas consisting of at least 0.4 ha (1 acre), and locations separated from adjacent river banks such as islands. Two of the well-used islands are shown in Figure 2.

Figure 2: Some Examples of Good Islands Used for Least Tern Habitation

The tour also consisted of observing several habitations that were not used by the terns for breeding. Various reasons for lack of use included land bridging of the island, heavy vegetation, steep banks, and human recreation. Some examples are shown in Figure 3.

(a) (b)

Figure 3: Some Examples of Islands Not Used by Least Terns for Habitation Due to (a) Heavy Vegetation and (b) Human Recreation

ORIGINATION OF DESIGN CONCEPT

A jetty is a rock structure that extends almost perpendicularly from the bank into the river to divert flow and prevent erosion (Fischenich, 2003). These structures are generally used within straight stretches of river and are efficient due to the relatively small amount of material needed for their construction.

Riprap is used extensively in the stabilization of riverbanks. Additionally, it provides protection from scour for a variety of hydraulic structures. The average diameter of the rock used in these applications is dependent on the characteristics of the river it is being used in or the hydraulic structure it is protecting. Use of a mixture of rock with a determined average diameter is recommended to provide proper settlement of the structure and less opportunity for structure movement caused by water flow. The riprap structure allows for flow manipulation to decrease erosion of the banks (Frizell, 2003).

These concepts could be used for designing a structure to build and maintain an island. The single jetty structure symmetrically doubled would provide a chevron shape to manipulate the flow of the river and cause deposition in the middle of the river for island formation.

METHODS OF DESIGN ANALYSIS

The design strategy followed in this project utilized a system of checks and balances in determining the overall feasibility of design considerations. Several methods of simulation were used to verify the validity of the design. The initial studies were conducted using a stream trailer to simulate the flows and particle movement in the river. A physical scale model consisting of a concrete flume provided more accurate results with the use of similitude modeling. The final design concept developed by the physical modeling analysis was further verified using two-dimensional computer modeling analysis.

Stream Trailer Design Method

After careful investigation of previous design attempts in other environmental conditions and of basic hydrodynamic prototypes used for various projects, several basic design considerations were selected and tested. A rudimentary examination of the possible design concepts was performed using a stream trailer to simulate river flow. The stream trailer was available for use from the Oklahoma State University Biosystems and Agricultural Engineering Department.

Description of Stream Trailer Design Method

The first set of tests involved the basic setup of the stream trailer without any alterations. Finely crushed buttons in the stream trailer represented sand particles. These buttons were molded into a riverbed with a normal slope symmetric on both sides. Gravel was set up in various arrangements in the center for flow manipulation, and two test flows, 3.2 x 10^{-4} and 1.6 x 10^{-4} m^3/s (2.5 and 5 gpm), were used to approximately simulate typical river conditions. Particulate was introduced into the initial flow to critique and analyze the formation of islands.

It was determined that the flow should originate from the center of the streambed rather than at the sides for more accurate design analysis. PVC pipe was used to extend the original flow outlet to the middle of the bed. Also a thin tarp was placed over the riverbed particulate to keep the sides of the channel and the riverbed stable throughout the experiment. The main design considerations and their respective setups are outlined in the following sections.

Results of Stream Trailer Design Method

A variety of designs were tested using this method with varying success. The designs that provided the most promising results are detailed below.

Preliminary Design 1. The first design consideration consisted of two inverted V's placed in the center of the river channel. The shaping and spacing of the gravel caused sediment to fall out behind the gravel, forming an island in the center of the river channel. The channel upstream of the structure was straight, so the flow would evenly hit the tip of the first riprap frontally. The shape of the gravel was a triangular structure with a wide base that gradually becomes narrow towards the top. A picture of design simulation produced in the stream trailer is shown in Figure 4. Figure 4 illustrates the deposition of material that occurred in the center of the channel with scour on either side.

Figure 4: Stream Trailer Simulation of Preliminary Design 1

Preliminary Design 2. The second design consideration consisted of two inverted V's placed in the center of the river channel. The gravel was shaped in the same triangular structure as preliminary design 1. Both sides of the riverbed were reinforced with triangular shaped gravel structures with the points toward the inside of the river channel to concentrate all flow to the center of the river. A picture of design simulation produced in the stream trailer is shown in Figure 5.

Figure 5: Stream Trailer Simulation of Preliminary Design 2

Preliminary Design 3. The third design consideration was similar to preliminary design 1 in that it consisted of two inverted V's placed in the center of the river channel. The second structure had the point of the V facing in the downstream direction. Deposition of material occurred in the center of the channel with scour on either side.

Preliminary Design 4. The fourth design consideration is similar to Design 2 except the point of the second structure is facing downstream, resembling Design 3.

Discussion of Stream Trailer Design Method Results

The methods used for stream trailer testing were not accurate enough for design verification. Because the dimensions of the models were not scaled correctly to portray the prototype dimensions. Therefore the results of this testing procedure were used only to determine possible designs that could be further tested using other methods.

Both preliminary designs 1 and 3 appeared to be reasonable based on the location of the deposition and scour. These designs yielded the most promising results and were used as the basis for the designs tested using physical scale modeling.

Physical Scale Model Design Method

The stream trailer analysis provided initial design concepts that could be considered as possible solutions for the project. However, it was necessary to develop a testing method that would render a more exact analysis of the design considerations. The USDA-Agricultural Research Service (ARS) Hydraulic Engineering Research Unit located adjacent to Lake Carl Blackwell in Stillwater, Oklahoma houses a variety of hydraulic testing resources available for the research purposes of this project. A setup for physical scale modeling of the Arkansas River was provided at this facility.

Description of Physical Model Design Method

The apparatus and the theory used in this method are described in the following section. The calibration and modeling parameters that were determined during initial testing are described in detail as well.

Concrete Flume. A concrete flume with dimensions of 29 m (96 ft) long by 1.8 m (6 ft) wide by 2.4 m (8 ft) tall was utilized in this procedure. The flume consisted of a 21 m (70 ft) straight reach of usable testing area. The north side of the flume allowed the experiments to be viewed from above, while the south side of the flume allowed the model to be viewed just below eye level. Two windows located in the south wall of the flume permitted a better view of the model and easy access to the model. Tracks were in place on the top of the flume walls for a gondola structure that was used to set up structures in the flume and analyze results without disturbance of the bed material. A maximum flow rate of 0.08 m^3/s (3 cfs) through a 0.1 m (4 in) orifice plate was available for the flume. Flow rates for testing could be adjusted using the pressure differential of a manometer and a calibration table relating pressure to flow for the orifice plate. Concrete sand with an average diameter of 0.6 mm (0.024 in) was utilized as the bed material.

Regime Theory of Modeling. The Lacey regime theory is a method of dimensional similitude used for self-formed channels. It states that width is directly proportional to the square root of the flow rate, and depth is directly proportional to the cubed root of the flow rate (Henderson, 1966). These conditions result in scaling equations of

$$X_r = Q_r^{1/2}$$

and

$$Y_r = Q_r^{1/3}$$

for the horizontal and vertical components, respectively. These yield scaling factors of 165 for X_r and 40 for Y_r. The width and flow rate for the model, which are shown in Table 1, were calculated based on this theory. The theory also assumes that the bed material of the model is the same dimension as the bed material of the prototype (Henderson, 1966). To match the ideal island height of 8.5 feet, a model height of approximately 2.55 inches was targeted for each design.

Table 1: Flow rates and depths for the prototype and the model

Prototype		Model	
Flow Rate, Q (m^3/s)	Depth (m)	Flow Rate, Q (m^3/s)	Depth (m)
1700	3.7	6.2×10^{-2}	0.09
1130	3.0	4.2×10^{-2}	0.08
710	2.4	2.6×10^{-2}	0.06

Calibration of the Flume. The sand was leveled in the flume bed using a screed attached to the gondola. This was repeated for each testing procedure to ensure that the same conditions existed in each analysis. The flume was properly calibrated at each of the flow rates before actual testing was started to ensure accuracy of the model. This was done through bed and water surface profile analyses, which are shown in Figure A-1 of Appendix A.

Determination of Modeling Parameters. Initial studies were done to determine the parameters of the physical model. It was found that two designs could be tested at a time without interference with each other. The structures needed to be left overnight or for approximately 15 hours to allow sediment deposition and scour to occur. Several materials were tested for use as the structure material and gravel ranging from 0.03 to 0.1 m (1 to 4 in) in diameter was determined to be the most suitable material for use in the flume. The designs were constructed, and initial flow rates relating to 40,000 cubic feet per second were continuously run through the flume to simulate river flow for island development. It was later determined that flow rates relating to 1700 m^3/s (60,000 cfs) would provide better simulation due to the size of the bed material.

Progression of Design Ideas. The design structures tested in the flume began with the most feasible designs determined in the stream trailer testing. The angles, heights, and spacing of the basic two chevron designs were adjusted to determine the impact of each characteristic. The orientation of the chevrons in the channel and the number of structures in each design were also adjusted to determine their respective impacts on island development and scour positioning. Finally the shape and slope of the design structures were adjusted to determine the impact on island formation.

Confetti Analysis. In order to observe how the design structures affected the velocities of the flow approaching and leaving the structures, confetti was introduced into the flume for several of the designs. The confetti was distributed across the flume upstream of the structures. Pictures were taken at approximately three second intervals to analyze the movement of water over the structures. This allowed for a rough estimation of how the surface velocities changed with the structures.

Results of Physical Model Design Method

A variety of structures incorporating different design concepts were testing using the model. All of the designs tested are outlined in the following sections and the specific details of each design are listed in Appendix A.

Designs 1a – 7b. The first sixteen designs utilize structures in the shape of chevrons combined in different numbers, orientations, and spacings. Although these designs provide varying island lengths and scour positions, they are listed together because they all produce results that left a shallow pool or gap in the center of the deposited formation. This can be seen in Figure 6, which shows the results of design 2a.

Figure 6: Physical Modeling Simulation of Design 2a

Design 8a. This design used a variation on the preceding attempts. Two chevrons were used in this design and were spaced 1.2 m (4 ft) apart. The first chevron was a straight horizontal line with a width of 0.3 m (1 ft). The second chevron was in a ‘V’ shape with an angle of 90 degrees and a width of 0.8 m (32.5 in). Both had heights of 0.06 m (2.5 in), with the middle of the second chevron slightly lower to increase sediment movement across it. The resulting island dimensions were a length of 3.7 m (12 ft), a width of 0.254 m (10 in), and a height of 0.05 m (2 in) from the water surface. Scouring occurred at the front and sides of the design at a depth of 0.1 m (5 in) from the water surface with a width of 0.18 m (7 in). The design after testing is shown in Figure 7.

Figure 7: Physical Modeling Simulation of Design 8a

Design 9a. This design is similar to design 8a, with the spacing changed from 1.2 m (4 ft) to 0.9 m (3 ft) between the chevrons. The resulting island dimensions were a length of 3.4 m (11 ft), a width of 0.18 m (7 in), and a height of 0.05 m (2 in) from the water surface. Scouring occurred at the front and sides of the design at a depth of 0.15 m (6 in) from the water surface and a width of 0.2 m (8 in). The design after testing is shown in Figure 8.

Figure 8: Physical Modeling Simulation of Design 9a

Design 9b. This design was similar to design 8a with the width of the first chevron extended to 0.6 m (2 ft). The resulting island dimensions were a length of 3.7 m (12 ft), a width of 0.4 m (17 in), and a height of 0.08 m (3 in) from the water surface. Scouring occurred at the front and sides of the design at a depth of 0.14 m (5.5 in) from the water surface with a width of 0.15 m (6 in). The design after testing is shown in Figure 9.

Figure 9: Physical Modeling Simulation of Design 9b

Results of Confetti Analysis

The result of a confetti analysis performed on one of the design structures is shown in Figure 10. A definite separation of the confetti was exhibited on most of the analyses. This shows a large decrease in velocity over the structures that will likely result in sediment deposition in the actual river.

Figure 10: Confetti Surface Velocity Test after 3 Seconds

Discussion of Physical Model Design Results

The greatest limitation of the model is its inability to accurately display the proper amount of sediment deposition. The average particle size of the sand used in the model is larger than the average particle size found in the Arkansas River. The model is unable to move the sediment to heights that would accurately portray island height development. Therefore the physical modeling results can be used to determine only the placement of sediment and the position of scour that would occur, not the height of deposition.

Designs 1a-7b consistently contained large gaps in the middle of the deposition area, which does not lead to an effective solution to the problem because it would be possible that the least terns would not utilize this type of island. Therefore, these designs should not be considered as possibilities for a suitable final design. Design 8a, 9a, and 9b all utilized variations of a similar design. Design 9a yielded the best results because it produced a wider island than design 8a and, although the island created by design 9b was considerably wider, the island from 8a was much more consistent in its deposition area. The two-dimensional and three-dimensional surface graphs for design 9a are shown in Figures A-2, A-3, A-4, and A-5 of Appendix A. The design schematics for the final flume design, design 9a, are shown in Figures B-1 and B-2 of Appendix B.

Computer Model Design Method

A two-dimensional computer modeling program was used to further analyze the validity of the best design determined using physical scale modeling. The model was developed at the National Center for Computational Hydroscience and Engineering at the University of Mississippi. The model software is still in its Beta version and has not yet been introduced onto the market due to final system changes that are being implemented.

Description of Computer Model Design Method

The two dimensional depth-averaged mass and momentum governing equations used in the program are

$$\frac{\partial h}{\partial t} + \frac{\partial hu}{\partial x} + \frac{\partial hv}{\partial y} = 0$$

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + g\frac{\partial \eta}{\partial x} = \frac{1}{\rho h}\frac{\partial h\tau_{xx}}{\partial x} + \frac{1}{\rho h}\frac{\partial h\tau_{xy}}{\partial x} - \frac{\tau_{bx}}{\rho h} + f_{cor}v$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + g\frac{\partial \eta}{\partial y} = \frac{1}{\rho h}\frac{\partial h\tau_{yx}}{\partial x} + \frac{1}{\rho h}\frac{\partial h\tau_{yy}}{\partial x} - \frac{\tau_{by}}{\rho h} + f_{cor}u$$

where h is depth of flow, *u* and υ are longitudinal and transverse velocity components, x and y are spatial coordinates in the longitudinal and transverse directions, t is time, g is the acceleration of gravity, η is water surface elevation, ρ is water density, τ_{xx} and τ_{yy} are normal turbulent stresses in the longitudinal and transverse directions, τ_{xy} and τyx are shear stresses, τ_{bx} and τ_{by} are bed shear stresses in the longitudinal and transverse directions, and f_{corr} is a Coriolis parameter (Khan, 2001). The bed shear analyses were performed using

$$\tau_{xx} = 2\rho v_t \frac{\partial u}{\partial x}$$

$$\tau_{xy} = \tau_{yx} = \rho v_t \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right)$$

$$\tau_{yy} = 2\rho v_t \frac{\partial v}{\partial y}$$

$$v_t = 0.17 \kappa u_* h$$

where v_t is turbulent eddy viscosity. The model uses a numerical scheme to solve the momentum equations using a quadrilateral mesh system (Khan, 2001).

Results of Computer Model Design Method

The velocity and shear analyses resulting from the computer modeling are shown in Figures C-1, C-2, and C-3 of Appendix C. The scaled velocity analysis of the Arkansas River is shown in Figure C-4 of Appendix C. The sediment analyses of the flume and river were not performed during modeling due to complications in the program.

Discussion of Computer Model Design Results

The computer modeling reinforced the conclusions drawn in physical scale modeling regarding the validity of design 9a. Low or no velocity occurred over the central region between and following the structures where sediment deposition is expected to occur. Relatively high shear occurred evenly on the sides of the structure indicating a continual flow through this area that will decrease the possibility of land bridging.

ASSESSMENT OF TESTING RESULTS

Three design methods were utilized in determining a feasible solution to the problem. Each design method has its own strengths as well as weaknesses and the utilization of more than one method provided verification of the overall feasibility of the designs. The discussion of the different designs shows that varying success was obtained from the solutions. The designs that appeared to be suitable in the stream trailer proved to be ineffective when tested in the more precise physical model. This led to the development of a design variation that proved to be quite effective; utilizing a straight riprap structure followed by a chevron structure. This design provided the proper scour conditions and deposition in the required areas of the river channel. Further verification of the position of scour and velocity using the computer model was also obtained.

In order to determine if the velocities over the top of the island are high enough to scour vegetation from the island, velocity was calculated and compared to permissible velocities for grassed waterways (USDA-SCS, 1954). The empirical calculations of the expected velocities through the use of Manning's equation show that the velocities will be sufficient to scour the island of sparse vegetation during flows of 1130 m^3/s (40,000 cfs). However, if dense clumps of vegetation occur on the island, flows of 1700 m^3/s (60,000 cfs) will be necessary for complete removal of vegetation.

RECOMMENDATION

The following is a recommendation of the design solution that should be implemented to solve the least tern habitation problems. The location of the island, the description of design structure, the implementation of design structure, and a cost analysis have been developed so that the USACE may determine the feasibility of utilizing the design structures in the Arkansas River or other rivers to aid in recovery of the Least Tern habitat and species population.

Location of Island

The proposed location of the island structure is in Tulsa County within the section of the river adjacent to 121st Street south of Jenks, Oklahoma, as shown in Figure 11. This location is ideal for several reasons. It is centered in a straight section of river channel, which will cause the flow to evenly distribute itself on either side of the structure upon initial impact. A large tributary, Polecat Creek, feeds into the river upstream of the location providing a source of food for the birds. Additionally, the City of Tulsa is considering financial assistance with the construction of an environmental refuge for the least tern species in this area.

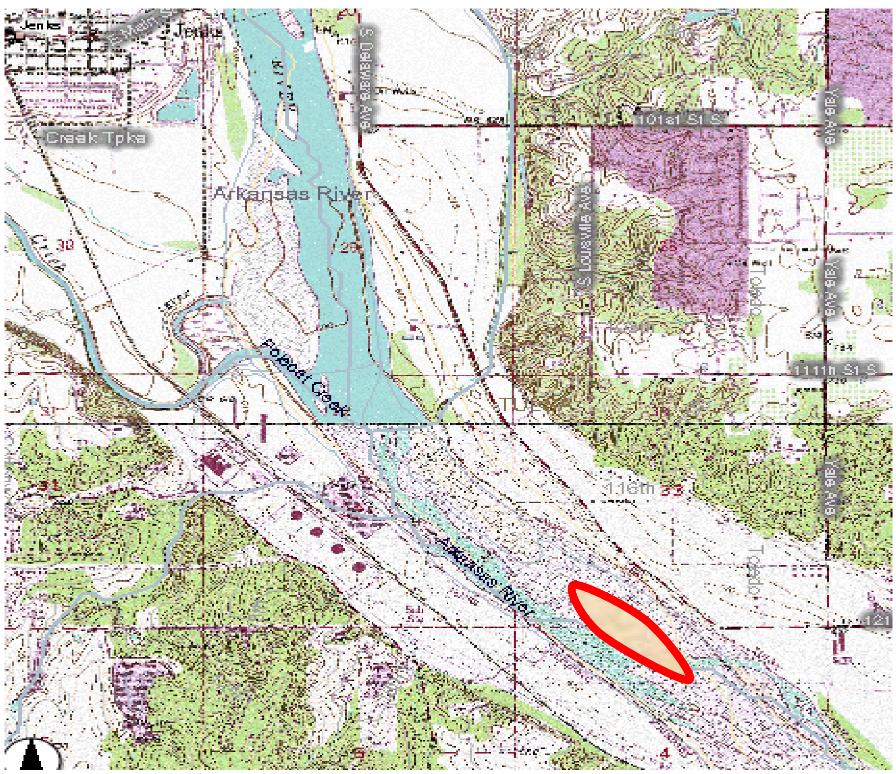

Figure 11: Proposed Location of Island

Descriptions of Design Structure

The final design schematic is shown in Figures D-1 and D-2 of Appendix D. The schematic is the scaled up prototype version of the final design with the addition of 1.5 m (5 ft) of tow below the front of each piece of the structure to prevent undercutting and degradation of the structure. Riprap diameter of 0.76 m (2.5 ft) is recommended for the structure. This was calculated based on the Colorado State University (CSU) procedure (Haan, 1994). The equations used in this procedure are

$$\eta = \frac{21\tau_{\max}}{\gamma(SG-1)D_{50}}$$

$$\eta' = \eta\frac{1+\sin(\lambda+\beta)}{2}$$

$$SF = \frac{\cos\alpha\tan\phi}{\eta'\tan\phi+\sin\alpha\cos\beta}$$

where η is stability factor, η’ is channel wall stability factor, τ_{max} is maximum shear on the channel bank, γ is specific weight, λ is the stream line angle, α represents the sideslope angle, and ϕ is the angle of the repose (Haan, 1994). Since the CSU equations are typically used to calculate riprap for bank stabilization, the λ angle was tripled to account for riprap placed in the middle of the river channel. The safety factor (SF) was determined to be 1.3 for our design structures. Stabilization of the banks on either side of the structure is also recommended based on the increased velocities expected on either side of the structure shown in the velocity profiles from the computer modeling.

Implementation of Design

The structure should be implemented during low flow conditions of the late summer months. Construction in August or September would provide minimal interference with nesting of the least terns due to the small overlap with the typical nesting season. It would also provide easier access to the river for construction due to the lower flows typical of the later season, and would allow for a longer period to establish the initial island. It was not possible to estimate sediment deposition time using the testing procedures, but full deposition can be expected to occur before the habitation period of the following nesting season. Allowing a full year for the island to develop would make it feasible for Keystone Dam to release a series flows greater than or equal to the necessary 1130 m^3/s (40,000 cfs).

Cost Analysis

An approximation of $50 per cubic yard was used to determine the cost of design material and construction (Bass, 2003). This results in a total cost of $270,000. Because of the large expense involved in implementation of the design structure, it is strongly recommended that a small prototype be built and tested in or near the proposed location. This will allow for final design verification without affording the total expense of the project. Setting a limit of $10,000 for the cost of materials and construction, the dimensions of a riprap structure would be 13 m (43 ft) wide by 3 m (10 ft) long by 0.9 m (3 ft) high for the front structure and 17 m (56 ft) wide by 3 m (10 ft) long by 0.9 m (3 ft) high for the rear structure. In order to reduce installation time and the use of heavy machinery, Quikrete® was proposed as the design structure material of a small prototype. The use of Quikrete® and a limit of $10,000 would allow for a structure with dimensions of 9.3 m (30.5 ft) wide by 2.1 m (7 ft) long by 0.76 m (2.5 ft) high for the front structure and 12 m (40 ft) wide by 2.1 m (7 ft) long by 0.76 m (2.5 ft) high for the rear structure. The small prototype would be best served if it were installed on an existing low-level island. This would allow the design structures to be verified and for the existing island to be stabilized.

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APPENDIX A: FLUME TESTING RESULTS

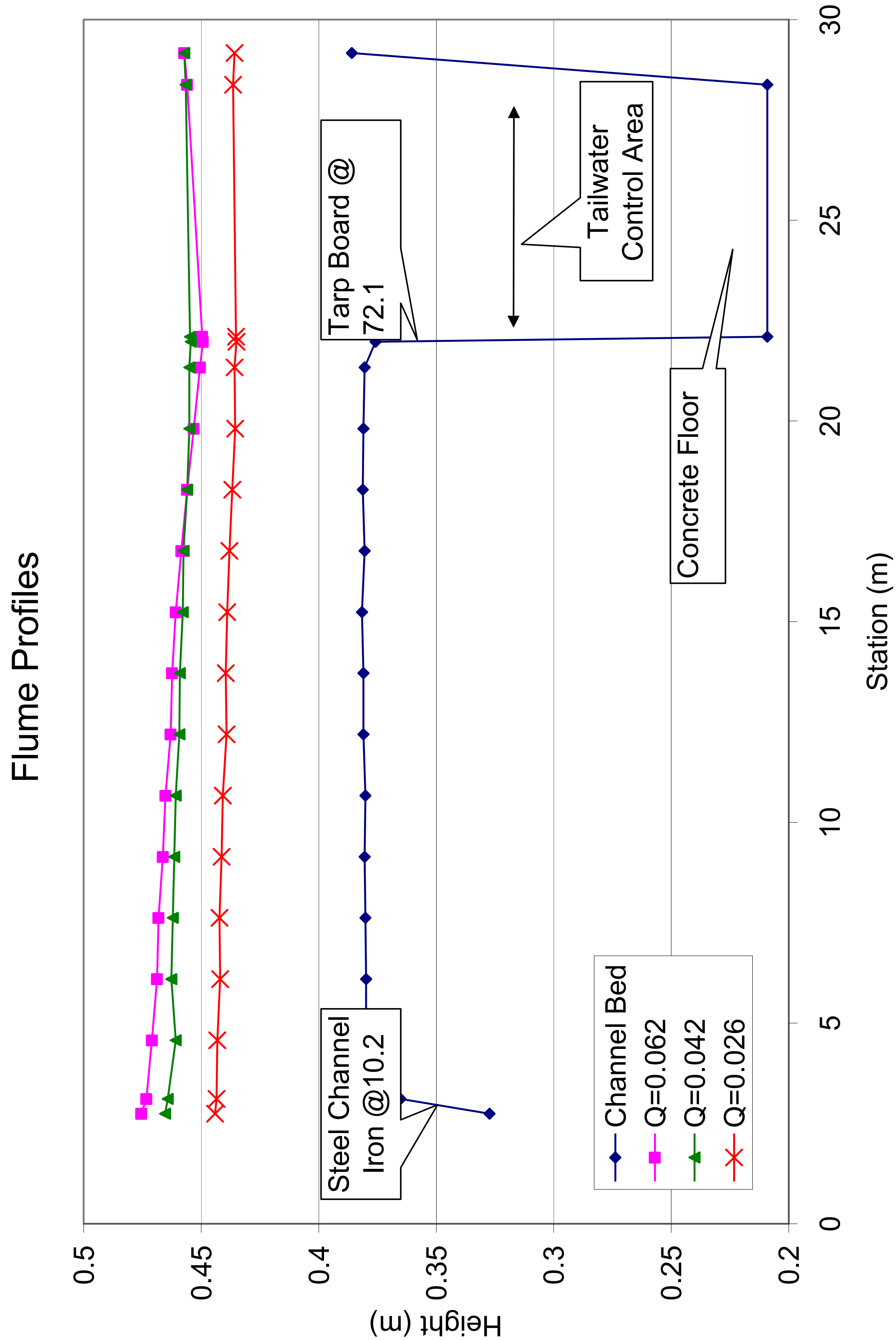


Figure A-1: Flume Water and bed Surface Profiles

ARS Hydraulic Engineering Research Lab Physical Model Testing

Date 3/10/03

Trial # 1b
Flow (cfs) 1.47
Start Time
Stop Time

Location of Front Chevron in Flume (ft) 48

Number of Chevrons 2

Height of Chevron (in)

1	3
2	3
3	
4	
5	
6	

Angle of Chevron (degrees)

Need Protractor

1	22" bw
2	32.5" bw
3	
4	
5	
6	

Width of Chevron (in)

1	22
2	32.5
3	
4	
5	
6	

Length of Chevrons
1.) 2 ft
2.) 2 ft

Spacing of Chevrons (in)

1 to 2	30
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

Date 3/11/03

Velocities (fps)

Over the top	
Left side	
Right side	

Island Dimensions

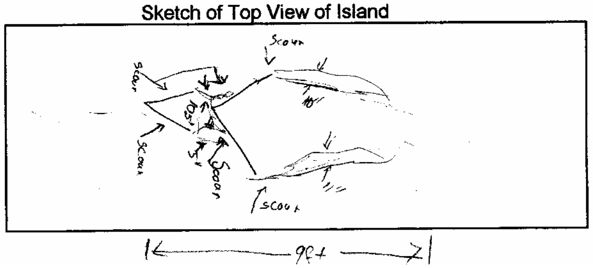
Width (in)	10.5", 5", 10", 11"
Length (in)	~ 9 ft
Height (in)	1" from H2O surface

Island Scour

Location	front both chevrons
	Back of last chevron
Depth (in)	4.5" side back 5" front chevrons
Width (in)	7" side back

Sketch of Top View of Island

NOTE: Label dimensions and scour locations on sketch of island.



Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Date 3/10/03

Trial # 1a
Flow (cfs) 1.47
Start Time 5:00 pm
Stop Time 9:00 am

Location of Front Chevron in Flume (ft) 61

Number of Chevrons 2

Height of Chevron (in)

1	3"
2	3"
3	
4	
5	
6	

Angle of Chevron (degrees)

Need Protractor

1	32.5" back width
2	22" back width
3	
4	
5	
6	

Width of Chevron (in)

1	32.5"
2	22"
3	
4	
5	
6	

Length of Chevron
1. 2 ft
2. 2 ft

Spacing of Chevrons (in)

1 to 2	30
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

Date 3/11/03

Velocities (fps)

Over the top	
Left side	
Right side	

Island Dimensions

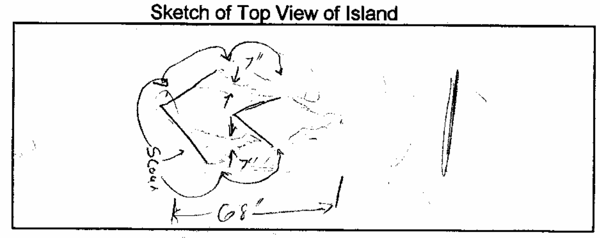
Width (in)	7"
Length (in)	68"
Height (in)	1.5" from H2O surface

Island Scour

Location	along sides, some in front of 1st chevron
Depth (in)	4.5" on sides 3.75" in front of chevron
Width (in)	12" on to the wall, 2" in front

Sketch of Top View of Island

NOTE: Label dimensions and scour locations on sketch of island.



Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Date 3/10/03

Trial #	1d	Start Time	
Flow (cfs)	1.47	Stop Time	

Location of Front Chevron in Flume (ft) 21

Number of Chevrons 2

Height of Chevron (in)		Angle of Chevron (degrees)	
1	3	1	22" bw
2	3	2	22" bw
3		3	
4		4	
5		5	
6		6	

Length of Chevrons
1.) 2ft
2.) 2ft

Width of Chevron (in)		Spacing of Chevrons (in)	
1	22	1 to 2	30
2	22	2 to 3	
3		3 to 4	
4		4 to 5	
5		5 to 6	
6			

Results

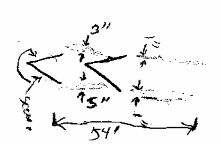
Date 3/11/03

Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	3", 5", 1"
Length (in)	54"
Height (in)	3" below water surface

Island Scour	
Location	Front of 1st chevron
Depth (in)	.5
Width (in)	2

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Date 3/10/03

Trial #	1c	Start Time	
Flow (cfs)	1.47	Stop Time	

Location of Front Chevron in Flume (ft) 35

Number of Chevrons 2

Height of Chevron (in)		Angle of Chevron (degrees)	
1	3	1	32.5" bw
2	3	2	32.5" bw
3		3	
4		4	
5		5	
6		6	

Length of Chevron
1.) 2ft
2.) 2ft

Width of Chevron (in)		Spacing of Chevrons (in)	
1	32.5	1 to 2	30
2	32.5	2 to 3	
3		3 to 4	
4		4 to 5	
5		5 to 6	
6			

Results

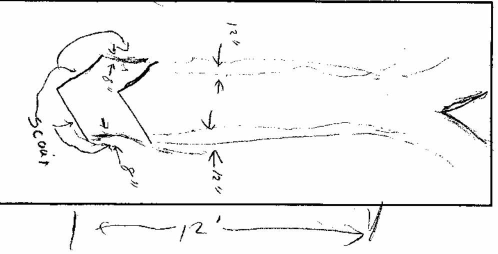
Date 3/11/03

Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	8" front 12" Back
Length (in)	12' = 144"
Height (in)	2.5" from the surface

Island Scour	
Location	sides, front of 1st chevron
Depth (in)	4.5" on sides 3" front (from water surface)
Width (in)	17" on both sides 3" front

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Date 3/12/03

Trial #	2b	Start Time	5:00pm
Flow (cfs)	1.47	Stop Time	9:00am

Location of Front Chevron in Flume (ft): 48

Number of Chevrons: 2

Height of Chevron (in)		Angle of Chevron (degrees)	
1	3	1	~60°
2	2.25	2	90°
3		3	
4		4	
5		5	
6		6	

Width of Chevron (in)		Spacing of Chevrons (in)	
1	22	1 to 2	30
2	32.5	2 to 3	
3		3 to 4	
4		4 to 5	
5		5 to 6	
6			

Results

Date 3/13/03

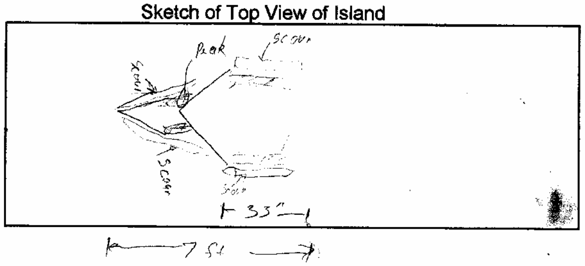
Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	4"
Length (in)	7 ft
Height (in)	.5" from surface

Island Scour	
Location	front, sides
Depth (in)	3" front 3.5" sides
Width (in)	4" front 2" sides

Sketch of Top View of Island

NOTE: Label dimensions and scour locations on sketch of island.



Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Date 3/12/03

Trial #	2a	Start Time	3:00
Flow (cfs)	1.47	Stop Time	

Location of Front Chevron in Flume (ft): 24

Number of Chevrons: 2

Height of Chevron (in)		Angle of Chevron (degrees)	
1	3	1	90°
2	2.4	2	~60°
3		3	
4		4	
5		5	
6		6	

Width of Chevron (in)		Spacing of Chevrons (in)	
1	32.5	1 to 2	30
2	22	2 to 3	
3		3 to 4	
4		4 to 5	
5		5 to 6	
6			

Results

Date 3/13/03

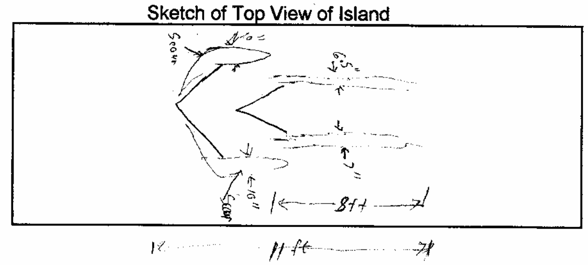
Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	6.5" 7"
Length (in)	8ft
Height (in)	1.5" from H_2O surface

Island Scour	
Location	Front of 1st & along sides
Depth (in)	5", 5.5" sides 4.5" front
Width (in)	10" side 7" front

Sketch of Top View of Island

NOTE: Label dimensions and scour locations on sketch of island.



Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Date 3/13/03

Trial #	2b
Flow (cfs)	2.17
Start Time	4:30
Stop Time	
Location of Front Chevron in Flume (ft)	48
Number of Chevrons	2

Chevron	Height of Chevron (in)	Width of Chevron (in)	Angle of Chevron (degrees)
1	2.25	22	~60
2	2.25	32.5	90
3			
4			
5			
6			

Spacing of Chevrons (in)	
1 to 2	30
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

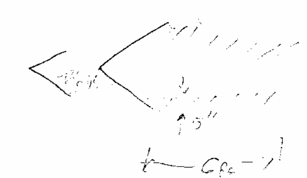
3/14/03

Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	3"
Length (in)	9ft, 6ft
Height (in)	[illegible]

Island Scour	
Location	front Sides
Depth (in)	
Width (in)	

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Date 3/13/03

Trial #	3a
Flow (cfs)	2.17
Start Time	4:30 pm
Stop Time	8:30 am
Location of Front Chevron in Flume (ft)	24
Number of Chevrons	2

Chevron	Height of Chevron (in)	Width of Chevron (in)	Angle of Chevron (degrees)
1	2.4	22	~60
2	2.4	32.5	90
3			
4			
5			
6			

stop lowdown

Spacing of Chevrons (in)	
1 to 2	30
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

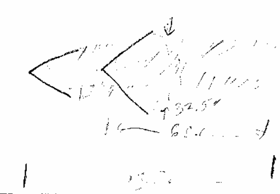
3/14/03

Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	32.5"
Length (in)	9ft, 6ft
Height (in)	2.3 [illegible]

Island Scour	
Location	Front & sides
Depth (in)	
Width (in)	

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

date 3/14/03

Trial #	4b
Flow (cfs)	1.47
Start Time	6:30pm
Stop Time	10:00pm

Location of Front Chevron in Flume (ft): 48

Number of Chevrons: 3

Chevron	Height of Chevron (in)	Width of Chevron (in)	Angle of Chevron (degrees)
1	2.25	12	
2	2.25	12	
3	2.25	32.5	~90
4			
5			
6			

Spacing of Chevrons (in)

1 to 2	30
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

Velocities (fps)

Over the top	
Left side	
Right side	

date 3/15/03

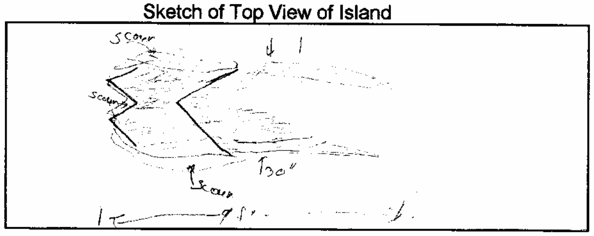
Island Dimensions

Width (in)	30"
Length (in)	9 ft
Height (in)	1.5" from H_2O surface

Island Scour

Location	front of 1st
	sides of both
Depth (in)	3.5" from surface
Width (in)	5" from surface

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

date 3/14/03

Trial #	4a
Flow (cfs)	1.47
Start Time	6:30pm
Stop Time	

Location of Front Chevron in Flume (ft): 29

Number of Chevrons: 2

Chevron	Height of Chevron (in)	Width of Chevron (in)	Angle of Chevron (degrees)
1	2.4	22 sloping down	~60
2	2.9	32.5	90
3			
4			
5			
6			

Spacing of Chevrons (in)

1 to 2	30
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

Velocities (fps)

Over the top	
Left side	
Right side	

Date 3/15/03

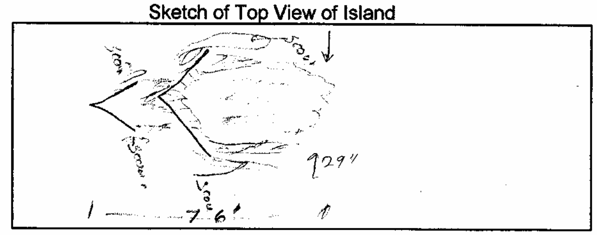
Island Dimensions

Width (in)	29" back
Length (in)	78"
Height (in)	2 from surface

Island Scour

Location	Sides
	Some front of second chevron
Depth (in)	4" sides
Width (in)	7" sides

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

3/17/03

Trial #	5b
Flow (cfs)	7 turns back wide open
Start Time	1:00 pm
Stop Time	10:00 am
Location of Front Chevron in Flume (ft)	48
Number of Chevrons	4

#	Height of Chevron (in)	Angle of Chevron (degrees)	Width of Chevron (in)
1	2.25	60	22
2	2.25	60	22
3	2.25	60	31.5
4	2.25	270	31.5
5			
6			

Spacing of Chevrons (in)	
1 to 2	0
2 to 3	30"
3 to 4	6ft
4 to 5	
5 to 6	

Results

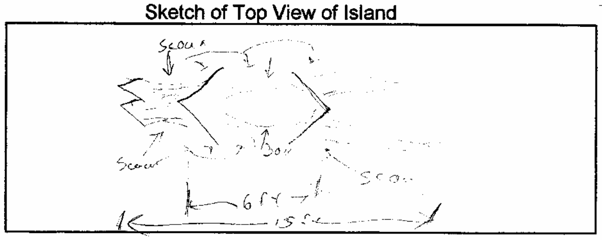
Velocities (fps)	
Over the top	
Left side	
Right side	

3/18/03

Island Dimensions	
Width (in)	30"
Length (in)	15 ft
Height (in)	1.5" from surface

Island Scour	
Location	Sides
Depth (in)	5.5" all
Width (in)	5"

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

3/17/03

Trial #	5a
Flow (cfs)	7 turns back from wide open
Start Time	1:00 pm
Stop Time	10:00 am
Location of Front Chevron in Flume (ft)	24
Number of Chevrons	2

#	Height of Chevron (in)	Angle of Chevron (degrees)	Width of Chevron (in)
1	2.25	~60	22
2	2.4	90	32.5
3			
4			
5			
6			

Spacing of Chevrons (in)	
1 to 2	30
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

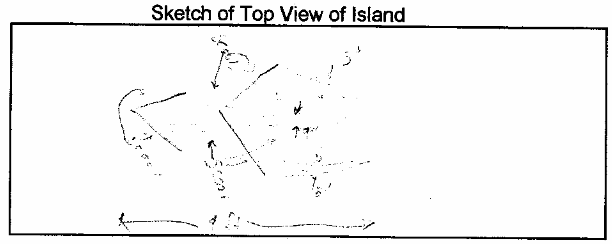
Velocities (fps)	
Over the top	
Left side	
Right side	

3/18/03

Island Dimensions	
Width (in)	9", 8"
Length (in)	9 ft
Height (in)	2" from surface

Island Scour	
Location	front, middle, behind
Depth (in)	5, 4.5", 4.5'
Width (in)	9", 2", 4"

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Trial #	6b	Start Time		3/24/03
Flow (cfs)	7 turns below full [illegible] brick	Stop Time		

Location of Front Chevron in Flume (ft) 48

Number of Chevrons 2

Height of Chevron (in)	
1	
2	
3	
4	
5	
6	

Angle of Chevron (degrees)	
1	
2	
3	
4	
5	
6	

Width of Chevron (in)	
1	
2	
3	
4	
5	
6	

Spacing of Chevrons (in)	
1 to 2	2 ft
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

3/25/03

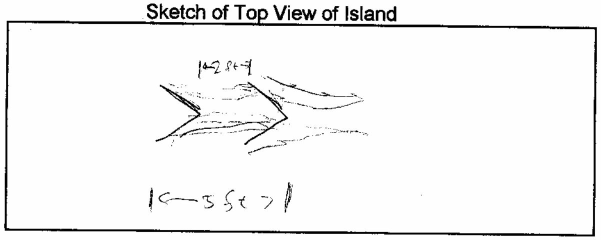
Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	
Length (in)	
Height (in)	

Island Scour	
Location	
Depth (in)	
Width (in)	

NOTE: Label dimensions and scour locations on sketch of island.

Sketch of Top View of Island



Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Trial #	6a	Start Time		3/24/03
Flow (cfs)	7 turns below full w/brick	Stop Time		

Location of Front Chevron in Flume (ft) 24

Number of Chevrons 2

Height of Chevron (in)	
1	
2	
3	
4	
5	
6	

Angle of Chevron (degrees)	
1	90
2	90
3	
4	
5	
6	

Width of Chevron (in)	
1	
2	
3	
4	
5	
6	

Spacing of Chevrons (in)	
1 to 2	2 ft
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

3/25/03

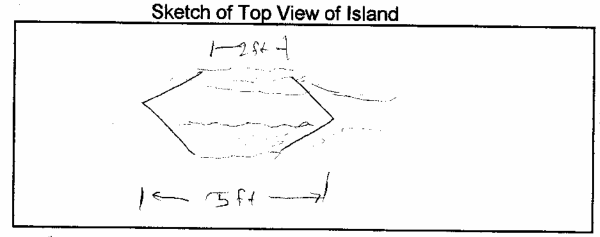
Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	
Length (in)	
Height (in)	

Island Scour	
Location	
Depth (in)	
Width (in)	

NOTE: Label dimensions and scour locations on sketch of island.

Sketch of Top View of Island



Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

3/26/03

Trial #	7b	Start Time	4:09pm
Flow (cfs)	133" deflection	Stop Time	9:00am

Location of Front Chevron in Flume (ft): 48

Number of Chevrons: 3

	Height of Chevron (in)	Width of Chevron (in)	Angle of Chevron (degrees)
1	2.5	16	60
2	2.5	16	60
3	2.5	32.5	90
4			
5			
6			

3 greater than that

Spacing of Chevrons (in)	
1 to 2	48
2 to 3	
3 to 4	
4 to 5	
5 to 6	

60
48
12

Results

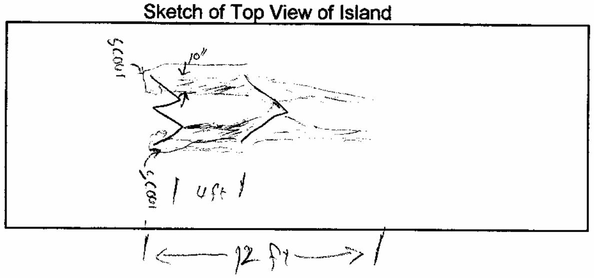
Velocities (fps)	
Over the top	
Left side	
Right side	

3/27/03

Island Dimensions	
Width (in)	16"
Length (in)	12 ft
Height (in)	2.5 from H2O surface

Island Scour	
Location	front, sides
Depth (in)	6.5
Width (in)	14"

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

3/26/03

Trial #	7a	Start Time	4:09pm
Flow (cfs)	133" deflection	Stop Time	9:00am

Location of Front Chevron in Flume (ft): 24

Number of Chevrons: 3

	Height of Chevron (in)	Width of Chevron (in)	Angle of Chevron (degrees)
1	2.5	16"	60
2	2.5	16"	60
3	2.5	32.5	96
4			
5			
6			

Spacing of Chevrons (in)	
1 to 2	4ft
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

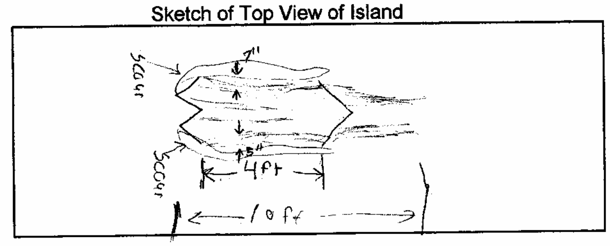
Velocities (fps)	
Over the top	
Left side	
Right side	

3/27/03

Island Dimensions	
Width (in)	7"
Length (in)	10 ft
Height (in)	4" from H2O surface

Island Scour	
Location	front, sides
Depth (in)	6"
Width (in)	8"

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

3/27/03

Trial #	8b	Start Time	
Flow (cfs)	133" deflect.	Stop Time	

Location of Front Chevron in Flume (ft): 48ft

Number of Chevrons: 3

Height of Chevron (in)		Angle of Chevron (degrees)	
1	2.5in	1	~60°
2	2.5in	2	~60°
3	2.5in	3	90°
4		4	
5		5	
6		6	

Width of Chevron (in)		Spacing of Chevrons (in)	
1	1ft	1 to 2	4ft
2	1ft	2 to 3	
3	32.5in	3 to 4	
4		4 to 5	
5		5 to 6	
6			

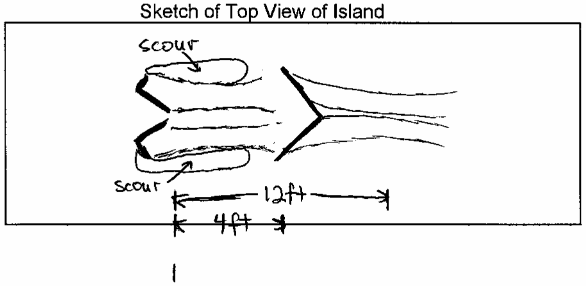
Results

Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	7in
Length (in)	12ft
Height (in)	2in

Island Scour	
Location	Front side
Depth (in)	5.5in
Width (in)	6in

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

3/27/03

Trial #	8a	Start Time	4:00
Flow (cfs)	133" deflection	Stop Time	9:00

Location of Front Chevron in Flume (ft): 24

Number of Chevrons: 2

Height of Chevron (in)		Angle of Chevron (degrees)	
1	2.5	1	180°
2	2.5	2	90°
3		3	
4		4	
5		5	
6		6	

middle low.

Width of Chevron (in)		Spacing of Chevrons (in)	
1	1ft	1 to 2	4ft
2	32.5"	2 to 3	
3		3 to 4	
4		4 to 5	
5		5 to 6	
6			

Results

Velocities (fps)	
Over the top	
Left side	
Right side	

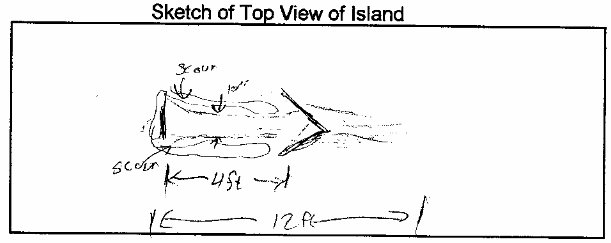
3/28/03

36

Island Dimensions	
Width (in)	10"
Length (in)	12ft
Height (in)	2" from H_2O surface

Island Scour	
Location	front, side
Depth (in)	5"
Width (in)	7"

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Trial #	9b	Start Time	4:00PM
Flow (cfs)	133in deflect.	Stop Time	9:00AM

Location of Front Chevron in Flume (ft) 48ft   4/1/03

Number of Chevrons: 2

Height of Chevron (in)		Angle of Chevron (degrees)	
1	2.5in	1	180°
2	2.5in low middle pt.	2	90°
3		3	
4		4	
5		5	
6		6	

Width of Chevron (in)		Spacing of Chevrons (in)	
1	24in	1 to 2	48in
2	32.5in	2 to 3	
3		3 to 4	
4		4 to 5	
5		5 to 6	
6			

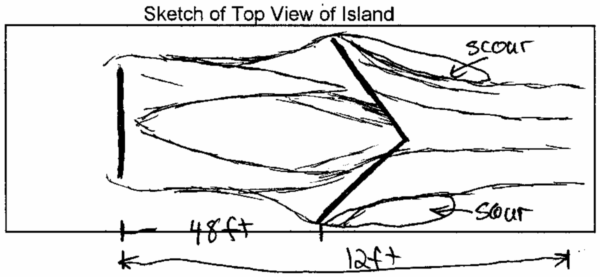
Results

Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	17in
Length (in)	12ft
Height (in)	3in from H₂O Surface

Island Scour	
Location	Front and sides
Depth (in)	5.5in from H₂O Surface
Width (in)	6in

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Trial #	9a	Start Time	4:00pm
Flow (cfs)	133in deflect.	Stop Time	9:00AM

Location of Front Chevron in Flume (ft) 24ft   4/01/03

Number of Chevrons: 2

Height of Chevron (in)		Angle of Chevron (degrees)	
1	2.5in	1	180°
2	2.5in low chevron pt.	2	90°
3		3	
4		4	
5		5	
6		6	

Width of Chevron (in)		Spacing of Chevrons (in)	
1	12in	1 to 2	36in = 3ft
2		2 to 3	
3		3 to 4	
4		4 to 5	
5		5 to 6	
6			

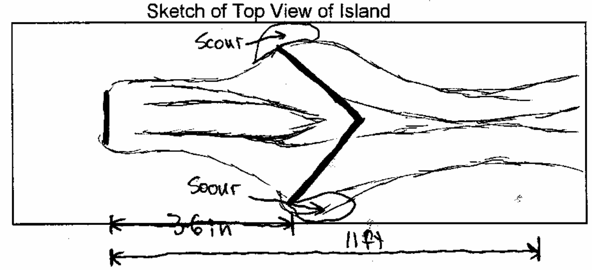
Results

Velocities (fps)	
Over the top	
Left side	
Right side	

Island Dimensions	
Width (in)	7in
Length (in)	11ft
Height (in)	2in from H₂O surface

Island Scour	
Location	Front and sides
Depth (in)	6in from H₂O surface
Width (in)	8in

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

ARS Hydraulic Engineering Research Lab Physical Model Testing

Trial #	10a	Start Time	1:00PM
Flow (cfs)	128in deflect.	Stop Time	9:00AM

Location of Front Chevron in Flume (ft): 42ft

Number of Chevrons: 2

Height of Chevron (in)

1	3in
2	3in
3	
4	
5	
6	

low middle pt.

Angle of Chevron (degrees)

1	180°
2	90°
3	
4	
5	
6	

Width of Chevron (in)

1	12in
2	32.5in
3	
4	
5	
6	

Spacing of Chevrons (in)

1 to 2	36in
2 to 3	
3 to 4	
4 to 5	
5 to 6	

Results

Velocities (fps)

Over the top	
Left side	
Right side	

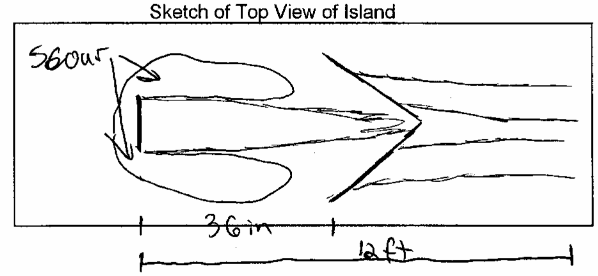
Island Dimensions

Width (in)	9in
Length (in)	12ft
Height (in)	2.5in from H_2O surface

Island Scour

Location	Front sides
Depth (in)	4.5in
Width (in)	4.0in

Sketch of Top View of Island



NOTE: Label dimensions and scour locations on sketch of island.

Endangered Engineering

A-13

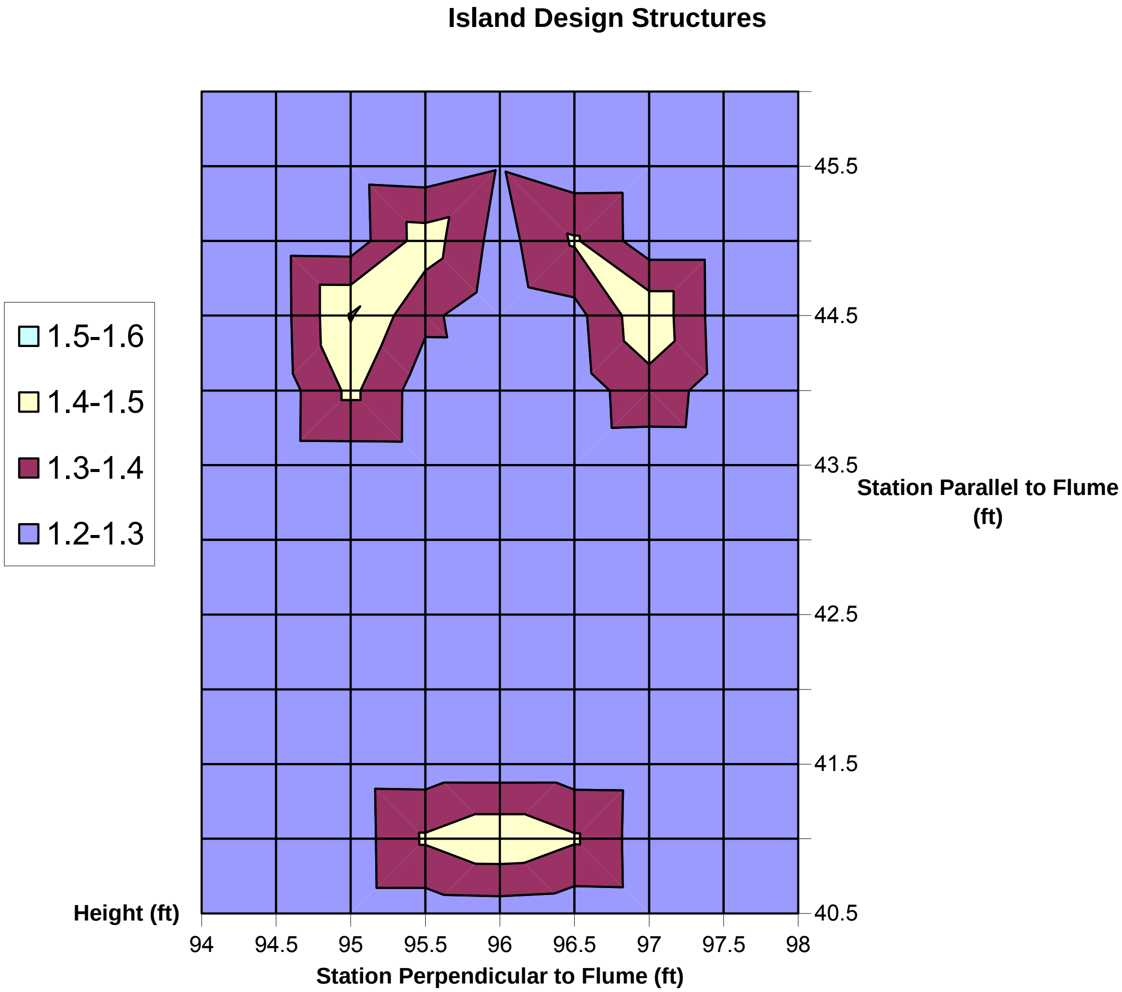


Figure A-2: Top View of Final Flume Design

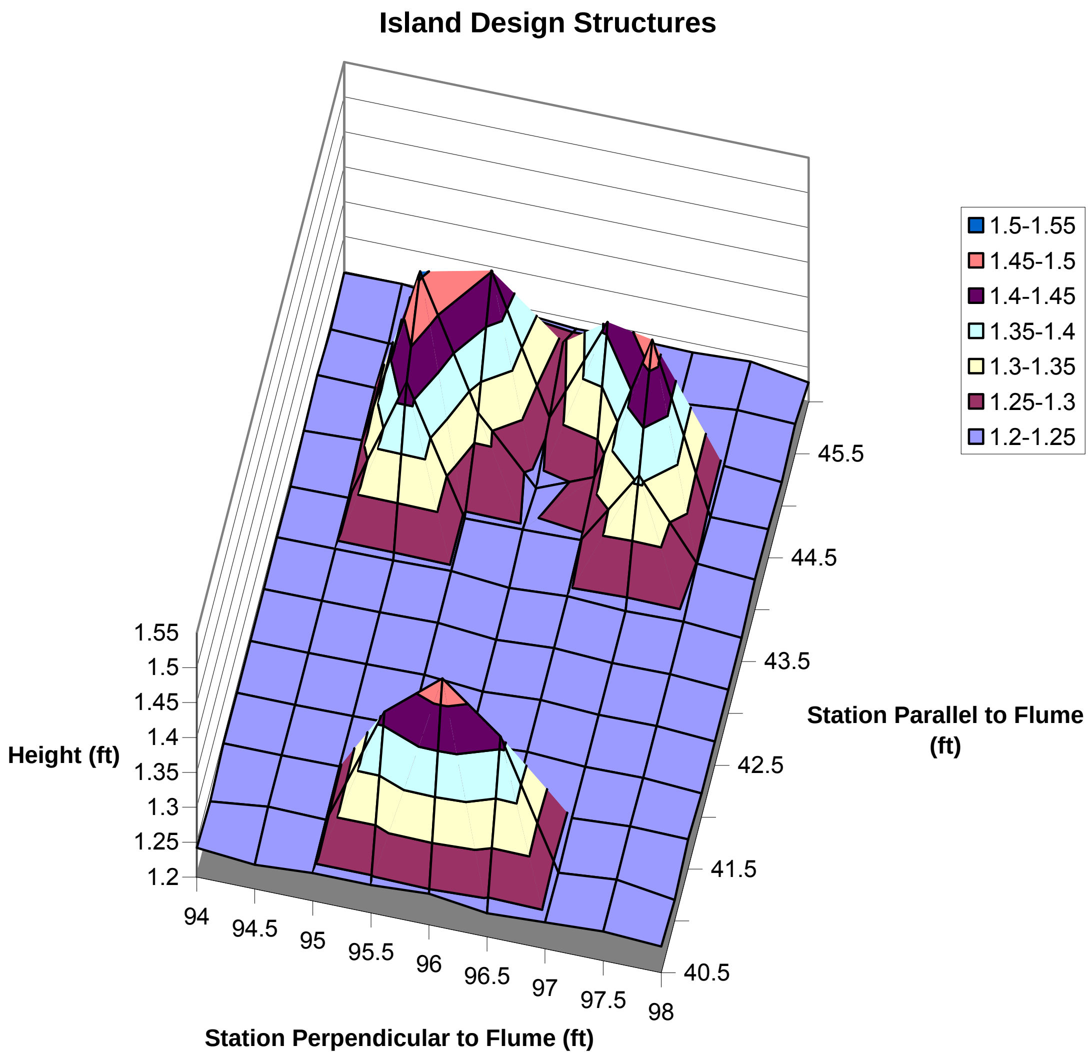


Figure A-3: Three Dimensional View of Final Flume Design

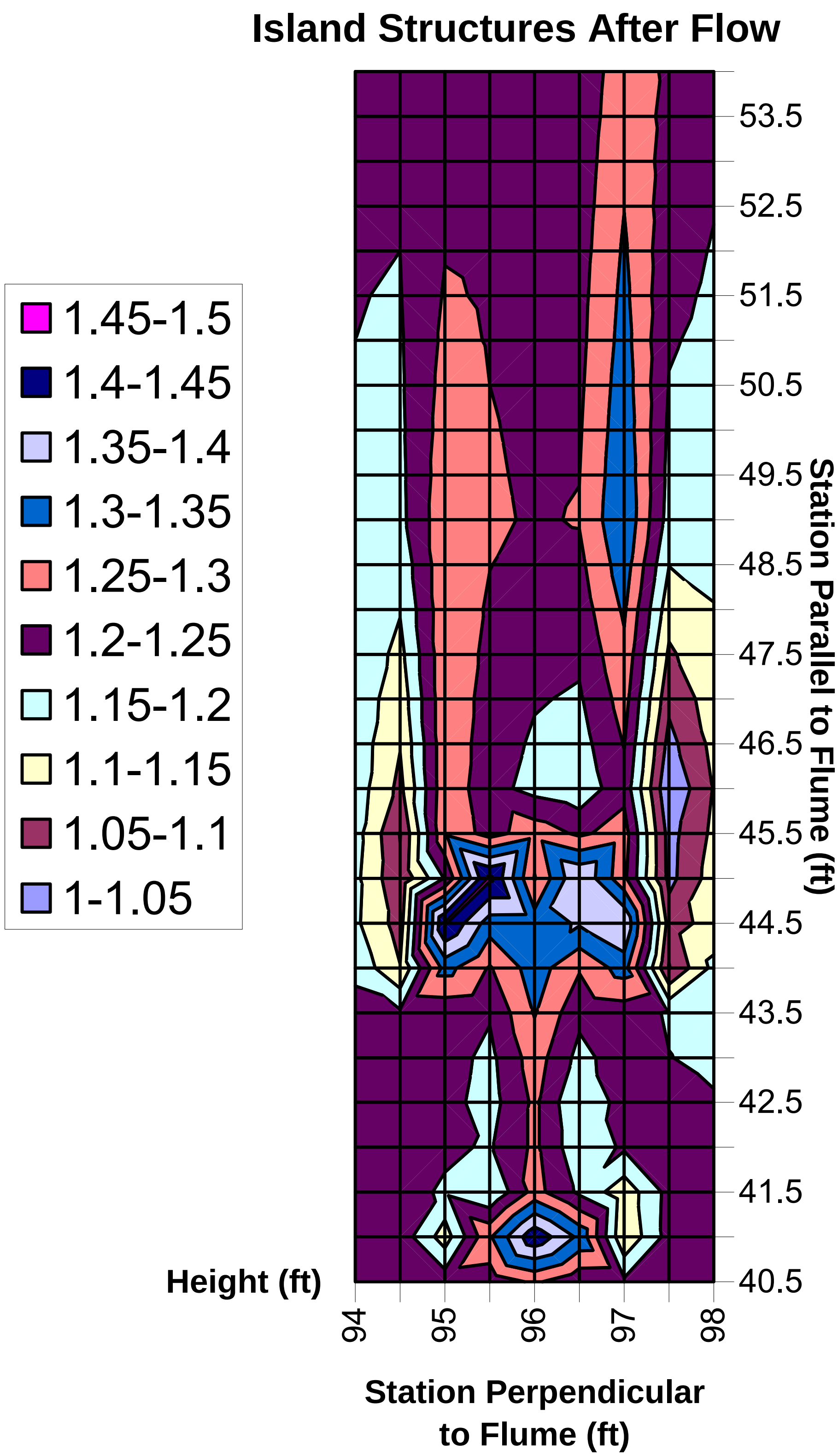


Figure A-4: Top View of Final Flume Design after Testing

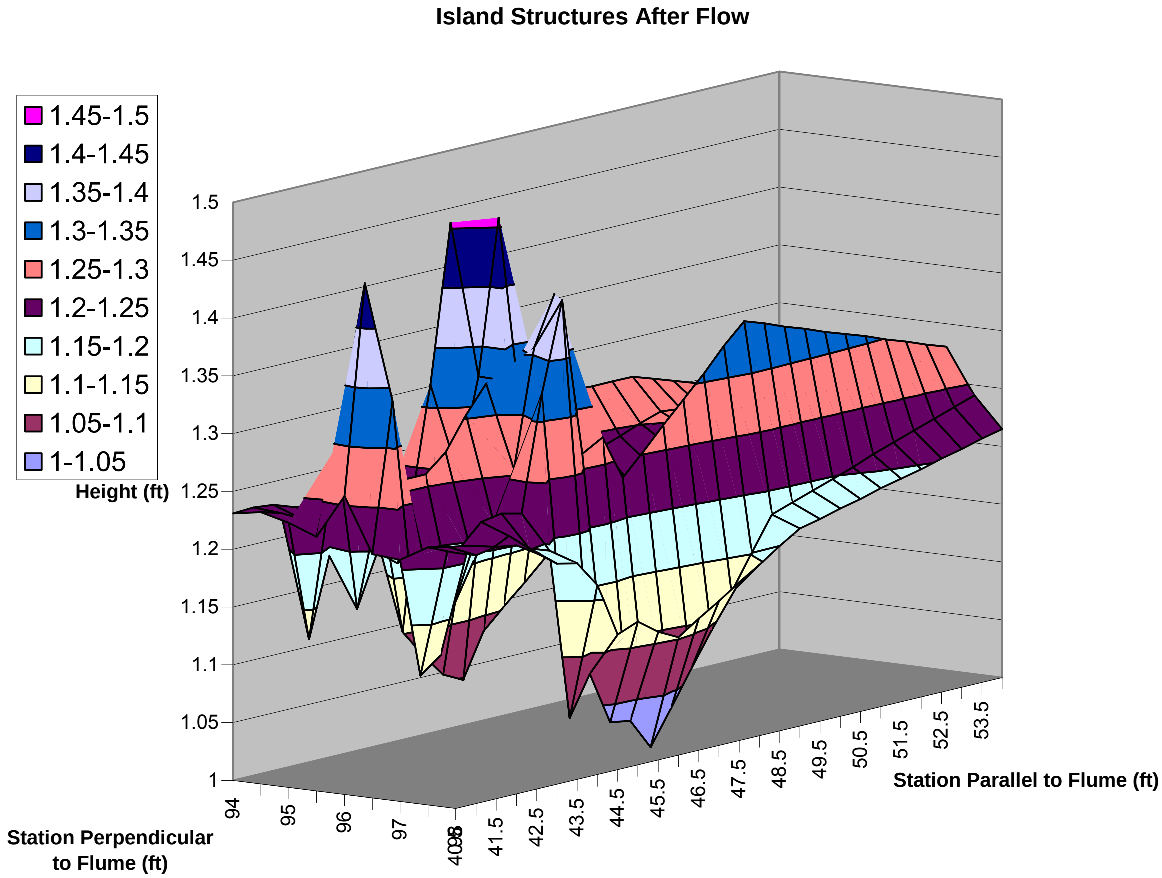


Figure A-5: Three Dimensional View of Final Flume Design after Testing

APPENDIX B: FINAL DESIGN DRAWINGS OF FLUME DESIGN STRUCTURES

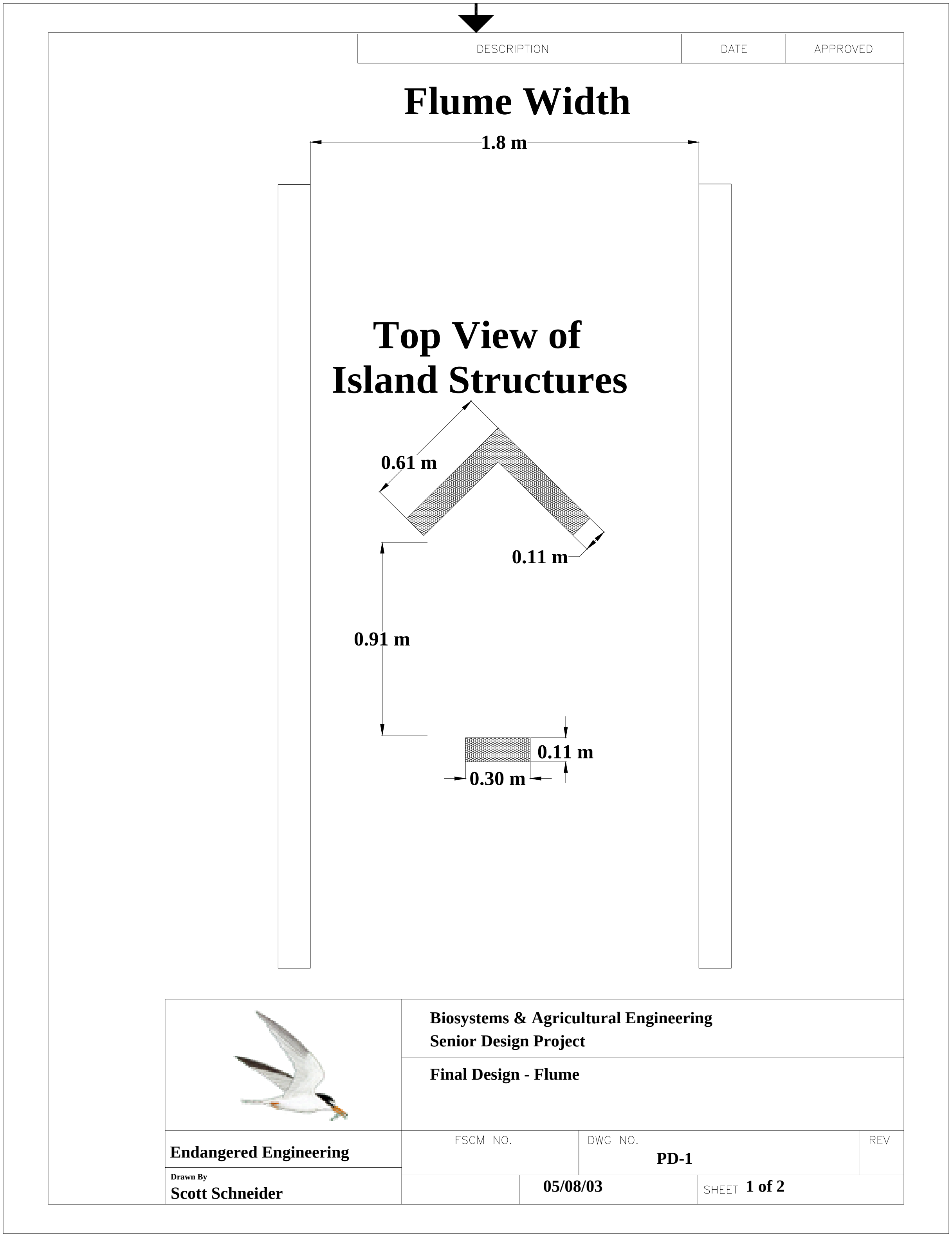


Figure B-1: Top View of Design Schematic for Flume Structure

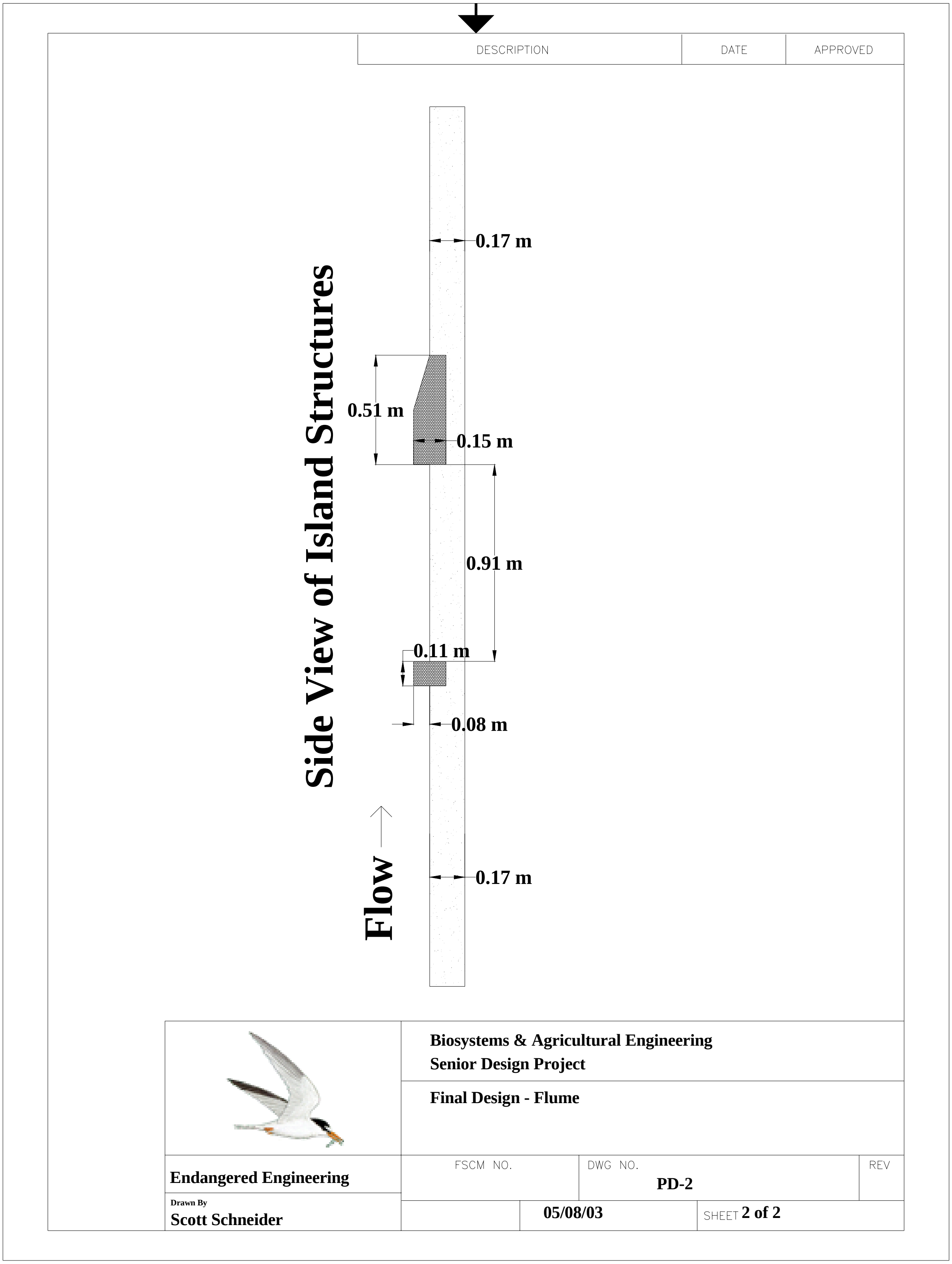


Figure B-2: Side View of Design Schematic for Flume Structure

APPENDIX C: COMPUTER MODEL TESTING RESULTS

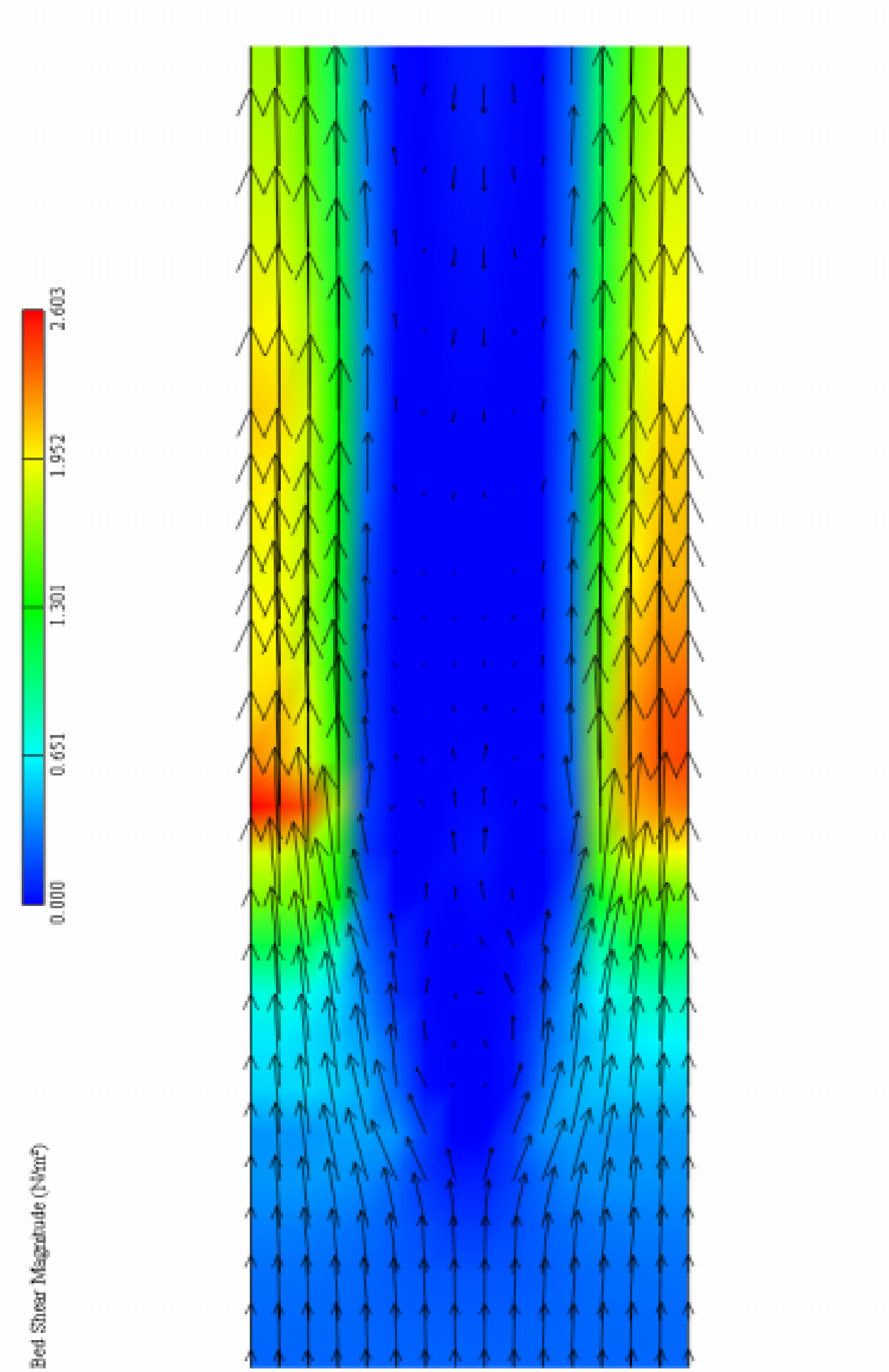


Figure C-1: Computer Modeling Bed Shear Profile with Directional Arrows

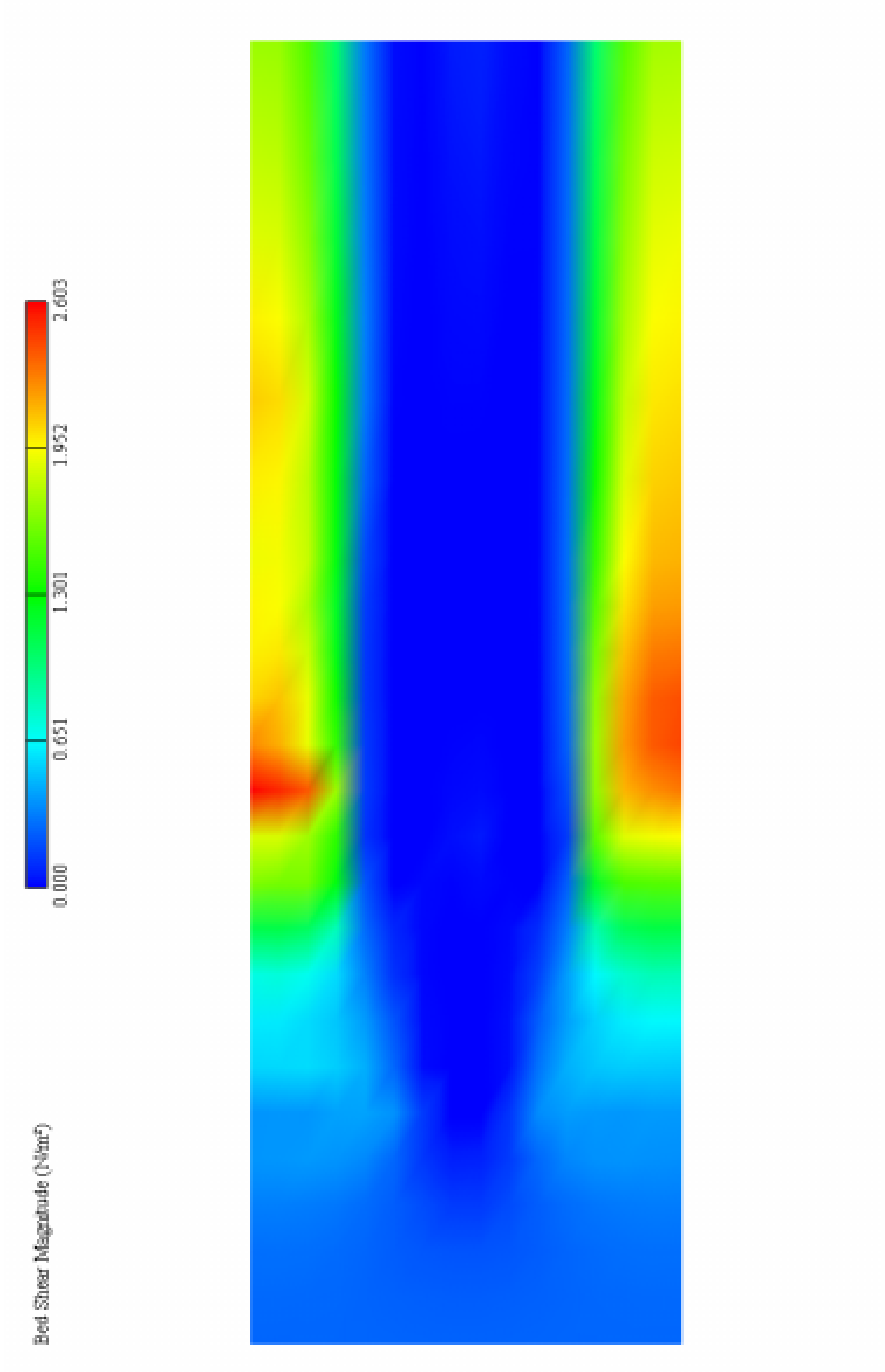


Figure C-2: Computer Modeling Bed Shear Profile

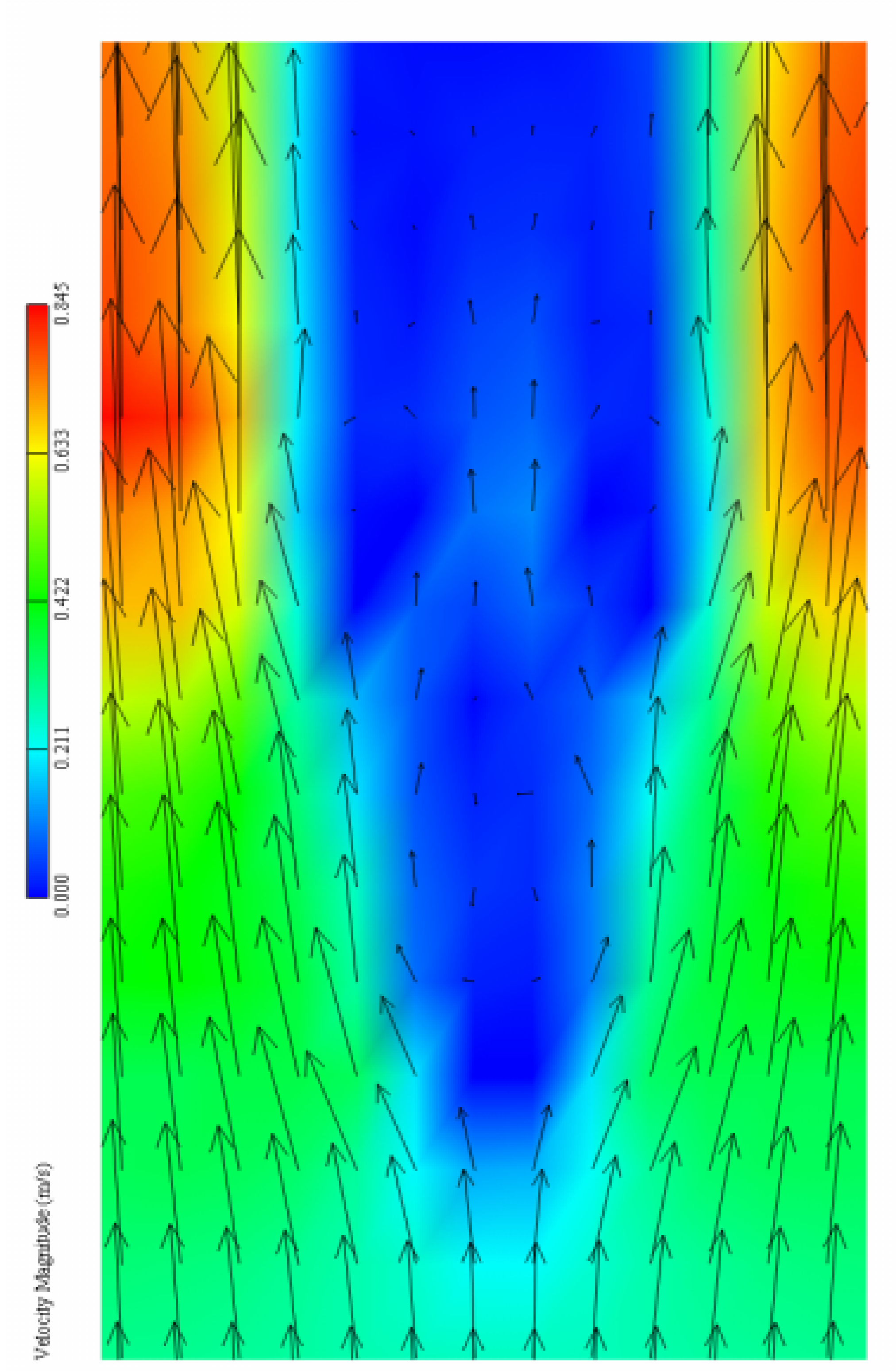


Figure C-3: Computer Modeling Velocity Profile for Flume

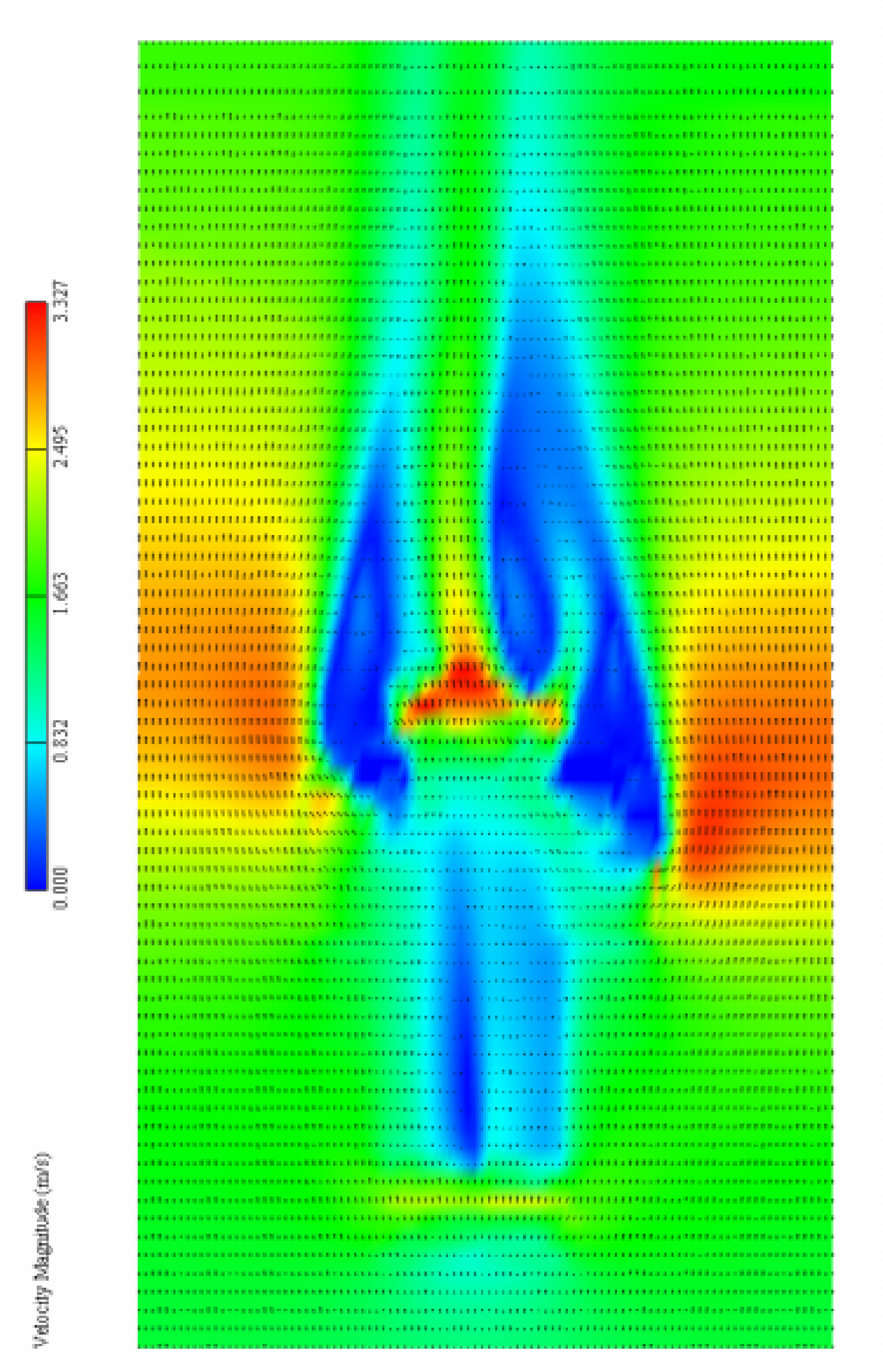


Figure C-4: Computer Modeling Velocity Profile for Arkansas River

APPENDIX D: FINAL DESIGN DRAWINGS OF PROTOTYPE DESIGN STRUCTURES

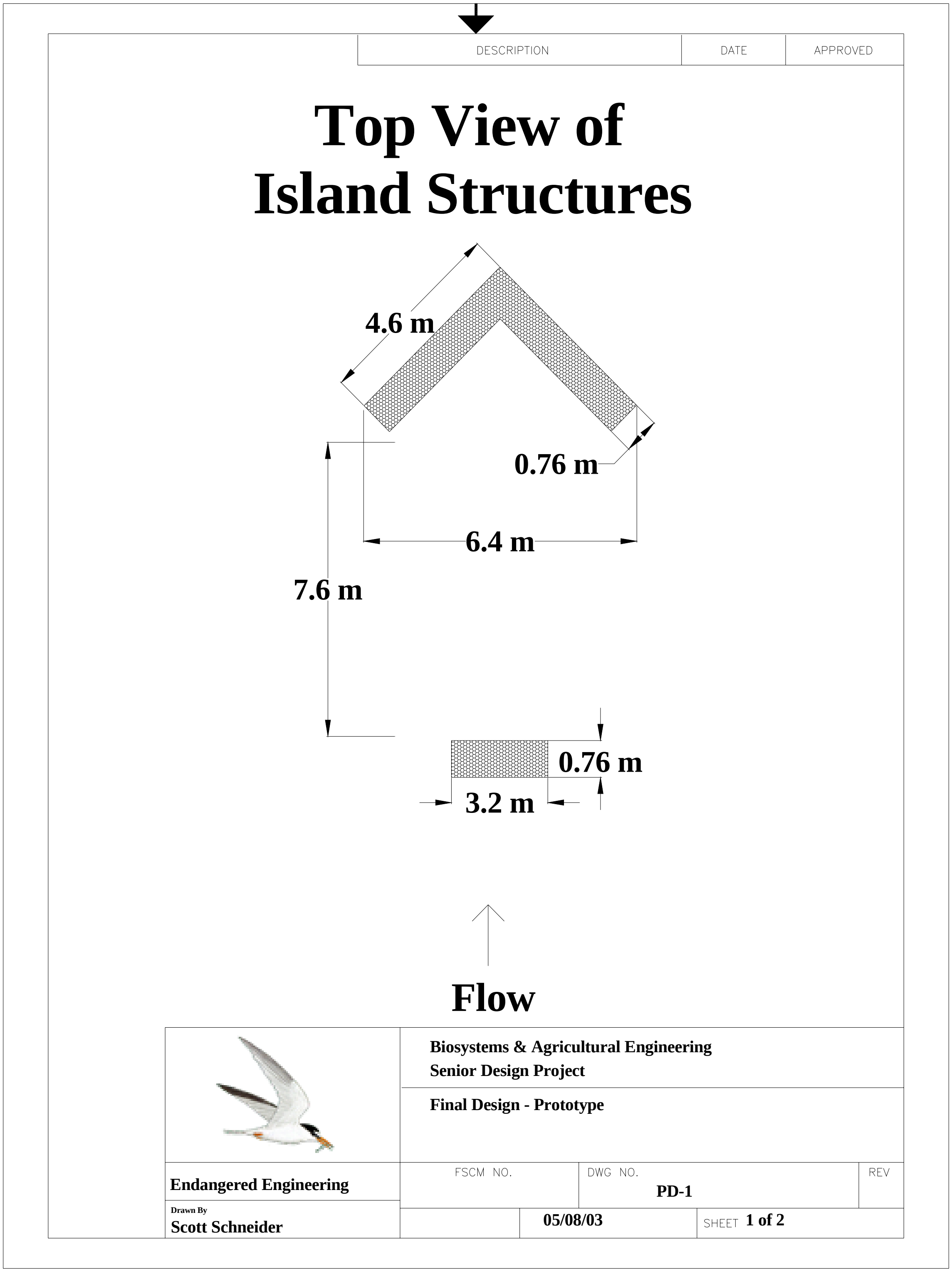


Figure D-1: Top View of Design Schematic for Prototype Structure

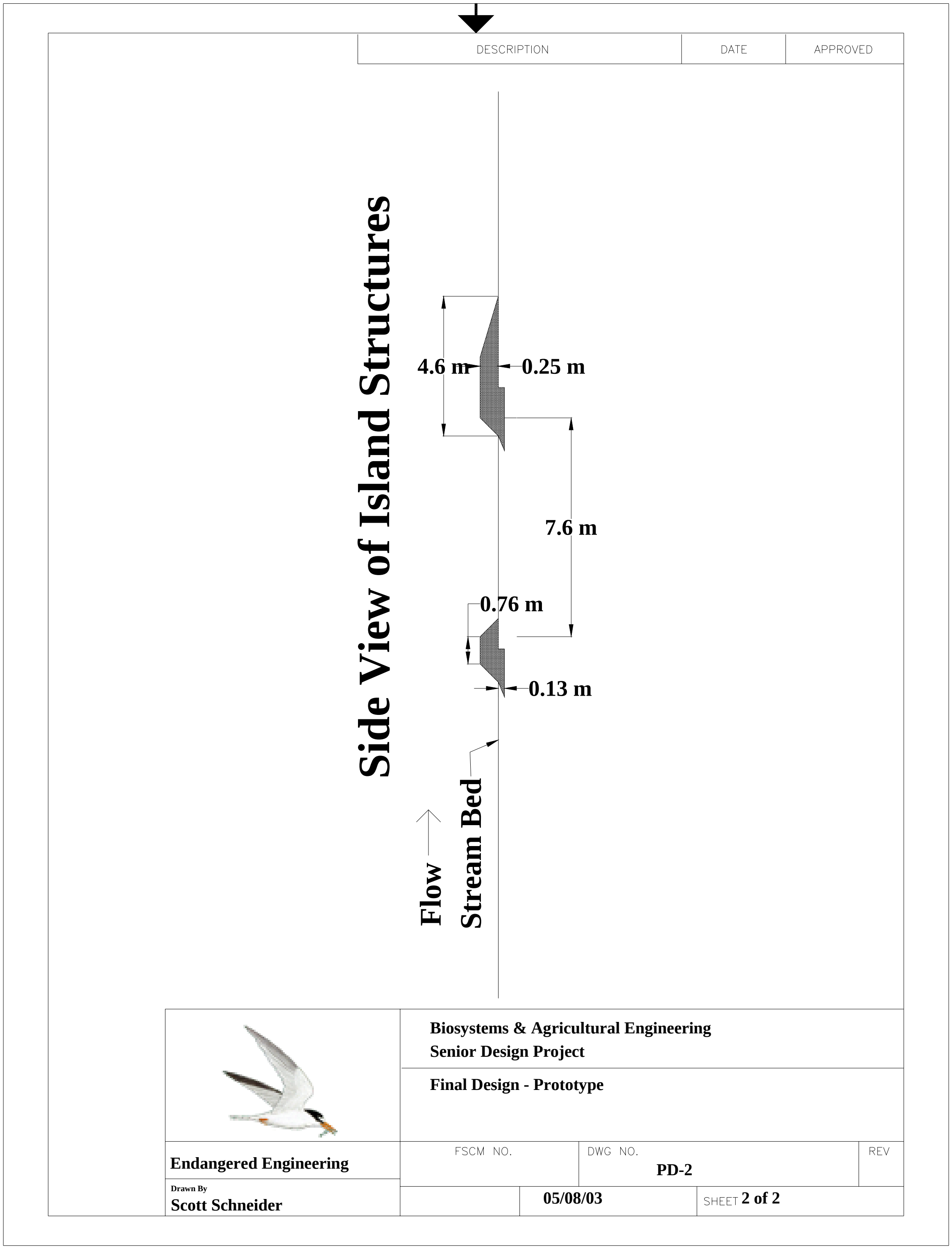


Figure D-2: Side View of Design Schematic for Prototype Structure

Interior Population of the Least Tern

Sterna Antillarum

Recovery Plan

DEPARTMENT OF THE INTERIOR • U.S. FISH AND WILDLIFE SERVICE

RECOVERY PLAN FOR THE INTERIOR POPULATION OF THE

LEAST TERN (*Sterna antillarum*)

September 1990

Prepared by

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Approved: James C. Gritman 9/19/90
Regional Director Date

EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR THE LEAST TERN

CURRENT STATUS: The interior population of the least tern (*Sterna antillarum*), a breeding migratory bird in mid-America, was listed as endangered on June 27, 1985 (50 *Federal Register* 21,784-21,792). Census data currently indicate about 5,000 interior least terns.

Habitat Requirements and Limiting Factors: Interior least terns breed in the Mississippi and Rio Grande River Basins from Montana to Texas and from eastern New Mexico and Colorado to Indiana and Louisiana. From late April to August they occur primarily on barren to sparsely vegetated riverine sandbars, dike field sandbar islands, sand and gravel pits, and lake and reservoir shorelines. Threats to the survival of the species include the actual and functional loss of riverine sandbar habitat. Channelization and impoundment of rivers have directly eliminated nesting habitat. This recovery plan outlines recovery strategies to increase the interior population of the least tern to approximately 7,000 birds throughout its range.

Recovery Objective: Delisting

Recovery Criteria: Assure the protection of essential habitat by removal of current threats and habitat enhancement, establish agreed upon management plans, and attain a population of 7,000 birds at the levels listed below.

1. Adult birds in the Missouri River system will increase to 2,100 and remain stable for 10 years.
2. Current numbers of adult birds (2,200-2,500) on the Lower Mississippi River will remain stable for 10 years.
3. Adult birds in the Arkansas River system will increase to 1,600 and remain stable for 10 years.
4. Adult birds in the Red River system will increase to 300 and remain stable for 10 years.
5. Current number of adult birds in the Rio Grande River system (500) will remain stable for 10 years.

Actions Needed:

1. Determine population trends and habitat requirements.
2. Protect, enhance and increase populations during breeding.
3. Manage reservoir and river water levels to the benefit of the species.
4. Develop public awareness and implement educational programs about the interior least tern.
5. Implement law enforcement actions at nesting areas in conflict with high public use.

Cost of Recovery: Estimated to be $1,720,000 - $2,000,000, to reach recovery criteria set out above, and complete subsequent monitoring for 10 years.

Date of Recovery: Delisting should be initiated in 2005, if recovery criteria have been met.

DISCLAIMER

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U. S. Fish and Wildlife Service only after they have been signed by the Regional Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature Citation should read as follows:

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I. INTRODUCTION

The interior population of the least tern (Sterna antillarum) (hereafter referred to as the interior least tern) has been a species of concern for many years because of its perceived low numbers and the vast transformation of its riverine habitat. Barren sandbars, the interior least tern's most common nesting habitat, were once a common feature of the Mississippi, Missouri, Arkansas, Ohio, Red, Rio Grande, Platte, and other river systems in the central United States. Sandbars are still common at normal river stages on the Lower Mississippi River and on portions of other river systems. Sandbars generally are not stable features of the natural river landscape, but are formed or enlarged, disappear or migrate depending on the dynamic forces of the river. However, stabilization of major rivers to achieve objectives for navigation, hydropower, irrigation, and flood control has destroyed the dynamic nature of these processes (Smith and Stucky 1988). Many of the remaining sandbars are unsuitable for nesting because of vegetation encroachment or are too low and subject to frequent inundation. The number and distribution of interior least terns probably have declined accordingly.

The interior least tern was listed as an endangered species on June 27, 1985 (50 Federal Register 21,784-21,792) in the following States: Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana (Mississippi River and it's tributaries north of Baton Rouge), Mississippi (Mississippi River), Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Tennessee, and Texas (except within 80 km of Gulf Coast). The States of Arkansas, Illinois, Indiana, Iowa, Missouri, Nebraska, Tennessee, Texas, Kansas, Kentucky, New Mexico, Oklahoma, and South Dakota list the interior least tern as endangered under State laws. Although not legislatively designated as endangered in North Dakota, the interior least tern is regarded as endangered by the North Dakota Game and Fish Department and conservation organizations within the State.

Section 4 of the Endangered Species Act directs the Secretary of the Interior to develop and implement recovery plans for the conservation and survival of endangered and threatened species listed pursuant to Section 4 unless he finds that such a plan will not promote the conservation of the species. The Secretary, in developing and implementing recovery plans (1) shall, to the maximum extent practicable, give priority to those endangered species or threatened species most likely to benefit from such plans, particularly those species that are, or may be, in conflict with construction or other developmental projects or other forms of economic activity. The interior least tern occurs along rivers which are heavily regulated by numerous dam and irrigation projects.

The goal of this recovery plan is to describe actions for the conservation and survival of the interior least tern and to return the species to non-endangered status throughout its range. This plan summarizes available biological data, details various actions to stabilize and/or restore the interior least tern, and establishes criteria to remove it from the federal list of endangered species.

Description

Least terns (all currently recognized subspecies and populations) are the smallest members of the subfamily Sterninae and family Laridae of the order Charadriiformes, measuring about 21-24 cm long with a 51 cm wingspread. Sexes are alike, characterized by a black-capped crown, white forehead, grayish back and dorsal wing surfaces, snowy white undersurfaces, legs of various orange and yellow colors depending on the sex, and a black-tipped bill whose color also varies depending on sex (Watson 1966, Davis 1968, Boyd and Thompson 1985). Boyd and Thompson (1985) developed the following criteria to distinguish the sexes in the field based upon their work in Kansas:

1) Females usually have a wing chord less than 171 mm long while males usually have a wing chord greater than 174 mm.
2) A male's feet are brighter than its mate's feet; the male's are bright orange, while the female's feet are bright to pale yellow, or rarely grey.
3) A male's bill is larger than the female's; the female's bill depth at its widest point is 4.5 mm to 5.5 mm, while the male's is 6.0 mm or greater.
4) A male's bill is orange to bright yellow, whereas the female's bill is light or dull yellow, or straw-colored.

Immature birds have darker plumage than adults, a dark bill, and dark eye stripes on their white foreheads. Jackson (1976) described the developmental stages of least tern chicks. Further details on plumage development and variation were presented by Massey and Atwood (1978) and Thompson and Slack (1983).

Taxonomy

The least tern (*Sterna antillarum*) in North America was described by Lesson in 1847 (Ridgway 1895, American Ornithologists' Union 1957, 1983). The least tern in interior North America was described later as a race (*Sterna albifrons athalassos*) of the Old World little tern (*Sterna albifrons*) (Burleigh and Lowery 1942). Two other described New World races were the eastern or coastal least tern (*Sterna albifrons antillarum*), and the California least tern (*Sterna albifrons browni*). The coastal least tern breeds along the Atlantic and Gulf coasts and the California least tern breeds along the California coast.

As a result of studies on vocalizations and behavior of this group of terns in the Old and New Worlds, the American Ornithologists' Union (1983) now treats the New World least terns as a distinct species, *Sterna antillarum*. Subspecies of New World least terns recognized by the American Ornithologists' Union (1957, 1983) are the interior least tern (now *Sterna antillarum athalassos*), the eastern or coastal least tern (now *Sterna antillarum antillarum*), and the California least tern (now *Sterna antillarum browni*).

However, the validity of least tern subspecies has been questioned by several authors in recent years. Massey (1976) reported no consistent morphological, behavioral, or vocal differences between *S. a. antillarum* and *S. a. browni*. In Texas, where both *S. a. antillarum* and *S. a. athalassos* occur, electrophoretic analyses indicate little genetic differentiation between least terns produced on the Texas coast and Texas Panhandle rivers (McCament and Thompson 1987, McCament-Locknane 1988). Coastal least terns have populated interior breeding sites. Boyd and Thompson (1985) reported an incubating least tern at Quivira National Wildlife Refuge, Kansas, that originally had been banded as a chick on the Texas coast. The most recent morphometric and biochemical assessment of North American least terns could not distinguish subspecies (Thompson et al. In prep)

Originally, *S. a. athalassos* was proposed for endangered status. Because of the taxonomic uncertainty of least tern subspecies in North America, the U. S. Fish and Wildlife Service did not list the subspecies and instead designated as endangered those least terns occurring in interior North America. The California least tern has been listed as endangered since 1970 (U. S. Fish and Wildlife Service 1980).

Distribution

The interior least tern is migratory and historically bred along the Mississippi, Red and Rio Grande River systems and rivers of central Texas. The breeding range extended from Texas to Montana and from eastern Colorado and New Mexico to southern Indiana. It included the Red, Missouri, Arkansas, Mississippi, Ohio and Rio Grande River systems (American Ornithologists' Union 1957, Anderson 1971, Coues 1874, Burroughs 1961, Hardy 1957, Youngworth 1930, 1931, Ducey 1981). Incidental occurrences of least terns in Michigan, Minnesota, Wisconsin, Ohio and Arizona have been reported (Campbell 1935, Janssen 1986, Jung 1935, Mayfield 1943, Monson and Phillips 1981, Phillips et al. 1964).

Current Distribution

The interior least tern continues to breed in most of the aforementioned river systems, although its distribution generally is restricted to less altered river segments (Figure 1) (Tables 1-5).

Missouri River System: The explorers, Lewis and Clark, observed the least terns along the Missouri River frequently and believed them to be "a native of this country and probably a constant resident" (Burroughs 1961). In the Dakotas, most interior least terns occur on those segments of the Missouri River and its tributaries that are not affected by impoundments or channelization. In South Dakota, the interior least tern nests primarily on flowing segments of the Missouri River and Cheyenne River (Nebraska Game and Parks Commission, Schwalbach 1988, Schwalbach et al. 1986, 1988). Breeding areas in North Dakota constitute about 192 km of the Missouri River from Garrison Dam to the mouth of the Cannonball River south of Bismarck (Dryer and Dryer 1985, Mayer and Dryer 1988), and about 29 km of the Yellowstone River in North Dakota from the Montana border to the river's confluence with the Missouri River (Kreil and Dryer 1987). A few interior least terns nest on islands, shorelines and sandbars along the reservoir, Lake Oahe, an impoundment on the Missouri River in North and South Dakota (Schwalbach 1988, Mayer and Dryer 1988). In Montana, breeding interior least terns recently have been recorded on the Yellowstone River, and on the Missouri River between Fort Peck Reservoir and North Dakota. A few interior least terns have been recorded on islands and shoreline within the Fort Peck Reservoir (Charles M. Russell National Wildlife Refuge). These locations are the western most nesting sites of the interior least tern.

Interior least terns breed along the lower section of the Niobrara River, Nebraska, from Keya Paha and Rock Counties to the Missouri River (Nebraska Game and Parks Commission 1985a). Current distribution probably is similar to the historic distribution because the Niobrara River has been little changed by man (Ducey 1985). On the Platte River, Nebraska, interior least terns nest on sandbars and at sand and gravel pits from the Missouri River to North Platte (Nebraska Game and Parks Commission 1987) and along the South Platte River as far west as Ogallala. On the Loup River, a tributary of the Platte River, interior least terns breed as far west as Arcadia but are most common between Saint Paul, Nebraska and the Loup's confluence with the Platte River at Columbus, Nebraska. A few interior least terns also occur along the Elkhorn River, another tributary of the Platte River.

The interior least tern no longer nests in the Missouri reaches of the Missouri River (Smith 1985, Sidle et al. 1988, Smith and Renken 1990). The hydrology of the River in Missouri has been drastically altered by channelization, and studies show that river levels are typically too high during the breeding season to expose suitable nesting habitat (Smith and Renken 1990).

<u>Arkansas River System</u>: Breeding interior least terns occur along the Arkansas River system in Colorado, Kansas, Oklahoma, Arkansas and Texas (Table 2). In Colorado, interior least terns nest at Adobe Creek reservoir (Blue Lake) and have been observed at Nee Noshe reservoir (Carter 1989). Both reservoirs are located on small tributaries of the Arkansas River.

In Kansas, interior least terns nest on the Cimarron River in Meade, Comanche and Clark Counties, and Quivira National Wildlife Refuge, and in the recent past at Cheyenne Bottoms Wildlife Management Area (Boyd 1983, 1986, 1987; Schulenberg and Ptacek 1984).

The interior least tern occurs on several tributaries of the Arkansas River in Oklahoma. It breeds along the Salt Fork of the Arkansas River at the Salt Plains National Wildlife Refuge (Hill 1985, Grover and Knopf 1982); Optima Reservoir at the fork of the Coldwater Creek and Beaver River in the Oklahoma Panhandle; and on the Cimarron River in Beaver, Harper, Woods, Woodward, Major, Blaine, Kingfisher, Logan, and Payne Counties (Boyd 1987, L. Hill personal communication).

Along the Arkansas River in Oklahoma, the interior least tern breeds in Kay, Osage, Pawnee, Creek, Tulsa, Wagoner, Muskogee, and Sequoyah Counties (Hoffman 1986, L. Hill personal communication). In Arkansas, the breeding range on the Arkansas River is above Little Rock (Smith and Shepherd 1985, Smith et al. 1987, K. Smith 1986).

Along the Canadian River, interior least terns breed in Ellis, Roger Mills, Dewey, Cleveland, McClain, Haskell, and Sequoyah Counties, Oklahoma and in Hemphill, Roberts and Hutchinson Counties, Texas (McCament and Thompson 1985, 1987; U. S. Fish and Wildlife Service, unpublished data).

Mississippi and Ohio Rivers: On the Mississippi River, interior least terns occur almost entirely in the lower valley south of Cairo, Illinois to Vicksburg, Mississippi (Sidle et al. 1988) (Table 3). Surveys by the U. S. Army Corps of Engineers (Rumancik 1985, 1986, 1987, and 1988; M. Smith 1986) and Missouri Department of Conservation (J. Smith 1985, 1986, 1987, and 1988, Smith and Renken 1990) indicate that about one-half of all interior least terns occur along 1100 km of the Lower Mississippi River.

On the Ohio River system, the interior least tern occurs just above the confluence of the Tennessee and Ohio Rivers and at one artificial site on the Wabash River in Indiana.

Red River System: Interior least terns are known to occur on the Prairie Dog Town Fork of the Red River in the eastern Texas Panhandle and along the Texas/Oklahoma boundary as far east as Burkburnett, Texas (McCament and Thompson 1985, 1987) (Table 4).

Rio Grande River System: Interior least terns occur at three reservoirs along the Rio Grande River and along the Pecos River at the Bitter Lake National Wildlife Refuge, New Mexico (McCament and Thompson 1985, 1987; Neck and Riskind 1981, Seibert 1951, Marlatt 1984, 1987) (Table 5).

Wintering Areas: The wintering area of interior least terns is unknown. However, least terns of unknown populations or subspecies are found during the winter along the Central American coast and the northern coast of South America from Venezuela to northeastern Brazil. Roger Boyd (personal communication 1986) reports that about 35 least terns have been recaptured in South America, mostly in Guyana. One interior least tern banded by Boyd, was captured in El Salvador two years later. Also, a banded California least tern was recaptured in Guatemala.

Table 1. Known breeding areas for interior least terns along the Missouri River system in 1985-1988.

State	County	Locations
Montana	Valley	Fort Peck Reservoir, Charles M. Russell National Wildlife Refuge
	Garfield	Fort Peck Reservoir, Charles M. Russell National Wildlife Refuge
	Prairie	Yellowstone River sandbars
	McCone	Missouri River sandbars
	Richland	Missouri River sandbars
North Dakota	McLean	Missouri River sandbars
	Burleigh	Missouri River sandbars
	Oliver	Missouri River sandbars
	Morton	Missouri River sandbars
	Emmons	Lake Oahe
	Mercer	Missouri River sandbars
	Sioux	Missouri River sandbars
	McKenzie	Yellowstone River sandbars
South Dakota	Charles Mi	Missouri River sandbars
	Bon Homme	Missouri River sandbars
	Yankton	Missouri River sandbars
	Clay	Missouri River sandbars
	Union	Missouri River sandbars
	Sully	Lake Oahe
	Hughes	Lake Oahe
	Stanley	Lake Oahe
	Walworth	Lake Oahe
	Campbell	Lake Oahe
	Corson	Lake Oahe
	Potter	Lake Oahe
	Dewey	Lake Oahe
	Ziebach	Cheyenne River sandbars
	Haakon	Cheyenne River sandbars
Nebraska	Dixon	Missouri River sandbars
	Cedar	Missouri River sandbars
	Knox	Missouri River sandbars
	Howard	Loup River sandbars and sand/gravel pits
	Nance	Loup River sandbars and sand/gravel pits
	Sherman	Loup River sandbars and sand/gravel pits
	Platte	Loup River sandbars and sand/gravel pits
	Valley	Loup River sandbars and sand/gravel pits
	Douglas	Elkhorn River sandbars and sand/gravel pits
	Cumming	Elkhorn River sandbars and sand/gravel pits
	Stanton	Elkhorn River sandbars and sand/gravel pits
	Boyd	Niobrara River sandbars

	Holt	Niobrara River sandbars
	Keya Paha	Niobrara River sandbars
	Brown	Niobrara River sandbars
	Knox	Niobrara River sandbars
	Rock	Niobrara River sandbars
	Cass	Platte River sandbars and sand/gravel pits
	Sarpy	Platte River sandbars and sand/gravel pits
	Saunders	Platte River sandbars and sand/gravel pits
	Douglas	Platte River sandbars and sand/gravel pits
	Dodge	Platte River sandbars and sand/gravel pits
	Colfax	Platte River sandbars and sand/gravel pits
	Butler	Platte River sandbars and sand/gravel pits
	Platte	River sandbars and sand/gravel pits
	Polk	Platte River sandbars and sand/gravel pits
	Hall	Platte River sandbars and sand/gravel pits
	Buffalo	Platte River sandbars and sand/gravel pits
	Kearney	Platte River sandbars and sand/gravel pits
	Phelps	Platte River sandbars and sand/gravel pits
	Dawson	Platte River sandbars and sand/gravel pits
	Hamilton	Platte River sandbars and sand/gravel pits
	Merrick	Platte River sandbars and sand/gravel pits
	Lincoln	Platte River sandbars and sand/gravel pits
	Lincoln	So. Platte River sandbars/sand/gravel pits
	Keith	So. Platte River sandbars/sand/gravel pits
Iowa	Woodbury	Iowa Public Service ash ponds
	Pottawattamie	Iowa Power and Light ash ponds

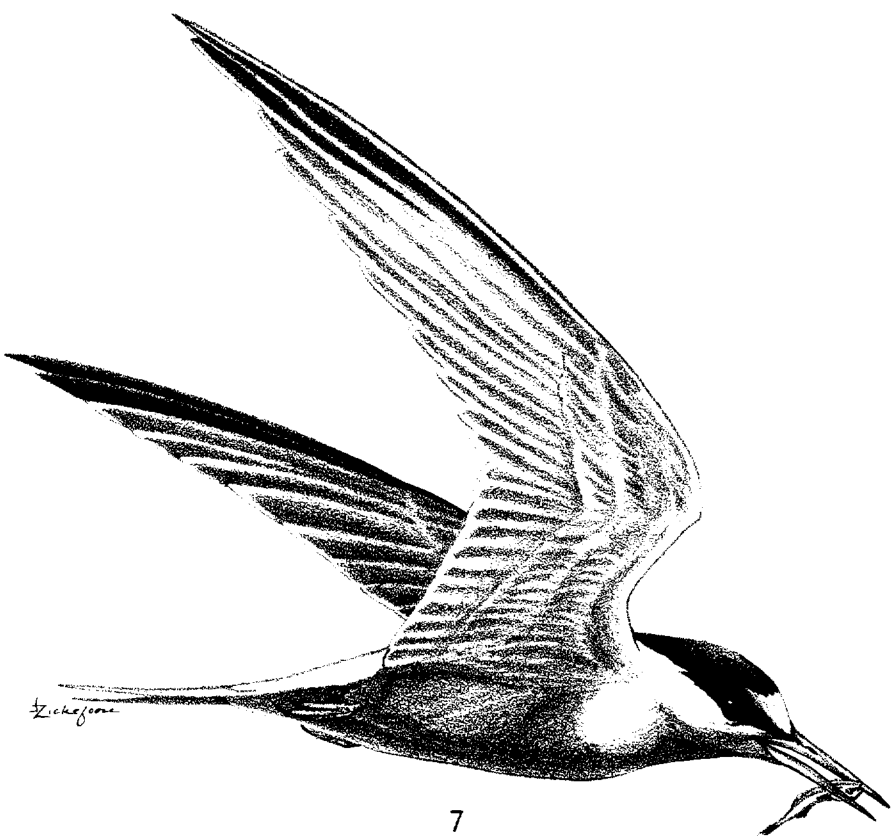


Table 2. Known breeding areas for interior least terns along the Mississippi and Ohio Rivers, 1985-1988.

State	County or Parish	Location
Missouri	Pemiscott	Mississippi River sandbars and dike fields
	New Madrid	Mississippi River sandbars and dike fields
	Mississippi	Mississippi River sandbars and dike fields
	Scott	Mississippi River sandbars and dike fields
Kentucky	Fulton	Mississippi River sandbars and dike fields
	Hickman	Mississippi River sandbars and dike fields
	Carlisle	Mississippi River sandbars and dike fields
Tennessee	Dyer	Mississippi River sandbars and dike fields
	Lake	Mississippi River sandbars and dike fields
	Lauderdale	Mississippi River sandbars and dike fields
	Tipton	Mississippi River sandbars and dike fields
	Shelby	Mississippi River sandbars and dike fields
Arkansas	Mississippi	Mississippi River sandbars and dike fields
	Crittenden	Mississippi River sandbars and dike fields
	Lee	Mississippi River sandbars and dike fields
	Phillips	Mississippi River sandbars and dike fields
	Deska	Mississippi River sandbars and dike fields
	Chicot	Mississippi River sandbars and dike fields
Mississippi	Desoto	Mississippi River sandbars and dike fields
	Tunica	Mississippi River sandbars and dike fields
	Coahoma	Mississippi River sandbars and dike fields
	Bolivar	Mississippi River sandbars and dike fields
	Washington	Mississippi River sandbars and dike fields
	Issaguena	Mississippi River sandbars and dike fields
	Warren	Mississippi River sandbars and dike fields
Louisiana	East Carroll	Mississippi River sandbars and dike fields
	Madison	Mississippi River sandbars and dike fields
Illinois	Alexander	Mississippi River sandbars and dike fields
	Pulaski	Ohio River sandbars and dike fields
Indiana	Gibson	Public Power plant along Wabash River at East Mt. Carmel

Table 3. Known breeding areas for interior least terns along the Arkansas River system,1985-1988.

State	County	Location
Arkansas	Pulaski	Arkansas River sandbars and dike fields
	Faulkner	Arkansas River sandbars and dike fields
	Conway	Arkansas River sandbars and dike fields
	Perry	Arkansas River sandbars and dike fields
	Pope	Arkansas River sandbars and dike fields
	Logan	Arkansas River sandbars and dike fields
	Johnson	Arkansas River sandbars and dike fields
	Sabastian	Arkansas River sandbars and dike fields
	Crawford	Arkansas River sandbars and dike fields
Oklahoma	Osage	Arkansas River sandbars
	Kay	Arkansas River sandbars
	Pawnee	Arkansas River sandbars
	Creek	Arkansas River sandbars
	Tulsa	Arkansas River sandbars
	Wagoner	Arkansas River sandbars
	Muskogee	Arkansas River sandbars
	Beaver	Cimarron River sandbars
	Harper	Cimarron River sandbars
	Woods	Cimarron River sandbars
	Woodward	Cimarron River sandbars
	Major	Cimarron River sandbars
	Blaine	Cimarron River sandbars
	Kingfisher	Cimarron River sandbars
	Logan	Cimarron River sandbars
	Payne	Cimarron River sandbars
	Alfalfa	Salt Plains National Wildlife Refuge
	Texas	Optima Reservoir
	Ellis	Canadian River sandbars
	Roger Mills	Canadian River sandbars
	Dewey	Canadian River sandbars
	Haskell	Sequoyah National Wildlife Refuge
	Sequoyah	Sequoyah National Wildlife Refuge
	Cleveland	Canadian River sandbars
	McClain	Canadian River sandbars
Texas	Hemphill	Canadian River sandbars
	Roberts	Canadian River sandbars
	Hutchinson	Canadian River sandbars

Kansas	Barton	Cheyenne Bottoms
	Comanche	Cimarron River sandbars
	Clark	Cimarron River sandbars
	Meade	Cimarron River sandbars
	Stafford	Quivira National Wildlife Refuge
Colorado	Kiowa	Adobe Creek Reservoir
		Nee Noshe Reservoir
	Bent	Adobe Creek Reservoir

Table 4. Known breeding areas for interior least terns along the Red River system, 1985-1988.

State	County	Location
Texas	Childress	Prairie Dog Town Fork sandbars
	Hall	Prairie Dog Town Fork sandbars
	Briscoe	Prairie Dog Town Fork sandbars

Table 5. Known breeding areas for interior least terns along the Rio Grande system, 1985-1988.

State	County	Location
Texas	Zapata	Falcon Reservoir
	Webb	Lake Casa Blanca
	Val Verde	Amistad Reservoir
New Mexico	Chaves	Bitter Lake National Wildlife Refuge

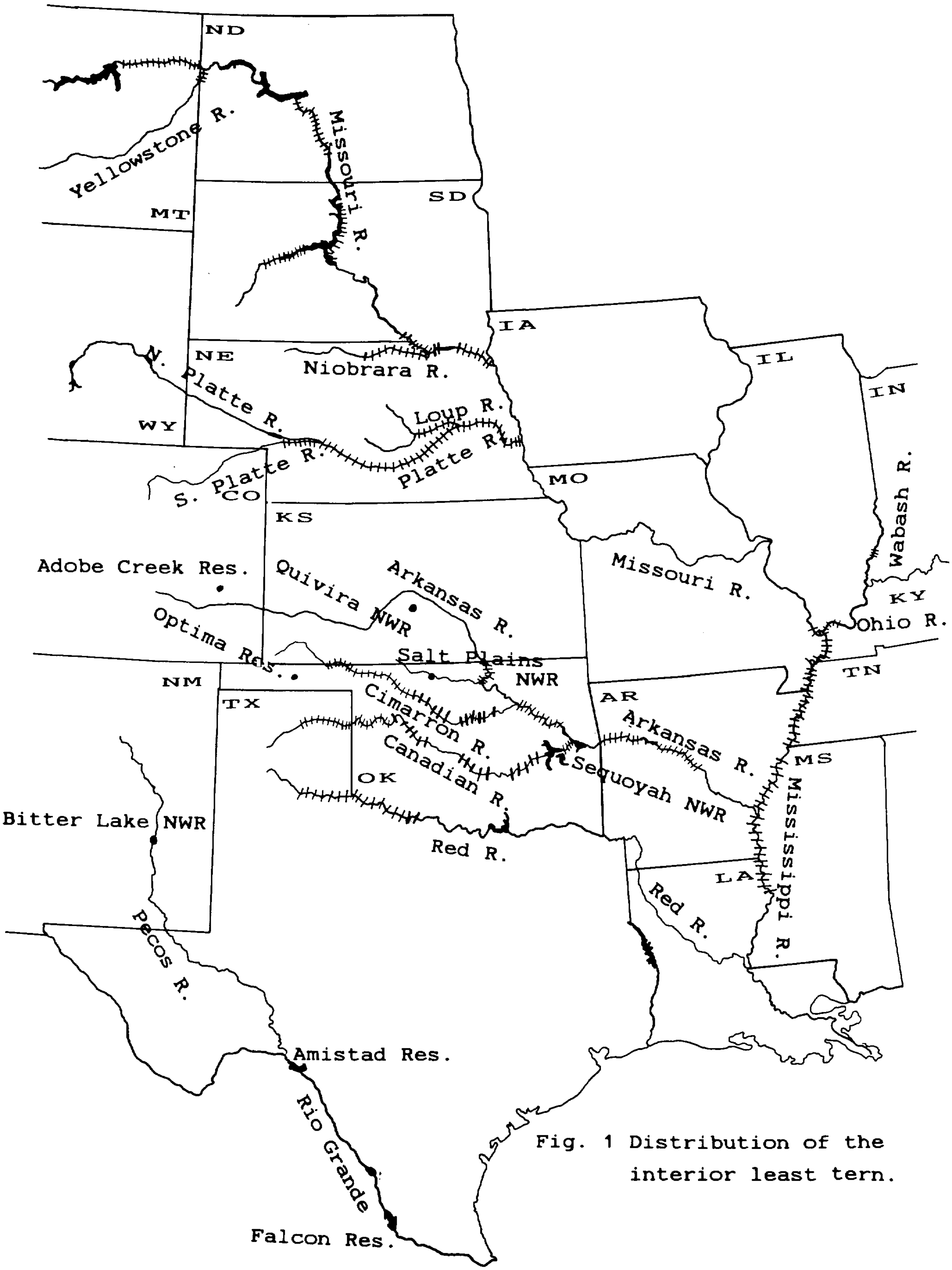


Fig. 1 Distribution of the interior least tern.

Life History

Breeding Behavior: Interior least terns spend about 4-5 months at their breeding sites. They arrive at breeding areas from late April to early June (Faanes 1983, Hardy 1957, U. S. Fish and Wildlife Service 1987a, Wilson 1984, Wycoff 1960, Youngworth 1930). Courtship behavior of least terns is similar throughout North America. Courtship occurs at the nesting site or at some distance from the nest site (Tomkins 1959). It includes the fish flight, an aerial display involving pursuit and maneuvers culminating in a fish transfer on the ground between two displaying birds. Other courtship behaviors include nest scraping, copulation and a variety of postures, and vocalizations (Ducey 1981, Hardy 1957, Wolk 1974).

The nest is a shallow and inconspicuous depression in an open, sandy area, gravelly patch, or exposed flat. Small stones, twigs, pieces of wood and debris usually lie near the nest. Least terns nest in colonies or terneries, and nests can be as close as just a few meters apart or widely scattered up to hundreds of meters (Ducey 1988, Anderson 1983, Hardy 1957, Kirsch 1990, Smith and Renken 1990, Stiles 1939). The benefit of semi-colonial nesting in least terns may be related to anti-predator behavior and social facilitation (Burger 1988).

Interior least tern eggs are pale to olive buff and speckled or streaked with dark purplish-brown, chocolate, or blue-grey markings (Hardy 1957, Whitman 1988). Occasionally, eggs are pink instead of pale to olive buff (P. Mayer and M. Schwalbach, personal communication), The birds usually lay two or three eggs (Anderson 1983, Faanes 1983, Hardy 1957, Kirsch 1987-89, Sweet 1985, Smith 1985). The average clutch size for interior least terns nesting on the Mississippi River during 1986-1989 was 2.4 eggs (Smith and Renken 1990). Egg-laying begins by late May. Both sexes share incubation which generally lasts 20-25 days but has ranged from 17 to 28 days (Faanes 1983, Hardy 1957, Moser 1940, Schwalbach 1988, G.R. Lingle, personal communication).

The precocial behavior of interior least tern chicks is similar to that of other least terns. They hatch within one day of each other, are brooded for about one week, and usually remain within the nesting territory but as they mature, wander further. Fledging occurs after three weeks, although parental attention continues until migration (Hardy 1957, Massey 1972, 1974; Tomkins 1959). Departure from colonies by both adults and fledglings varies but is usually complete by early September (Bent 1921, Hardy 1957, Stiles 1939). Thompson (1982) presented the following longevity data for coastal least terns revealed by band recoveries:

Age (years)	Percentage of Recoveries Known and Assumed Dead (N)
0-5	74 percent (58)
5-10	9 percent (7)
10-15	10 percent (8)
15-20	4 percent (3)
>20	3 percent

Population Biology: The interior least tern's annual reproductive success varies greatly along a given river or shoreline (Table 6). Because tern's use ephemeral habitats, they are susceptible to frequent nest and chick loss. Consequently there are great local differences in productivity. In 1987, total number of interior least terns reached 4,800 (Table 7). This is considerably higher than the 1,200 interior least terns estimated by a partial survey in 1975 by Downing (1980). There are no comprehensive historic numbers to compare with these figures, although early qualitative descriptions indicate that the interior least tern was rather common (Burroughs 1961, Hardy 1957). Increased censusing efforts during the past few years probably account for the differences among recent census figures and earlier surveys.

Table 6. Some examples of the productivity of interior least terns.

Locations	Year	Nest Success	Fledgings per Pair	Frequency of Visits	% Population Monitored	Source
Missouri River North Dakota	1988 1989	0.62 0.56	0.42 0.21	7-10 days "	100% "	Mayer and Dryer 1989
Missouri River South Dakota	1986 1987		0.20 0.64	7-10 days "	100% "	Schwalbach 1988
Missouri River South Dakota	1988 1989	0.36 0.51	0.44 0.55	7-10 days "	100% "	Dirks 1990
Lower Platte River River Nebraska	1987 1988 1989	0.57 0.67 0.43	0.29 0.71 0.47	2-3 days " "	39% 44% 42%	Kirsch 1987-89
Cimarron River Kansas	1982-83	0.18	1.09-0.56	--	--	Schulenberg and Ptacek 1984
Salt Plains NWR, Oklahoma	1987	0.44- 0.33	0.44- 0.15	1-3 days		Hill 1987

Dispersal Patterns: Breeding site fidelity of coastal and California least terns is very high (Atwood et al. 1984, Burger 1984). This may also be true for the interior least tern in its riverine environment. An interior least tern banded in 1988 as a breeding adult on the Missouri River in North Dakota returned in 1989 to breed on a Missouri River sandbar in North Dakota (Mayer and Dryer 1990). In the Mississippi River valley, a bird banded as a breeding adult in 1987 was observed nesting at the same site in 1989, and three others banded as breeding adults in 1988 returned to nest within the same stretch of the Mississippi River in 1989 (Smith and Renken 1990). Two of those birds had returned to within 4.8 km of their former nesting site. Along the Platte River in Nebraska, interior least terns demonstrate a strong return pattern to previous nesting sites on the river and at sand and gravel pits regardless of reproductive success (E.Kirsch, G. Lingle, personal communication). One interior least tern captured in 1987 as a breeding adult at a Mississippi River ternery in Missouri had been banded as a chick in 1980 by Marsha Waldron; this bird was nesting at a site 131 km upriver from its natal Tennessee colony (Smith 1987, Smith and Renken 1990). Chick dispersal may be as far as that reported by Boyd and Thompson (1985) for a breeding Kansas bird that had been banded as a chick on the Texas coast.

Home Range and Territoriality: The interior least tern's home range during the breeding season usually is limited to a reach of river near the sandbar nesting site. At Salt Plains National Wildlife Refuge, home ranges were highly variable, ranging from 11 to 1,015 ha (Talent and Hill 1985). Variation likely was due to food limitations and chick loss. The home range may change if renesting birds select a different breeding site. At sand and gravel pits along the central Platte River in Nebraska, nesting interior least terns utilize the pit area as well as an adjacent stretch of river. Nesting territories are defended and birds defend any nest in the colony. In defending the territory, the incubating bird will fly up and give an obvious alarm call followed by repeated dives at the intruder (Hardy 1957). The strong defense of territories facilitates locating terneries during census surveys.

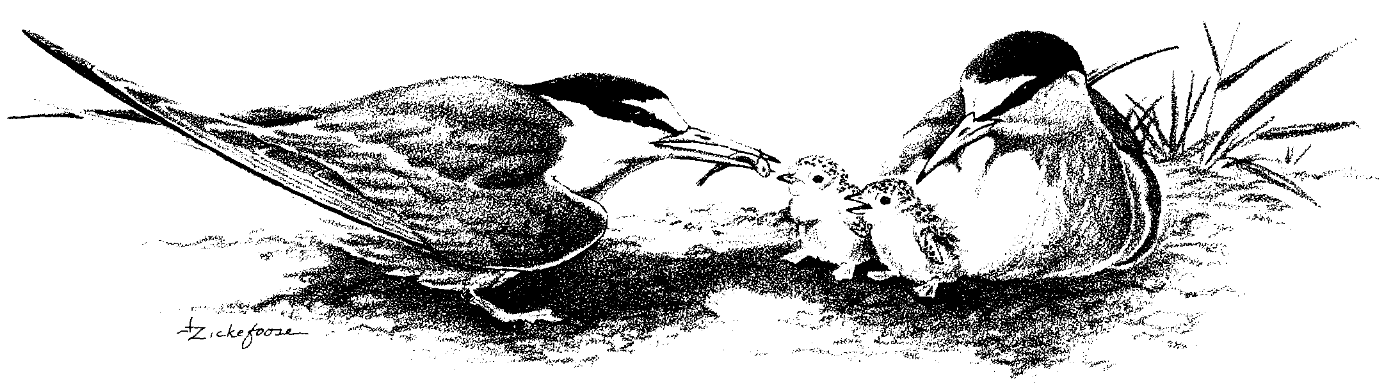


Table 7. Census data on the interior population of the least tern, 1985-1988[1].

Location	Number of adult least terns 1985	1986	1987	1988	Approximate length of river stretch (km) where nesting least terns intermittently occur	Source
			Mississippi River Basin			
1. Ft. Peck Reservoir, Missouri River, Montana	-*	--**	4	2	-	(Alfonso, unpublished data, Montana Piping Plover) Recovery Committee 1988)
2. Below Ft. Peck Reservoir, Missouri River, Montana	-	--	--	18	22	(D. Christopherson, unpublished data)
3. Yellowstone River, Montana	-	--	--	12	-	(Gorges, unpublished data)
4. Below Garrison Dam, Missouri River, North Dakota	114	169	175	142	192	(Dryer and Dryer 1985, Mayer and Dryer 1988)
5. Lake Sakakawea, Missouri River, North Dakota	-	-	-	7	-	(Mayer and Dryer 1988)
6. Lake Oahe, Missouri River	-	-	-	7	-	(Mayer and Dryer 1988)
7. Yellowstone River, North Dakota	-	22	20	24	30	(Kreil and Dryer 1987, Mayer and Dryer 1988)
8. Cheyenne River, South Dakota	-	31	54	27	26	(Schwalbach et al. 1986, 1988; Schwalbach 1988)

Table 7 (continued)

Location	Number of adult least terns 1985	1986	1987	1988	Approximate length of river stretch (km) where nesting least terns intermittently occur	Source
9. Lake Oahe, Missouri River, South Dakota	-	16	21	61	-	(Schwalbach et al. 1986, 1988; Schwalbach 1988)
10. Below Fort Randall and Gavins Point Dam, MO River, South Dakota to Ponca, NE	202	206	292	297	140	(Schwalbach et al. 1986, 1988; Schwalbach 1988)
11. Power plant ash lagoons near Council Bluffs, Iowa	18	28	22	22		(Dinsmore and Dinsmore 1989, Wilson 1984)
12. Niobrara R., Nebraska	174	-	143	200	190	(Nebraska Game and Parks Commission 1985a)
13. Platte River, Nebraska	256	438	606	635	502	(Nebraska Game and Parks Commission 1988; G. R. Lingle, personal communication)
14. Loup River, Nebraska	-	-	100	155	70	(S. Gauthreaux and Nebraska Game and Parks Commission, unpublished data)
15. Elkhorn River, Nebraska	2	8	4	-	-	(J. Dinan, Nebraska Game and Parks Commission, personal communication)
16. Mississippi R., Cape Girardeau, Missouri to Vicksburg, Mississippi	1264	2244	2488	2356	1100	(Rumancik 1985, 1986; J.W. Smith 1985, 1986, 1987, 1988; M. Smith 1986; W. King personal communication; Smith and Renken 1990)
17. Power plant, Wabash River, E. Mt. Carmel, IN	2	4	4	-	-	(Johnson 1987, Mills 1987)

Table 7 (continued)

Location	Number of adult least terns 1985	1986	1987	1988	Approximate length of river stretch (km) where nesting least terns intermittently occur	Source
18. Arkansas River, Arkansas (above Little Rock)	50	80	130	119	256	(Smith and Shepherd 1985, K. Smith 1986, Smith et al. 1987)
19. Arkansas River, Oklahoma	-	78	200	200	119	(Hoffman 1986, L. Hill personal communication)
20. Quivira National Wildlife Refuge, Kansas (Rattlesnake Creek of Arkansas River)	48	48	54		-	(Boyd 1986, 1987)
21. Adobe Creek Reservoir Colorado	-	-	6	10	-	(Barbara Campbell, personal communication)
22. Salt Plains National Wildlife Refuge, Oklahoma (Salt Fork of the Arkansas River)	-	140	210	-	-	(Boyd 1986, 1987)
23. Cimarron River, Kansas and Oklahoma	82	150	132	-	121	(Boyd 1986, 1987)
24. Optima Reservoir, Oklahoma (Beaver River)	46	52	60	38	-	(Boyd 1986, 1987; L. Hill)
25. Canadian River, western Oklahoma and Texas	127	182	20	16	253	(McCament and Thompson 1985, 1987; U. S. Fish and Wildlife Service, unpublished data)

Table 7 (continued)

Location	Number of adult least terns 1985	1986	1987	1988	Approximate length of river stretch (km) where nesting least terns intermittently occur	Source
26. Canadian River, Eufaula Dam to Arkansas River, including Sequoyah National Wildlife Refuge	-	-	105	34	43	(L. Hill personal communication)
27. Canadian River at Norman, Oklahoma	-	-	-	12	3	(L. Hill, personal communication)
28. Prairie Dog Town Fork of Red River, Texas	44	50	12	16	241	(McCament and Thompson 1985, 1987; B. Thompson, pers. commun.)
Rio Grande River Basin						
29. Falcon Reservoir, Rio Grande River	500	150	50	222	-	(McCament and Thompson 1985, 1987; B. Thompson, pers. commun.)
30. Lake Casa Blanca	5	-	14	50	-	(McCament and Thompson 1985, 1987; B. Thompson, pers. commun.)
31. Amistad Reservoir, Rio Grande River	20	9	-	14	-	(McCament and Thompson 1985, 1987; B. Thompson, pers. commun.)

Table 7 (continued)

Location	Number of adult least terns 1985	1986	1987	1988	Approximate length of river stretch (km) where nesting least terns intermittently occur	Source
32. Bitter Lake National Wildlife Refuge, New Mexico (Pecos River)	-	8	6	6	-	(Shomo, 1988 and S. Williams, New Mexico Game and Fish Department, unpublished report)
Total	2952	4113	4932	4702	3308	

[1]The census results should be viewed in light of the extent and frequency of census efforts. Increases or decreases from year to year may not be related to reproductive performance.

* no census conducted in that year.

** area surveyed but no birds found

Diet: The interior least tern is piscivorous, feeding in shallow waters of rivers, streams and lakes. Other least terns also feed on crustaceans, insects, mollusks and annelids (Whitman 1988). The terns usually feed close to their nesting sites. Fish prey is small sized and important genera include Fundulus, Notropis, Campostoma, Pimephales, Gambusia, Blonesox, Morone, Dorosoma, Lepomis and Carpiodes (Grover 1979, Hardy 1957, Rumancik 1988, 1989; Schulenberg et al. 1980, Smith and Renken 1990, Wilson et al. 1989). Moseley (1976) believed least terns to be opportunistic feeders, exploiting any fish within a certain size range. Fishing occurs close to the riverine colony. Terns nesting at sand and gravel pits and other artificial habitats may fly up to 3.2 km to fish. Radio-tagged terns at Salt Plains National Wildlife Refuge often traveled 3.2-6.4 km to fish (Talent and Hill 1985). Fishing behavior involves hovering and diving over standing or flowing water.

Interspecific Interactions: Interior least terns are breeding associates of the piping plover (Charadrius melodus) in the Missouri River system (Dryer and Dryer 1985, Faanes 1983, Nebraska Game and Parks Commission 1987, Schwalbach 1988) and the snowy plover (Charadrius alexandrius) and American avocet (Recurvirostra americana) in the Arkansas River system (Grover and Knopf 1982, Hill 1985). Nesting piping plovers usually can be found within or near nesting interior least terns at sand and gravel pits and on riverine sandbars.

Habitat Requirements

Least terns throughout North America nest in areas with similar habitat attributes.

Coastal Areas: Coastal and California least terns usually nest on elevated portions of level, unvegetated substrates near foraging areas (Carreker 1985). Beaches, sand pits, sandbars, islands and peninsulas are the principal breeding habitats (Moseley 1976). Nesting can be close to water but is usually between the dune environment and the high tide line (Akers 1975, Blodget 1978). Unconsolidated substrate such as small stones, gravel, sand, debris and shells comprise the nesting substrate. A mixture of coarse sand, shells and other fragments may be preferred over fine-grained substrates because of better cryptic qualities, stability in wind, and water permeability (Burroughs 1966, Craig 1971, Gochfeld 1983, Jernigan et al. 1978, Soots and Parnell 1975, Swickard 1972, Thompson and Slack 1982).

Vegetation at California and coastal least tern nesting sites is sparse, scattered and short. Vegetation cover is usually less than 20% at the time of nesting (Craig 1971, Thompson and Slack 1982, Gochfeld 1983). Least tern colonies in denser vegetation may be a response to habitat loss or a function of strong site tenacity.

Rivers: The riverine nesting areas of interior least terns are sparsely vegetated sand and gravel bars within a wide unobstructed river channel, or salt flats along lake shorelines. Nesting locations usually are at the higher elevations and away from the water's edge because nesting starts when the river flows are high and small amounts of sand are exposed. The size of nesting areas depends on water levels and the extent of associated sandbars. An examination of the interior least tern's nesting ecology on the Missouri River (Schwalbach et al. 1988) illustrates the changes caused by varying river flows. Along one stretch of the Missouri River in South Dakota the average size of nesting sandbars was 12 and 31 ha in 1986 and 1987, respectively; nest elevation and nest to water distance differed by a factor of three in both years.

The Lower Mississippi River is very wide and carries a tremendous volume of water and sand. Sandbars form annually, are washed away, and shift position. Many sandbars are over 3.2 km long and 1.2 km wide. Nest sites are often several hundred meters from the water (Rumancik 1987, 1988). Thus, nesting areas usually are several hundred hectares in size. Mississippi River levels at the onset of nesting also influences the number of nests at a colony. Smith and Renken (1990) observed Mississippi River colonies that averaged 100 nests/colony when habitat was restricted by high water early in the nesting period, but which averaged only 19.3 nests/colony during a year of more moderate river levels.

Artificial Nesting Habitat: Least terns nest on artificial habitats such as sand and gravel pits and dredge islands (Dryer and Dryer 1985, Haddon and Knight 1983, Kirsch 1987-89, Larkins 1984, Morris 1980). In North America the coastal and California least terns commonly nest on a variety of artificial nesting habitats, even roof-tops (Altman and Gano 1984, Atwood et al. 1979, Fisk 1975, 1978; Jernigan 1977, Massey and Atwood 1980, 1983; Swickard 1974).

The interior least tern nests on dike fields along the Mississippi River (Smith and Stucky 1988; Smith and Renken 1990), at sand and gravel pits (Kirsch 1987-89), ash disposal areas of power plants (Dinsmore and Dinsmore 1988, Johnson 1987, Wilson 1984), along the shores of reservoirs (Boyd 1987, Chase and Loeffler 1978, Neck and Riskind 1981, Schwalbach 1988) and at other manmade sites (Shomo 1988). The percentage of interior least terns nesting on pits adjacent to the lower reach (Columbus to Plattsmouth) of the Platte River varies depending on the flow and amount of exposed sandbar habitat (Kirsch 1987-89). Suitable nesting habitat in the upper Platte River channel has been severely reduced (Sidle et al. 1989) and in many stretches of the river, sand and gravel pits annually provide the only nesting habitat (Lingle 1989). It is unknown to what extent sand and gravel pits, dike fields, reservoir shorelines and other artificial habitats have replaced natural habitat. In the lower Mississippi River alone, 7,518 ha of bar and island habitat were lost in diked reaches between 1962 and 1976 (Nunnally and Beverly 1986, Smith and Stucky 1988).

Reasons For Current Status

Habitat alteration and destruction: Channelization, irrigation, and the construction of reservoirs and pools have contributed to the elimination of much of the tern's sandbar nesting habitat in the Missouri, Arkansas, and Red River systems (Funk and Robinson 1974, Hallber et al 1979, Sandheinrich and Atchison 1986). Ducey (1985), for example, describes the changes in the channel characteristics of the Missouri River since the early 1900s under the Missouri River Bank Stabilization and Navigation Project. The wide and braided character of the Missouri River was engineered into a single narrow navigation channel. Most sandbars virtually disappeared between Sioux City, Iowa and Saint Louis, Missouri (Sandheinrich and Atchison 1986, Smith and Stucky 1988).

Where sandbars still occur along the Nebraska-South Dakota boundary (Missouri River), approximately 3,156 ha of sandbar habitat have been lost between 1956 and 1975 (Schmulbach et al. 1981). Sandbars along the Nebraska-Iowa Missouri River boundary have been virtually eliminated with the exception of 890 ha inventoried along the 80-km Missouri National Recreation Area (Schmulbach et al. 1981).

Current regulation of Missouri River dam discharges pose additional problems for interior least terns nesting in remaining habitats (Nebraska Game and Parks Commission 1985c, Schwalbach et al. 1988). Before regulation of river flows, summer flow patterns were more predictable. Peak flows occurred in March from local runoff and then again in May and June when mountain snowmelt occurs. Flows then declined during the rest of the summer allowing interior least terns to nest as water levels dropped and sandbars became available (Stiles 1939, Hardy 1957). Currently, the main stem system is supposed to be regulated for hydropower, navigation, water quality and supply, flood evacuation, irrigation, fish and wildlife conservation, and public recreation. However, system releases are designed to provide equitable service to power and navigation demands, except when they conflict with flood control functions of the system.

The demands are unpredictable and flows can fluctuate greatly. Flow regimes differ greatly from historic regimes. High flow periods may now extend into the normal nesting period, thereby reducing the quality of existing nest sites and forcing interior least terns to initiate nests in poor quality locations. Extreme fluctuations can flood existing nests, inundate potential nesting areas, or dewater feeding areas. Interior least terns along the Arkansas River in Oklahoma and Arkansas contend with dam discharge problems similar to those on the Missouri River.

Along the Lower Mississippi River, and elsewhere, natural river discharge may exert considerable influence on reproductive success. A wet spring may delay river fall and habitat may not be available until later. Rises in the river during the spring and summer may inundate nests and wash away chicks (Rumancik 1986, 1989, Smith and Renken 1990). Renesting, however, does occur and may be an adaptation to river fluctuations. Dike construction has created many sandbars between the dikes and many nesting colonies are located on these sandbars (Landin et al. 1985, Rumancik 1986, 1987, 1988, 1989; J. Smith 1985, 1986, 1987). The extent to which these sandbars are attaching to the riverbank and reducing tern habitat is not known but according to Smith and Stucky (1988) the processes of dike field terrestrialization are well underway at several least tern colony sites in the lower Mississippi River.

Reservoir storage of flows responsible for scouring sandbars has resulted in the encroachment of vegetation along many rivers such as the Platte River, Nebraska and greatly reduced channel width (Currier et al. 1985, O'Brien and Currier 1987, Eschner et al. 1981, Lyons and Randle 1988, Sidle et al. 1989, Stinnett et al. 1987). In addition, river main stem reservoirs now trap much of the sediment load resulting in less aggradation and more degradation of the river bed and subsequently less formation of suitable sandbar nesting habitat. Riverine habitat along the central Platte River may require extensive vegetation clearing and other intensive management. In contrast, the lower Platte River (Columbus, Nebraska to the Missouri River confluence) has not undergone as extensive habitat changes as the central Platte. During 1987-1989, riverine sandbar habitat hosted 72% of the nests on the lower Platte and only 12% of the nests on the central Platte (Kirsch 1989, Lingle 1989).

Human disturbance: Many rivers have become the focus of recreational activities. Human presence reduces reproductive success (Mayer and Dryer 1988, Smith and Renken 1990). In mid-America, sandbars are fast becoming the recreational counterpart of coastal beaches. Even sand and gravel pits and other artificial nesting sites receive a high level of human disturbance.

Conservation Efforts

During the past few years there has been a great increase in the number of interior least tern surveys, research projects and public relations endeavors to protect the birds on the part of both public and private conservation organizations. Proposed federal listing of the interior least tern prompted much of the interest in the northern Great Plains and elsewhere. Today, many state, federal and private organizations are collaborating to census the birds, curtail human disturbance and conduct research.

Under authority of Section 7 of the Endangered Species Act, the U. S. Fish and Wildlife Service is consulting with the U. S. Army Corps of Engineers on whether dam operations on the Missouri and Arkansas Rivers jeopardize the continued existence of the interior least tern (U.S Fish and Wildlife Service 1989, 1990). The outcome of these formal consultations is crucial to the recovery of the interior least tern. Areas of habitat along the Missouri River, for example, continue to degrade due to physical controls on the river and present water management schemes. Changes in the water release regime and physical manipulation of habitat will be necessary.

Aside from the Section 7 consultation on the Missouri River, the Corps Master Manual for river operations is under review. If upper Missouri River Basin states have their way for holding water in the reservoirs for recreation and fisheries, navigation in the Missouri River could be reduced and maintenance of the commercial navigation project above Omaha could become infeasible. The reach between Sioux City, Iowa and the mouth of the Platte River could once more be available to interior least terns.

Montana: Current efforts include surveys to determine the number and distribution of interior least terns along the Missouri and Yellowstone Rivers and along the shores of the Fort Peck Reservoir.

North Dakota: Censusing has been conducted along the Missouri River since 1982 and along the Yellowstone River since 1986. Habitat requirements are being estimated and recommendations are being made for the management of Missouri River habitat. Research continues on reproductive success and on methods to increase productivity. Resource agencies are involved with a variety of public relations efforts to curtail human disturbance on Missouri River sandbars and islands.

South Dakota: Detailed studies of interior least tern nesting ecology continue at Missouri and Cheyenne River sandbars and along the reservoir shoreline of Lake Oahe. Resource agencies are involved with public relations efforts to curtail human disturbance on the Missouri River. Management activities include the posting of nesting sites and informational signs at boat ramps and elsewhere. This has been complemented with enforcement actions being taken by state and federal officials. Recent amendments to South Dakota law prohibit the harassment of least tern nesting and rearing sites on the Missouri River.

Nebraska: Nebraska supports one of the largest breeding populations of interior least terns. Annual surveys have been carried out since 1979. Efforts are underway to quantify available nesting habitat on the Platte River at various river flows. Research on reproductive success, habitat selection, foraging ecology, predation and the value of sand and gravel pits continues along the Platte River (Kirsch 1987-89, Lingle 1989, Wilson et al. 1989).

A flow management plan has been prepared for the Missouri River (Nebraska Game and Parks Commission 1985c) and certain instream flows have been determined on the Platte River for the interior least tern, its habitat and forage fish, and for other wildlife and resources (Table 8). In 1990 the Federal Energy Regulatory Commission (FERC) ordered the Nebraska Public Power District to maintain the instream flows in Table 8 for interior least terns (50 FERC Report (CCH) 61,180) (Sidle et al. 1990). The District seeks a new license to operate diversion dams and other facilities associated with the Lake McConaughy reservoir on the North Platte River. Lake McConaughy was constructed in the late 1930s and licensed for 50 years. The dam, diversion structures, and other facilities have had a major impact on the downstream habitat of the interior least tern. When granting a new power license the Federal Power Act requires FERC to give equal consideration to the protection, mitigation of damage to, and enhancement of, fish and wildlife.

Posting, extensive news media efforts, posters, brochures, information signs at river entry points, and law enforcement patrols are some of the additional activities being carried out in Nebraska. The Platte River Whooping Crane Habitat Trust is trying to rehabilitate sandbars in the central Platte River (Lexington to Grand Island) by removing vegetation over extensive areas of the river channel. FERC also ordered the Nebraska Public Power District to construct eight permanent five- to ten-acre sites for interior least tern nesting in the central Platte River where nesting habitat has been severely degraded, in part by the upstream Lake McConaughy and associated water diversion canals and offstream reservoirs.

Finally, Nebraska law requires state agencies to consult with the Nebraska Game and Parks Commission on any action authorized, funded, or carried out by the state agencies. This insures that such actions do not jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of habitat. The Commission reviews state sponsored or authorized projects that may impact endangered or threatened species and issues biological opinions to the state agencies.

Colorado: The interior least tern is known to breed at Adobe Creek reservoir and has been observed at Nee Noshe reservoir. Public relation efforts and other endeavors are underway to address fluctuating water levels, human disturbance, vegetation encroachment, and predation.

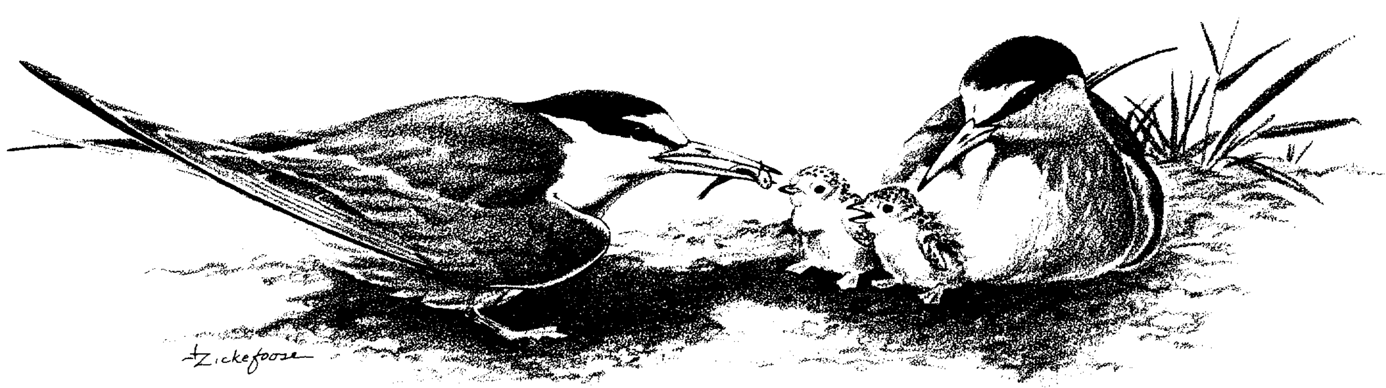
Iowa: Largely devoid of natural interior least tern habitat, Iowa's conservation efforts have focused on monitoring and protecting the few nest sites located on fly-ash disposal sites of two power generating stations along the Missouri River at Council Bluffs and Sioux City. Both sites are monitored to record the number of nesting pairs and reproductive success. The Council Bluffs nesting habitat also is protected by a management plan. The plan specifies that both people and heavy equipment will be kept out of the nesting area during the breeding season.

Interior least tern decoys have been set out at the DeSoto National Wildlife Refuge to attract terns which formerly nested there in the 1970s. Woody vegetation has been cleared and the areas are disked to maintain open habitat.

Table 8. Recommended annual flow regime for Central Platte River, Nebraska[1]

Time Period	Flow(cfs[2])	Species/Resources of Concern	Existing Median Flow(cfs) (1958-1985)
Jan 1-Mar 22	1,100	Bald Eagle, wet meadow sandhill crane, waterfowl, least tern forage fish, sport fish	1,710
Mar 23-May 10	2,000	Whooping crane, sandhill crane, waterfowl, least tern forage fish, sport fish	1,823
May 11-May 14	800	Least tern forage fish, sport fish	1,433
May 15-Sep 15	800	Least tern, piping plover, tern forage fish, sport fish	781
Sep 16-Nov 15	2,000	Whooping crane, sandhill crane, waterfowl, least tern forage fish, sport fish	893
Nov 16-Dec 9	1,000	Waterfowl, least tern forage fish, sport fish	1,186
Dec 10- Dec 31	1,100	Bald eagle, waterfowl, least tern forage fish, sport fish	1,253

[1]As measured at the U. S. Geological Survey gage at Grand Island.
[2]Cubic feet per second



Missouri: The Missouri Department of Conservation maintains an active conservation, management and research program for interior least terns. The Missouri River has been thoroughly surveyed for potential habitat; Mississippi River colonies are closely monitored and under detailed study; and management plans have been developed. Regulations provide special protective status for least tern nesting areas on Department owned islands and sandbars. Public information programs about the interior least tern are widespread.

Kansas: The Kansas Department of Wildlife and Parks has funded research on distribution, reproductive success, banding and inter-colonial movements, foraging ecology, and predation since 1980. Annual surveys along the Cimarron River and at the Quivira National Wildlife Refuge have been conducted since 1980. Successful habitat alteration and management has been on-going since 1985. Studies also have focused on the issue of inadequate instream flows in both the Cimarron and Arkansas rivers in Kansas.

Oklahoma: The largest concentration of least terns in Oklahoma is at Salt Plains National Wildlife Refuge. This area has been studied intermittently since 1977. Research at river nesting sites has been on-going since 1982. The Cimarron and Arkansas rivers have received more survey and distribution effort than the Red and Canadian rivers. Various studies of reproductive success, inter-colonial movements and foraging ecology have been conducted at Salt Plains, Optima Reservoir and the western reaches of the Cimarron River. Posting, fencing and extensive news media efforts have been successful at Optima Reservoir and the western reaches of the Cimarron River. Nesting sites on the Cimarron River continue to be threatened by several river diversion and impoundment proposals. A memorandum of understanding has been developed between The Nature Conservancy, U. S. Army Corps of Engineers, Oklahoma Department of Wildlife Conservation, U. S. Fish and Wildlife Service, Tulsa Audubon Society, River Parks Authority and riverbed landowners for protection and management of essential habitat on the Arkansas River in Tulsa County.

Mississippi River States: The U. S. Army Corps of Engineers has undertaken extensive census work along the Mississippi River between Illinois and Vicksburg, Mississippi, and along the Arkansas River to the Oklahoma border. Their surveys have provided the only information on the tern on the Mississippi River below the State of Missouri. The locations of colonies are monitored and the information is used by regulatory personnel to evaluate permit applications and in planning operations and maintenance activities on the lower Mississippi River.

Texas and New Mexico: The Texas Parks and Wildlife Department has examined the numbers and distribution of interior least terns along the Rio Grande River and rivers in the Texas Panhandle, and investigated genetic characteristics of coastal and interior least terns. The New Mexico Department of Game and Fish has conducted several years of surveys and studies and developed management recommendations for interior least terns at and near the Bitter Lake National Wildlife Refuge along Pecos River (Jungemann 1988).

II. RECOVERY

Recovery objective

The purpose of this plan is to describe actions necessary to achieve recovery of interior least terns. The first step in this approach is to set a quantifiable goal (i. e., recovery objective) that, when reached, will assure populations remain stable. The remainder of this plan outlines steps necessary to achieve the recovery objective. Recovery goals, objectives and tasks may change as we learn more about the interior least terns.

Recognizing that the interior least tern has a broad distribution, the recovery objective was set by taking into account: 1) current data on distribution and abundance of interior least terns in each river system; 2) knowledge of how thoroughly each river system has been surveyed; 3) historic population data, when available; 4) loss of viable habitat; 5) an assessment of the potential to increase breeding pairs at currently occupied sites; 6) assessment of the potential to establish breeding pairs at unoccupied sites. Technical experts and state and federal resource agencies were consulted to determine the status of current populations and habitats, as well as the potential for population increase.

Therefore, in order to be considered for removal from the endangered species list, interior least tern essential habitat will be properly protected and managed and populations will have increased to 7,000 birds:

I. Missouri River System
   A. Number of birds in the Missouri River system will increase to 2,100 adults.
   B. Essential breeding habitat (Appendix 4) will be protected, enhanced and restored.
   C. The breeding pairs will be maintained in the following distribution for 10 years (assuming at least four major censuses will have been conducted during this time):
      Montana - 50 adults
      North Dakota - 250 adults
      South Dakota - 680 adults (includes 400 shared with Nebraska on the Missouri River).
      Missouri River below Gavin's Pt. Dam - 400 adults
      Lake Oahe - 100 adults
      Missouri River below Ft. Randall - 80 adults
      Other Missouri River sites - 20 adults
      Cheyenne River - 80 adults
      Nebraska - 1520 adults (includes 400 adults shared with South Dakota on the Missouri River).
      Missouri River - 400 adults
      Niobrara River - 200 adults
      Loup River - 170 adults
      Platte River - 750 adults
      Missouri and Iowa - Opportunities for habitat restoration and reestablishment of breeding pairs will be determined.

II. Mississippi and Ohio Rivers
   A. Current number of adult birds (2,200-2,500) on the Lower Mississippi River will remain stable for the next ten years.
   B. Essential breeding habitat (Appendix 4) will be protected, enhanced, and restored.

III. Arkansas River System
   A. Numbers of birds on the Arkansas River system will increase to 1,600 adults.
   B. Essential breeding habitat (Appendix 4) will be protected, enhanced and restored.
   C. The 1,600 breeding adults will be maintained in the following distribution for 10 years:
      Arkansas River, Arkansas - 150 adults
      Arkansas River, Oklahoma - 250 adults
      Quivira National Wildlife Refuge - 100 adults
      Salt Plains National Wildlife Refuge - 300 adults
      Cimarron River Basin - 400 adults
      Canadian River - 300 adults
      Beaver/ North Canadian River - 100 adults

IV. Red River System
   A. Number of birds in the Red River system will increase to 300 breeding adults.
   B. Essential Breeding habitat (Appendix 4) will be protected, enhanced and restored.
   C. The 300 adults will be distributed along the Prairie Dog Town Fork where interior least terns currently occur and at other essential habitat sites yet to be determined.

V. Rio Grande River System
   A. Current number of adult birds (500) in the Rio Grande River system will remain stable for 10 years.
   B. Essential breeding habitat will be protected, enhanced and restored.
   C. The birds will be distributed along the Rio Grande and Pecos Rivers.

<u>Step-Down Outline</u>

The step-down outline lists tasks necessary to meet the recovery objective. Steps (or tasks) are not presented in order of importance. Some steps are underway, while others may take years before they are begun. An explanation of these steps is presented in the Narrative section of this plan. Following the Narrative, the Implementation Schedule lists and sets priorities to be taken in the next three years. The step-down outline is very similar to the step-down outline in the Great Lakes/Northern Great Plains Piping Plover recovery plan (U. S. Fish and Wildlife Service 1988a) because both species breed in the same habitat areas in the Missouri River system and require similar recovery tasks.

1. Determine current distribution and population trends of the interior least tern.
   11. Assess status and distribution of breeding populations.
      111. Survey sandbars, reservoir shorelines, sand and gravel pits and other suitable habitats to determine breeding

distribution.
112. Develop a method for standardization of census techniques and timing of censuses.
113. Census known and potential breeding sites.
114. Monitor reproductive success.
115. Assess dispersal patterns and genetic diversity.
116. Assess mortality.
117. Further identify life history parameters and develop population models.
12. Assess status and distribution for the migration period.
13. Assess status and distribution during the winter.
131. Survey beaches and other suitable habitat to determine winter distribution.
132. Census known wintering areas.
133. Monitor movement of birds between wintering sites and assess mixing of populations.
134. Assess mortality on wintering areas.

2. Determine current habitat requirements and status.
21. Determine breeding habitat requirements and status.
211. Assess the characteristics, including prey resources, of breeding habitat.
212. Quantify and evaluate available breeding habitat.
213. Examine historic aerial photography and hydrographic surveys of river systems to determine the previous extent of potential habitat and vegetational changes.
22. Determine current migration habitat requirements and status.
221. Assess the characteristics, including prey resources, of migration habitat.
222. Quantify and evaluate available migration habitat.
23. Determine current habitat requirements and status on wintering areas.
231. Assess the characteristics, including prey resources, of winter habitat.
232. Quantify and evaluate winter habitat.
3. Protect, enhance, and increase interior least tern populations.
31. Protect, enhance, and increase populations during the breeding season.
311. Increase reproduction and survival at occupied breeding sites.
3111. Evaluate predator impacts on eggs and chicks and identify species responsible for the predation.
3112. Evaluate techniques for predator management and implement where appropriate.
3113. Restrict public use within nesting areas and investigate enforcement options.
3114. Manage water levels and river flows to reduce nest and chick loss.
3115. Modify or eliminate construction activities that adversely impact reproductive success.

3116. Investigate the effects of environmental contaminants at breeding areas.

32. Protect and enhance populations during migration and winter.

321. Manage areas to maximize survival of birds during migration.

322. Manage winter areas to maximize survival of birds during winter.

3221. Investigate the effects of human activities on winter survival.

3222. Investigate the effects of environmental contaminants.

4. Preserve and enhance habitat.

41. Provide protection and management of breeding habitat.

411. Identify areas of essential breeding habitat.

412. Continue to evaluate areas for consideration as essential breeding habitat.

413. Establish liaison with agencies and organizations with land and water management responsibilities.

414. Revise, establish, or utilize land and water laws and regulations to provide protection along rivers and lakes.

415. Develop criteria and priorities for breeding habitat protection.

416. Develop management plans for breeding habitat.

4161. Determine direct, indirect and cumulative effects of manipulation of river hydraulics, flow regimes, and sediment discharge on breeding and foraging habitat.

4162. Identify river flow regimes that will protect and enhance breeding and foraging habitat.

4163. Determine the relationship of existing artificial breeding sites to river sites.

4164. Identify need and techniques of improving habitat by management of substrate and by vegetation control through physical and/or non-toxic chemical means.

4165. Study feasibility and determine need for creating new habitat and implement trials to determine success rates of creating new habitat.

4166. Develop lake and reservoir control policies where existing and potential interior least tern habitat is threatened.

4167. Identify needs and techniques for managing water levels.

417. Evaluate success of protection and management techniques.

42. Provide protection and management of migration habitat.

43. Provide protection and management of winter habitat.

431. Identify areas of essential winter habitat.

432. Develop criteria and priorities for winter habitat protection.

433. Develop management techniques.

434. Modify construction activities that may reduce or negatively alter winter habitat.

435. Evaluate success of protection and management techniques.

5. Develop and implement an education program that publicizes information on the interior least tern, including its life history, reasons for

current status, and options for recovery.

51. Inform and educate the public on the bird's plight and recovery efforts.
    - 511. Identify target audiences among the general public.
    - 512. Develop and distribute educational materials appropriate to various audiences.
    - 513. Develop materials for newspapers, radio, and television that highlight specific interior least tern projects.
    - 514. Provide controlled viewing opportunities if and when appropriate.

52. Inform and educate public resource management agencies.
    - 521. Identify critical resource agency constituents.
    - 522. Develop educational materials appropriate to respective agencies and their management authority.
    - 523. Provide public resource agencies with periodic updates on the interior least tern's status and progress of recovery efforts.

6. Coordinate recovery efforts.
    61. Designate a recovery plan coordinator.
    - 611. Coordinate research and management activities with federal,state, local and private organizations.
    - 612. Coordinate international research and management activities.
    - 613. Coordinate development of a public information program at the national and international level.

Narrative

The Narrative gives further details and justification for each task in the Step-Down Outline. The steps critical for recovery in the next three years are outlined and given priority in the Implementation Schedule.

1. <u>Determine current distribution and population trends of the interior least tern.</u>

The effectiveness of current conservation efforts will not be well-understood until comprehensive distribution and census data have been collected. Future plans for recovery also will be curtailed until a more accurate picture of the species status is defined.

11. <u>Assess status and distribution of breeding populations</u>.

Most interior least tern censusing has been carried out during the breeding season. Results indicate interior least terns are widely distributed, as scattered pairs or in concentrations at breeding areas. The terns probably disperse great distances as suggested by Boyd and Thompson (1985). Continued search for new breeding areas and evaluation of known areas are necessary to complete our knowledge of the birds' status.

111. Survey sandbars, reservoir shorelines, sand and gravel pits and other suitable habitats to determine breeding distribution.

Currently, the distribution of the interior least tern on most of the Missouri River system is well-known and monitored, although reservoir shorelines in the Dakotas and Montana should be further surveyed for accurate population estimates especially during drought years when reservoir levels are low. Additional survey work is needed on the Loup River in Nebraska and elsewhere in the Platte River system. The Arkansas River system needs further survey work in Arkansas, Kansas, Oklahoma and Texas. The length of the Red River requires a thorough survey as does the Rio Grande River system and rivers in central Texas. Additional survey work is needed on the Lower Mississippi River to determine distribution when the river rises and floods nesting colonies. The Missouri Department of Conservation has a study in progress to address this need. The status of potential sites should be monitored and updated at least once every five years.

112. Develop a method for standardization of census techniques and timing.

The exposure of sandbars in the spring follows the reduction of river flows. The breeding cycle may commence at different times throughout the interior least tern's range. Differences in breeding chronology from south to north must be determined. Because of the length of time involved in surveying long stretches of rivers, surveys should be correlated with reported river levels and the exposure of sandbars. Surveys should account for renesting birds and later nesting by younger adults (Massey and Atwood 1981, Smith and Renken 1990).

113. Census known and potential breeding sites.

Once sites are identified as containing breeding pairs, annual censuses of breeding and non-breeding adults should be carried out at essential breeding habitat (Appendix 4) for several years. If the birds are established for several years, censusing should continue at least once every year.

114. Monitor reproductive success.

Census data provide an indication of an area's population size, but estimates of reproductive success are also necessary. More adults may be present in nesting areas than actually breed. Frequent nest destruction further lowers productivity of a site, rendering simple counts of breeding pairs less meaningful than censuses of adults and fledged chicks. Reproductive success or recruitment (measured in terms of number of chicks fledged per pair) should be monitored annually at essential sites and at least every three years, on a rotating basis, at other sites. Causes of reproductive failure should be identified whenever possible. Because of possible early fledgling departure from colonies, multiple counts of fledglings should be made for determination of the fledging rate (Thompson 1982, Thompson and Slack 1983).

115. Assess dispersal patterns and genetic diversity.
Little is known about the interaction between coastal least terns and the interior least tern. Boyd and Thompson (1985) found a nesting least tern in Kansas which had been banded as a chick on the Texas coast. It would be useful to know if coastal least terns serve as a reservoir to replenish the interior least tern population; and if the status of the coastal least tern population determines the numbers and distribution of interior least terns. Monitoring movements of marked birds in major breeding areas will fill the gap in our understanding of dispersal. Knowledge of how new nest sites are colonized, and where new birds originated will be useful in developing population management plans and models.

116. Assess mortality.
Factors such as human disturbance, predation, and water level regulation have reduced success of interior least tern eggs and chicks (Mayer and Dryer 1990). Factors affecting adult mortality, however, have never been fully addressed for any part of the annual cycle. Predation is a problem for some California and coastal least terns (Burger 1984, Minsky 1980, Massey 1981) and the closely allied little tern in Europe (Haddon and Knight 1983). During the breeding season, predation on interior least terns by coyote (*Canis latrans*), crow (*Corvus brachyrhynchos*), and raptors has been reported (G. R. Lingle, personal communication, Hill 1985, Kirsch 1990, Mayer and Dryer 1990) and predation on nesting adults by barred owls (*Strix varia*) has been recorded (Smith and Renken 1990). Predation is significant on the Missouri National Recreational River (U. S. Fish and Wildlife Service, unpublished data). It is important to determine the extent and cause of adult and juvenile mortality during the breeding season.

117. Further identify life history parameters and develop population models.
Field studies of interior least terns should be carried out without reducing reproductive success or site tenacity. Future breeding studies only should be undertaken after researchers have identified specific critical factors that require resolution in order to rehabilitate the species. It would be useful to compile all available life history data and develop a model to estimate potential population trends.

12. Assess status and distribution for the migration period.
Less is known about the migratory ecology for the interior least tern than for any other phase of the annual cycle. Migratory routes have not been adequately described for spring or fall. It is not known if interior least terns follow major river systems during migration or if they migrate directly north and south. Further, it is unknown if interior least terns join coastal least terns prior to coastal least tern migration to Latin America or if interior least terns have their own migration route. Before

intensive individual field studies are undertaken, it may be beneficial to coordinate surveys of potential sites with natural resource employees or local birders to determine if interior least terns are stopping en route to wintering sites.

13. Assess status and distribution during the winter.
Interior least terns spend 6-7 months at wintering sites. Most field research, however, has been carried out on breeding birds. Factors limiting non-breeding birds may be as severe or worse than threats encountered during other times of the year. Field studies should begin to at least locate wintering sites.

    131. Survey beaches and other suitable habitat to determine winter distribution.
    Biologists familiar with the avifauna of Atlantic and Caribbean coastal Latin America should be contacted to assist in determining the winter distribution of least terns. A survey of the north coast of South America should be carried out to identify those habitat types used by least terns. However, the surveys may be difficult. Accessibility of coastal areas along central America and the northern coast of South America may be problematic for geographical and political reasons. Color-banded individuals would provide the means to distinguish interior least terns from other races or populations.

    132. Census known wintering areas.
    Once winter sites are known, censuses of important areas will provide an indication of their continuing importance and status as post-breeding sites.

    133. Monitor movement of birds between wintering sites and assess mixing of populations.
    It is not known if post-breeding interior least terns mix with coastal least terns at wintering sites. Once the habitat types of interior least terns are known, habitat protection can begin. Monitoring movements of birds between different sites will provide this information, as well as indicate the degree to which individuals from various breeding populations mix during the winter.

    134. Assess mortality on wintering areas.
    The extent and cause of mortality to post-breeding interior least terns has not been addressed. It is not clear if adults and juveniles suffer differential mortality, or if post-breeding birds face greater threats than do breeding birds. Any information leading to further delineation of threats to the species during this time will be important.

2. <u>Determine current habitat requirements and status</u>.
Habitat alteration has been identified as one of the principal causes of the current status of the interior least tern (U. S. Fish and Wildlife Service 1985, Whitman 1988). Recovery of the species will be affected substantially by the ability to identify and protect essential breeding habitat and to intensively manage that habitat to maximize productivity and survival. Setting priorities for protection of remaining sites and determining habitat management actions will require detailed knowledge of interior least tern habitat requirements and the availability and quality of existing sites.

21. <u>Determine breeding habitat requirements and status</u>.
Our knowledge of interior least tern breeding habitat requirements has increased greatly during the past five years. Data on seemingly adequate but unoccupied habitat is needed. Comparison of habitat conditions among used sites along with data on reproductive success will provide the information necessary to set priorities for protection, and determine site-specific management actions to enhance breeding habitat.

211. <u>Assess the characteristics, including prey resources, of breeding habitat</u>.
The characteristics of breeding habitat must be investigated across the entire range of the interior least tern. At riverine sites, habitat variables to be measured should include: nesting area and height above water level, vegetative cover and distribution, substrate type, and river level fluctuations. Other variables may be of particular interest at local breeding areas. Measurements taken and methods employed at various breeding sites should be standardized to allow comparisons among areas. Few data are available on food resources at interior least tern breeding areas. Information on prey species occurrence and abundance are needed, as are estimates of the likelihood of food being a limiting habitat factor. The goals of these investigations should be identification of the range of habitat conditions tolerated by interior least terns, determination of habitat factors that affect nest densities, and elucidation of habitat conditions that may be related to maximum reproductive success rates.

212. <u>Quantify and evaluate available breeding habitat</u>.
As habitat assessment is undertaken, efforts to quantify existing interior least tern habitat should be initiated. The first task should be quantification of known and potential breeding habitat. As habitat quality data become available, existing sites should be evaluated with respect to habitat adequacy and deficiencies. Based on this information, recommendations for site protection or management actions should be given priorities. Remote sensing techniques such as aerial videography (Sidle and Ziewitz 1990) can be useful to quantify and, if possible, rate interior least tern breeding habitat. Sandbars are easily visible on satellite imagery of the Mississippi and Missouri Rivers. A catalog or compendium of interior least

tern nesting areas should be developed.

213. Examine historic aerial photography and hydrographic surveys of river systems to determine the previous extent of potential habitat and vegetational changes.
For many rivers periodic aerial photographs and hydrographic surveys are available. It would be useful for predictive purposes to measure the change, if any, in the quantity and quality of sandbar habitat since photo and hydrographic coverage began (Hamel et al. in press, Rodekohr and Engelbrecht 1988, Sidle et al. 1989). Such an endeavor would allow an accurate forecast of habitat trends.

22. Determine current migration habitat requirements and status.
Because migration patterns of interior least terns are not understood, no information on habitat requirements or status is available. Once stop-over sites, if they exist, are determined, evaluation of habitat requirements should be undertaken.

221. Assess the characteristics, including prey resources, of migration habitat.
If stop-over sites are identified, the habitats used should be described and variables characterizing those habitats quantified. Quantification (time activity budgets) of how interior least terns use the available habitats and their length of stay at stop-over sites also should be determined.

222. Quantify and evaluate available migration habitat.
Once migratory habitats are identified and characterized, the availability of such habitats should be determined. Initially, habitat availability in the vicinity of known stop-over sites should be quantified and its quality assessed. If migratory habitat in the vicinity of current stop-over sites is limited, a large scale survey of available habitat along suspected migratory corridors should be made.

23. Determine current habitat requirements and status on wintering areas.
No data are available on interior least tern winter habitat requirements. This task should be undertaken followed by a determination of the extent to which wintering habitats are traditionally used. Information on the role of winter habitat abundance, distribution, and quality in interior least tern population dynamics is totally lacking. Data relating winter habitat conditions to population status are needed.

231. Assess the characteristics, including prey resources, of winter habitat.
As primary wintering areas are identified, characteristics of the habitats used by interior least terns must be quantified and variables affecting quality of those habitats elucidated. Winter habitats should be assessed with regard to interior least tern prey abundance and distribution, roost site needs, and location of feeding and roosting habitat. Habitat characteristics near occupied sites, but not currently used by interior least terns, also should be assessed. Quantitative data on interior least tern use of winter habitats also are needed. Information on movements

among wintering areas, movements among habitats, time-activity budgets, the use of pre-migration staging areas, etc., may provide important information on habitat quality. The goal of these studies should be identification of habitat features that affect winter survival of interior least terns, assure adequate pre-breeding condition, and favor mixing among individuals from local breeding populations.

232. Quantify and evaluate winter habitat.
After baseline information on habitat characteristics and quality is available, the amount and distribution of winter habitat should be determined. Additionally, the quality of existing habitat should be rated and deficiencies identified. This effort may involve development of remote sensing techniques to identify and monitor winter habitat. Based on data generated under steps 231 and 232 the likelihood of winter habitat quantity limiting the growth of the interior least tern population should be evaluated. If winter habitat is found to be limited, further recommendations should be developed on the need for habitat protection or management of specific sites.

233. Eliminate current or potential threats to winter habitat.
As winter habitat is identified, current and potential threats to each site should be determined. Priority should be given to sites currently used by interior least terns. It is important to not only identify threats that could destroy winter habitats, but also those that could result in lowering the quality of remaining sites. Habitat ownership will have to be taken into consideration when assessing threats to the species.

3. Protect, enhance, and increase interior least tern populations.
Legal protection is often not enough to ensure perpetuation of breeding populations. Active management actions, including predator management, restricted access, and water level management are critical components of a comprehensive protection plan.

31. Protect, enhance, and increase populations during the breeding season.
To date, breeding activity of interior least terns has been more thoroughly investigated than activities at other times of the year. Current surveys have now identified most of the nesting areas in the U. S. Extensive survey work and research investigations of several major breeding areas have helped delineate many factors contributing to the species' current status, thus enabling the development of specific recommendations that may enhance the species' survival during the reproductive season.

311. Increase reproduction and survival at occupied breeding sites.
Activities that reduce interior least tern reproductive success and survival on its breeding grounds are probably among the principal factors responsible for the species' current status. Actions directed at eliminating or

minimizing such impacts are essential to the interior least tern's recovery.

3111. Evaluate predator impacts on eggs and chicks and identify species responsible for the predation.

Predation can be high in California and coastal least tern colonies (Atwood et al. 1979, Burger 1984, Massey 1981). Surveys on the Lower Mississippi River revealed that nest predation, especially by coyotes, has substantially reduced reproductive success at certain colonies. The vulnerability of terneries to such predation increases when island habitat accretes to the shoreline during periods of low water (Smith and Renken 1990). Studies conducted in the Missouri River system have documented a high percentage of interior least tern egg and chick loss to predation (Nebraska Game and Parks Commission, unpublished data, Mayer and Dryer 1990). During 1987-1989, predation accounted for most of the nest losses on the Platte River except riverine nests on the central Platte where flooding caused the mortality (Kirsch 1990, Lingle 1989). Both avian and mammalian species are among the suspected predators. Further studies that document such losses should continue. Investigations that focus specifically on identifying predators, and the cues they use in locating nests and/or chicks, determining the time of predation, etc., are necessary if egg and chick mortality are to be curtailed.

3112. Evaluate techniques for predator management and implement where appropriate.

Lethal and non-lethal methods for managing mammalian predators have been extensively developed for other wildlife management purposes. They include: eliminating or relocating the animal, erecting electric fences, and developing taste aversions. Electric fences have been used to protect nesting California and coastal least terns (Massey and Atwood 1980, 1982; Minsky 1980). The applicability of these and other techniques (e. g. predator exclusion cages) to the interior least tern should be investigated. Few management efforts have focused on managing avian predators, such as common ravens (*Corvus corax*), American crows, great horned owls (*Bubo virginianus*), great blue herons (*Ardea herodias*), California gulls (*Larus californicus*), and ring-billed gulls (*L. delawarensis*). Appropriate management measures should be implemented at interior least tern sites that are now experiencing significant and repeated loss due to predation.

3113. Restrict public use within nesting areas and investigate enforcement options.

Disturbance of California and coastal least tern colonies caused by foot traffic and recreational vehicles has been well-documented (Massey and Atwood 1979, Goodrich 1982, Burger 1984) and is also true for interior least terns (Schwalbach 1988, Kirsch 1987-90, Lingle 1989, Smith and Renken 1990). Losses incurred by these activities can be direct, by destroying eggs and chicks, as well as indirect, by inhibiting territory establishment, feeding behavior, incubation and other reproductive behavior. A variety of techniques that restrict access to nesting areas have been successful in a few states and should be implemented on a wider scale. These include posting, restricted access, and fencing (Morris 1979, 1980; Larkins 1984, Massey and Atwood 1979). Because many interior least tern nesting areas are located in remote areas, strict enforcement of regulations is often impractical. Although the site may receive substantial recreational use, budget restrictions rarely allow full-time monitoring by professional staff. It is essential, therefore, that actions to restrict recreational activities always be accompanied by an aggressive public relations effort that will effectively reach all potential visitors to an area and adequately explain the purpose of the regulations. "Tern wardens" who patrol nesting areas to explain the restrictions, should be considered for particularly important breeding areas (McCulloch 1982). The U. S. Army Corps of Engineers, U. S. Fish and Wildlife Service, and state wildlife agencies could become involved in public relations efforts and patrols to protect interior least tern nesting areas on the river systems. Agents of the Missouri Department of Conservation maintain an active enforcement program at Mississippi River terneries. Similar state and federal enforcement endeavors have begun on the Missouri River in North and South Dakota, and Nebraska, and on the Platte River in Nebraska. Field research on interior least terns should be carefully examined for its effects on the reproductive success of the birds (Brubeck et al. 1981). Research proposals should be scrutinized for their benefit to interior least tern recovery.

3114. Manage water levels and river flows to reduce nest and chick loss.

A significant proportion of the interior least tern population resides along rivers where much habitat has been destroyed by reservoir construction, channelization, water depletion, vegetative encroachment, and modification of flow regimes (Currier et al. 1985, Nebraska Game and Parks Commission 1985b, Schwalbach et al. 1986, 1988, Eschner et al. 1981, Smith and Stucky 1988, Sidle et al. 1989). This riverine habitat is subject to a number of additional threats, including untimely water releases from dams that flood sandbar nesting habitat (Dryer and Dryer 1985, Schwalbach et al. 1986, 1988; Schwalbach 1988, G. R. Lingle, personal communication). Managing water levels early in the spring along some rivers could help to resolve this problem. Nesting habitat, expected to be flooded late in the season, could be submerged when interior least terns begin establishing territories in early May, forcing them to seek higher grounds that would be safe throughout the nesting season. It is essential, however, that sufficient nesting habitat is available above the fluctuation zone. High waters in spring also helps keep sandbars devoid of vegetation by reducing sprouting of young herbaceous growth and by increasing deposition of coarse sediments (Currier et al. 1985, O'Brien and Currier 1987).

Annual flow regimes need to be developed for many river segments where interior least terns occur. For example, along the central Platte River the Service has developed flow recommendations to support a variety of wildlife including least tern nesting habitat and the bird's forage fish (Table 8). These recommendations have been accepted by the Federal Energy Regulatory Commission as part of the annual relicensing of upstream water projects in Nebraska (Sidle et al. 1990). The water releases will occur on the North Platte River, far upstream of interior least tern nesting habitat. The Ohio River has a major effect on the availability of interior least tern habitat in the lower Mississippi River. Management of this river and other rivers throughout the bird's range need to be examined for their effect on the interior least tern and its habitat.

3115. <u>Modify or eliminate construction activities that adversely impact reproductive success of interior least terns.</u>

Recreational and residential development along river fronts should be discouraged in nesting areas. Proposals for maintenance or development activities that do not directly disturb breeding habitat but that occur in the vicinity of nest sites should be closely scrutinized for their potential impact.

3116. <u>Investigate the effects of environmental contaminants during the breeding season.</u>

Contaminant effects on interior least terns are unknown. It would be useful to at least collect addled eggs during surveys and field studies for later contaminant analysis.

32. Protect and enhance populations during migration and winter.
Each year, 30 percent or less of the interior least tern's time is spent on the breeding grounds. A comprehensive protection plan also should focus on the species survival during migration and winter. However, migration and winter are the most poorly understood stages of the bird's life cycle and little can be recommended until migratory patterns are determined. The delineation of key areas where interior least terns spend non-breeding months is a critical step to enable the protection measures necessary for the birds' survival year-round.

321. Manage areas to maximize survival during migration.
Nothing is currently known about either the extent or causes of mortality that interior least terns might encounter during migration. Work that focuses on delineating migration routes (Step 12) should be expanded to focus on causes of mortality as well. When appropriate, measures should then be taken to lessen the impact upon the species.

322. Manage winter areas to maximize survival during winter.
During winter, interior least terns probably use open habitats. Sand, gravel, and/or cobbled marine beaches may be selected, as well as intertidal beach bars and flats.

3221. Investigate effects of human activities on winter survival.
Recreational, residential, and industrial developments each pose a potential threat to interior least terns by increasing the level of human activity. Moreover, hunting of terns in Latin America may be a factor. To date, research studies have focused primarily on describing the impacts of human activities on nesting grounds. Future efforts also should be directed at collecting similar data from wintering areas, once such areas are discovered.

3222. Investigate the effects of environmental contaminants in wintering areas.
During surveys for interior least tern wintering areas, attention should be paid to coastal pollution. Chemical use and its impacts on foreign wintering areas should be evaluated.

4. Preserve and enhance habitat.
Because of major habitat losses and increasing demands on available habitat, protecting and enhancing existing and potential interior least tern habitat is a major concern. Important breeding areas have been identified but enhancement and protection of essential habitat has been limited. Little is known about those areas along the migration route or on the wintering grounds.

41. Provide protection and management of breeding habitat.
Essential breeding habitat (Appendix 4) will need delineation,

protection, and enhancement to provide for recovery of the species. Efforts should include increased management activities to provide better use and protection of existing and potential areas. Compatibility of other uses (e.g., recreation) for breeding areas should be defined. All essential habitat needs permanent protection, where possible, through appropriate fee title acquisition, permanent easement, cooperative agreements, and memorandums of agreement or understanding among federal agencies and private organizations (Appendix 2).

411. Identify areas of essential breeding habitat.
Essential Habitat is listed in Appendix 4 to highlight known areas to be protected.

412. Continue to evaluate areas for consideration as essential breeding habitat.
Recognizing the fragile nature of much of the interior least tern's breeding habitat, continued evaluation and designation of essential habitat in primary breeding areas will protect areas from detrimental development.

413. Establish liaison with agencies and organizations with land and water management responsibilities.
Due to increasing pressure for development and use of land and water resources to meet human needs, efforts should be made to communicate with agencies, organizations, and individuals whose decisions affect the future of interior least tern habitat. The purpose would be to resolve conflicts between known development actions and future conflicts through planning of land and water development.

414. Revise, establish, or utilize land and water laws and regulations to provide protection along rivers and lakes.
Increasing demands for agricultural land and urban development, wetland drainage, power generation, water for irrigation, recreational space, and operation of river reservoirs have threatened or destroyed interior least tern habitat. Enforcement of laws and regulations, particularly those involving instream flow protection, 404 permits, and endangered or threatened species habitat protection, is needed to restrict or modify such developments on the remaining essential interior least tern habitat. All land- and water-use legislation should be scrutinized for potential impact to interior least tern habitat. Undesirable legislation should be modified and laws enacted that will expand the consideration given wildlife during water and land development planning.

415. Develop criteria and priorities for breeding habitat protection.
To provide adequate protection, some habitat will have to be purchased in fee title, or placed under a protective easement or cooperative landowner agreement. Although permanent protection of essential areas usually will be preferred, in some instances, temporary protection of ephemeral nesting areas may be achieved through agreements with private parties and public authorities. Protection of

areas listed as essential habitat (Appendix 4) is based upon tradition of occupancy, number of birds present, site productivity, proximity to other protected sites, imminence of habitat destruction, and ephemeral nature of the site.

416. Develop management plans for riverine breeding habitat. Techniques may vary from site to site depending on need and opportunity, but plans should be developed for management of essential riverine habitat (see Step 2).

4161. Determine direct, indirect, and cumulative effects of manipulation of river hydraulics, flow regimes, and sediment discharge on breeding and foraging habitat. Manipulation of river flow regimes and river hydraulics through water diversion, storage of flows by dams, discharge from dams for power generation, navigation and irrigation demands, bank stabilization, and channelization has significantly altered the natural dynamic processes responsible for loss and creation of sandbars used for nesting (Nunnally and Beverly 1986, Sandheinrich and Atchison 1986, Smith and Stucky 1988). As a result, breeding habitat could be lost at a higher rate than what is being created. Modifications of river flow regimes through operation of reservoirs and lock and dams also has caused concern for long-term effects of riverbed degradation on interior least tern habitat. Although many direct effects of human manipulations have been identified, suspected indirect and cumulative impacts of ongoing and future river developments need to be determined. Under Section 7 of the Endangered Species Act the U. S. Fish and Wildlife Service and the U. S. Army Corps of Engineers have consulted on the effects of proposed dams in the Platte River system, and are consulting on the effects of main stem dam operations on interior least terns along the Arkansas and Missouri Rivers (U. S. Fish and Wildlife Service 1987b, 1987c, 1989, 1990). Section 7 consultation provides an opportunity to protect much of the interior least tern's breeding habitat.

4162. Identify river flow regimes that will protect and enhance breeding and foraging habitat. Control of river flows is desirable to prevent inundation of nests and young (Nebraska Game and Parks Commission 1985c), discourage growth of woody vegetation, and to maintain a river with a nutrient base necessary for production of fish used as food by interior least terns. Proper instream flow is a major goal of ongoing Section 7 consultations regarding the interior least tern.

4163. Determine the relationship of existing artificial breeding sites to river sites.

California and coastal least terns readily use man-made habitats. Islands, spoil piles, and beaches formed by dredged sand and gravel, and located immediately adjacent to the Platte River in Nebraska and elsewhere are used by interior least terns. A large percentage of the Platte River breeding population of interior least terns nests at sand and gravel pits. Dike fields are commonly used along the Mississippi River (Hamel et al. in press, Landin et al. 1985, Rumancik 1987, Smith and Renken 1990). Terns may use barges filled with sand on river segments now devoid of sandbar habitat. The importance of artificial habitat to recovery of the species, and to what extent such habitat can replace lost natural sandbars, should be determined.

4164. Identify need and techniques of improving habitat by management of substrate and by vegetation control through physical and/or non-toxic chemical means.

Existing woody vegetation may have to be removed from sandbars to provide suitable nesting habitat through physical or chemical means. Annual control may be necessary. Dredging and spreading sand or gravel of particular particle size could improve substrates for nesting and increase the height of sandbars to prevent continuous inundation. Currently, the U. S. Army Corps of Engineers and the Platte River Whooping Crane Habitat Maintenance Trust have been clearing islands on the Missouri and Platte Rivers, respectively.

4165. Study feasibility and determine need for creating new habitat and implement trials to determine success rates of creating new habitat.

A variety of techniques have been used to create artificial nesting sites for the California and coastal least terns and to attract terns to the sites (Massey 1981, Fancher 1984, Kotliar and Burger 1984). Creation of artificial habitat may be necessary in areas where manageable habitat is non-existent. This may be particularly important in areas where natural habitat has been lost to channelization and water diversion. For example, most of the lower Missouri River (Iowa, Kansas, Missouri, and Nebraska) is now a channel and artificially created sites (e.g., ash disposal sites at power stations in Iowa) (Wilson 1984, 1986; Dinsmore and Dinsmore 1989) are the only habitat available. As part of the annual relicensing effort for upstream water projects along the Platte River in Nebraska, restored least tern nesting habitat has been ordered by the Federal Energy Regulatory Commission for each bridge segment in the central Platte (Sidle et al. 1990). Additional restoration will be needed elsewhere along the Platte River. Habitat on the Cimarron River appears to be progressively deteriorating from upstream to downstream as the channel narrows and woody vegetation encroaches. Vegetation control likely will be necessary to maintain essential habitat. Likewise, habitat restoration will be necessary if least terns are to recover in the Iowa and Missouri reaches of the Missouri River. In the Mississippi River, the Missouri Department of Conservation and the U. S. Army Corps of Engineers have developed a cooperative proposal to construct two artificial islands between St. Louis and Cape Girardeau, Missouri. Smith and Stucky (1988) discussed other recommendations, including modification of dike structures.

4166. Develop lake and reservoir control policies where existing and potential habitat is threatened.
Water levels affect interior least tern reproductive success by increasing or decreasing the amount of habitat available on the shoreline of reservoirs (e. g., Lakes Oahe and Sakakawea in the Dakotas, and Salt Plains National Wildlife Refuge, Oklahoma) and in dike fields. Changes in these levels during critical periods may delay initiation of nesting, flood nest sites or feeding areas, or increase the distance from nest sites to the water's edge. Lakes and reservoirs with interior least tern habitat must be identified and any policies controlling water levels need to be scrutinized to determine the effect on interior least tern reproductive success.

4167. Identify needs and techniques for managing water levels.
Lakes and reservoirs currently supporting nesting interior least terns or that provide suitable nesting habitat should be evaluated to determine if water level management is feasible. Where feasible, techniques should be developed to manage water levels to improve reproductive success.

418. Evaluate success of protection and management techniques.
Monitoring must be sufficient to detect and measure the positive effects of protection and management and to avoid potentially detrimental impacts on interior least tern habitat. Daily and seasonal activity patterns of interior least terns, along with locations of specific nesting areas, will provide key measures of the birds' response to various management practices. Monitoring vegetation to determine where changing habitat conditions exist and monitoring potential predator levels in the area should be considered. All techniques used to improve interior least tern habitat should be evaluated to determine their cost-efficiency.

42. Provide protection and management of migration habitat.
If migration sites are identified, their protection and enhancement will be essential. At that point, assessment of further needs of migrating interior least terns will be carried out. As stop-over habitats are identified, current and potential threats to those sites should be delineated. On publicly-owned sites, current land-use patterns or management actions that could conflict with interior least tern use of existing habitats should be identified. Feasibility of protecting major privately-owned stop-over sites should be assessed.

43. Provide protection and management of winter habitat.
Survival and continued existence of the species may depend on availability of suitable winter habitat. Furthermore, reproductive success of adults may partially be a function of their physical condition as they begin spring migration. Consequently, the quality and quantity of winter habitat may limit recovery of the species.

431. Identify areas of essential winter habitat.
Essential winter habitat first needs to be identified by surveys in Latin America.

432. Develop criteria and priorities for winter habitat protection.
Once further research is carried out in wintering areas, factors will be identified as being essential for winter habitat. At that point, a land protection strategy should be developed. Areas that support the greatest number of interior least terns, especially those supporting individuals from important sub-populations should be given priorities in a habitat management/protection plan.

433. Develop management techniques.
Once actual and/or potential interior least tern wintering habitat is identified, methods of managing those habitats should be developed and improved so that wintering habitat is of sufficient quantity and quality to accommodate and promote expansion of interior least tern populations to more stable levels.

5. Develop and implement an education program that publicizes information about the interior least tern, including its life history, reasons for current status and options for recovery.
Conservation of coastal least terns has benefitted greatly from public information endeavors (Jackson and Jackson 1985, Toups 1976). The interior least tern's successful recovery will depend on curtailing and/or redirecting human recreation and development activities. Therefore, resource managers and the general public should be provided with sufficient information to explain and justify changes in previous actions. Current efforts to develop a public information program have made an impressive start in this direction but must be intensified. These efforts also could benefit from better coordination at the national level to target specific audiences.

51. Inform and educate the public on the bird's plight and recovery efforts.
The first priority in developing a public information program

should be to educate the general public about the significance and value of the interior least tern. The public's support and cooperation ultimately will be essential to the species full recovery.

511. Identify target audiences among the general public.
Materials prepared to increase public awareness and appreciation of the interior least tern can be more effective if they are developed to meet specific interests and concerns of a particular audience. Time should be spent delineating which public groups are affected, either directly or indirectly, by interior least tern conservation efforts and how each audience can best be reached.

512. Develop and distribute educational materials appropriate for various audiences.
Current efforts should be expanded to make greater use of the various media, including newspapers, radio, and television. The primary focus of this task should be to provide background information describing the interior least tern's life history and habitat requirements and to describe how human activity/disturbance can threaten the survival of interior least terns. The public should also be made aware of the necessity to enact local regulations to protect the interior least tern. However, information materials should not increase the potential for observer disturbance to nesting birds. The Service's Tulsa office has produced an information brochure useful throughout the range of the interior least tern.

513. Develop materials for newspapers, radio, and television, that highlight specific interior least tern projects.
In several states, cooperative projects between state and federal agencies, as well as private organizations and individuals are underway to protect interior least terns. Such efforts which generate public support should be applauded and widely publicized, particularly at the local level.

514. Provide controlled viewing opportunities if and when appropriate.
Guided opportunities for observing interior least terns may be one of the best vehicles for generating public support and concern. Led by a qualified biologist under conditions that minimize or prevent disturbance to the birds, such trips can educate visitors first-hand about the need for strong protection and curtailment of some recreational activities.

52. Inform and educate public resource management agencies.
Some interior least terns occur on lands that are protected and/or managed by state and federal resource agencies. Recreation permitted on these areas (e.g., hiking, vehicle use, camping) can reduce the bird's reproductive success. In some areas an agency's own activities may also pose a threat (e.g., control of water levels in lakes and along rivers). Contact with

these agencies will facilitate better management of the areas for interior least terns.

521. Identify critical resource agency constituents.
Each resource agency (including state, federal, and private organizations) whose activities can impact the interior least tern should be identified.

522. Develop educational materials appropriate to respective agencies and their management authority.
Resource managers need to be provided with basic life history information about the interior least tern as well as specific management information and recommendations directly pertinent to their area of responsibility.

523. Provide public resource agencies with periodic updates on the interior least tern's status and progress of recovery efforts.
It is important that each public agency responsible for ensuring the interior least tern's survival, either directly or indirectly, be kept abreast of the success of their efforts at both the local and national level. Periodic updates not only inform them of progress being made, but also remind them of their responsibilities to the conservation of interior least terns.

6. Coordinate recovery efforts.
Development of a recovery plan for interior least terns involves coordination of biologists, agencies, and governments so that the most comprehensive, up-to-date information is collected and disseminated in an efficient way. Proper coordination would also help ensure rapid implementation of those actions necessary for full recovery.

61. Designate a recovery plan coordinator.
Designation of a coordinator is recommended. Duties of the coordinator would include: a) coordination of the implementation of the recovery plan; b) naming an individual in each state to coordinate and implement recovery tasks; c) monitoring execution of the plan's implementation schedule; d) maintaining collaboration with state, federal, and international agencies; disseminating critical annual data; and coordinating range-wide research activities for interior least terns. A least tern contact person should also be designated for each state.

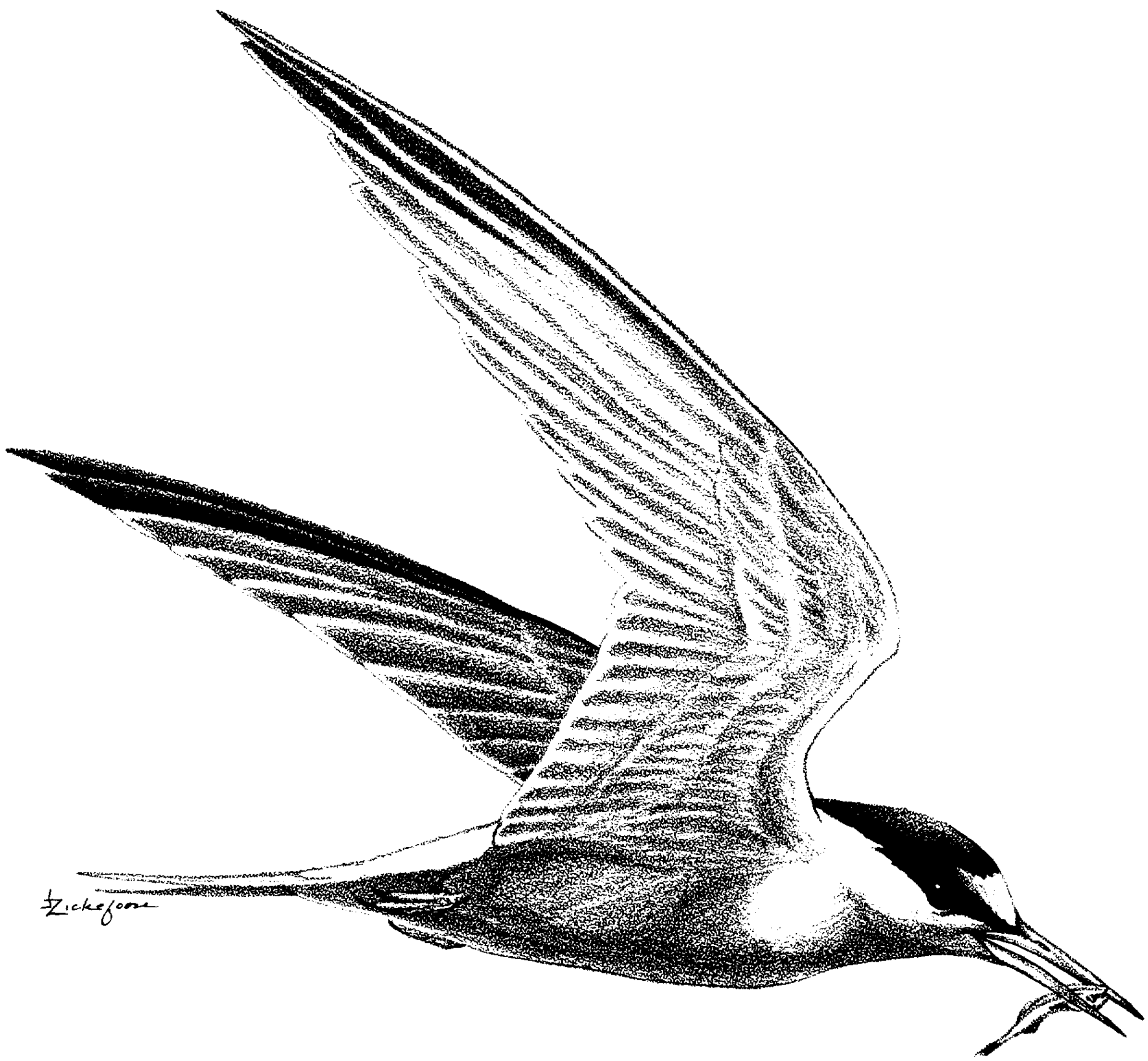
611. Coordinate research and management activities with federal, state, local, and private organizations.
Efficient achievement of recovery goals will be enhanced through coordination of research and management with private and governmental agencies. For example, it would be useful to establish and coordinate an international banding scheme whereby birds can be easily identified throughout the annual cycle. The recovery plan outlines many facets of interior least tern conservation that require urgent investigation. Repetition of efforts due to lack of coordination will slow the recovery process and may cause undue disturbance to the birds.

612. Coordinate international research and management activities.
Development of population management plans on an

international scale may be necessary. Interior least terns probably winter in Latin America and coordination with various nations and international conservation organizations may be necessary.

613. Coordinate development of a public information program at the national and international level.

Information and educational materials developed in one river system could be of equal benefit in other river systems. Some materials also may be helpful to states that support wintering populations. Coordination at the federal level will reduce duplication of effort and encourage more efficient use of time and money at the state level. A coordinated approach to raising an awareness of the interior least tern's plight at the international level would ensure protection throughout its range.



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III. IMPLEMENTATION

The Implementation Schedule outlines and gives priorities to tasks deemed necessary to be undertaken in the next three years to maximize recovery of the interior least tern. This process will be reviewed every three years until the recovery objective is met. Therefore, priorities and tasks may change in the future.

KEY TO IMPLEMENTATION SCHEDULE
General Category (Column 1):

Information and Research (I,R)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomy
6. Demographic studies
7. Propagation
8. Migration
9. Wintering
10. Predation
11. Competition
12. Disease
13. Environmental contaminant
14. Reintroduction
15. Other information

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Desease control
7. Pollution control
8. Public information
9. Other information

Priority (column 4) :

1. Those actions absolutely necessary to prevent extinction of the species in the foreseeable future.

2. Those actions necessary to maintain the species' current population status.

3. All other actions necessary to provide for full recovery of the species.

Agency Responsibility (column 6):

USFWS Regional Office	2 - Albuquerque
	3 - Twin Cities
	4 - Atlanta
	6 - Denver

USFWS Research = 8
USFWS Office of Migratory Bird Management = OMBM
USFWS Office of International Affairs = IA
SA = State Wildlife Agency
BR = Bureau of Reclamation
COE = U. S. Army Corps of Engineers
NPS = National Park Service
WCHT = Platte River Whooping Crane Habitat Maintenance Trust
CW = Colonial Waterbirds

MO = Missouri River System
MS = Mississippi River System
AR = Arkansas River System
RE = Red River System
RG = Rio Grande River System

IMPLEMENTATION SCHEDULE

Complete Implementation Schedule for First Three Years of Recovery Effort

General Category	Task	Task #	Priority #	Task Duration	Responsibility: Region (USFWS)	Responsibility: Other Agencies	Fiscal Year Costs: 1	Fiscal Year Costs: 2	Fiscal Year Costs: 3
I1	Survey, census and monitor breeding populations	111-114	2 (MO)	Annual	Regions 3,6	SA, COE	$15K	$15K	$15K
			2 (MS)	Annual	Regions 3,4	SA, COE	$15K	$15K	$15K
			2 (AR)	Annual	Regions 2,4	SA, COE	$20K	$20K	$20K
			2 (RE)	Annual	Regions 2,4	SA, COE	$ 5K	$ 5K	$ 5K
			2 (RG)	Annual	Region 2	SA	$10K	$10K	$10K
I6, R6	Assess mortality and identify life history parameters (including population modeling)	116-117	3 (MO)	Annual	Regions 3,6	SA, WCHT	$10K	$10K	$10K
			3 (MS)	Annual	Regions 3,4	SA, COE	$10K	$10K	$10K
			3 (AR)	Annual	Regions 2,4,6	SA, COE	$10K	$10K	$10K
			3 (RE)	Annual	Region 2,4	SA, COE	$10K	$10K	$10K
			3 (RG)	Annual	Region 2	SA	$10K	$10K	$10K
R9, R1 R6	Survey and census winter populations	131-132	2	Annual	8,OMBM,IA	CW	$35K	$35K	$15K
I2, R3	Quantify and evaluate breeding habitat and threats	211-213	2 (MO)	2 years	Regions 3,6	SA, BR, WCHT	$15K	$10K	$10K
			2 (MS)	2 years	Regions 3,4	SA, COE	$15K	$15K	$15K
			2 (AR)	2 years	Regions 2,4,6	SA, COE	$15K	$15K	$15K
			2 (RE)	2 years	Regions 2,4	SA, COE	$ 5K	$ 5K	$ 5K
			2 (RG)	2 years	Region 2	SA	$10K	$10K	$10K
M4, R10	Evaluate predator impacts; evaluate predator management techniques and implement	3111-3112	2 (MO)	Annual	Regions 3,6	SA, WCHT	$15K	$15K	$10K
			2 (MS)	Annual	Regions 3,4	SA, COE	$10K	$10K	$10K
			2 (AR)	Annual	Regions 2,4,6	SA, COE	$15K	$15K	$15K
			2 (RE)	Annual	Regions 2,4	SA	$ 5K	$ 5K	$ 5K
			2 (RG)	Annual	Region 2	SA	$ 5K	$ 5K	$ 5K

IMPLEMENTATION SCHEDULE

Complete Implementation Schedule for First Three Years of Recovery Effort

General Category	Task	Task #	Priority #	Task Duration	Responsibility: Region (USFWS)	Responsibility: Other Agencies	Fiscal Year Costs 1	Fiscal Year Costs 2	Fiscal Year Costs 3
M8, M9	Restrict human and vehicular access to nesting areas	3113	2 (MO)	Annual	Regions 3,6	SA, COE	$15K	$15K	$15K
			2 (MS)	Annual	Regions 3,4	SA	$10K	$10K	$10K
			2 (AR)	Annual	Regions 2,4,6	SA, COE	$15K	$15K	$15K
			2 (RE)	Annual	Regions 2,4	SA	$ 5K	$ 5K	$ 5K
			2 (RG)	Annual	Region 2	SA	$ 5K	$ 5K	$ 5K
M3, M9	Manage water levels to reduce nest and chick loss	3114	1 (MO)	Annual	Regions 3,6	COE	$20K	$20K	$20K
			1 (MS)	Annual	Regions 3,4	COE	$15K	$15K	$15K
			1 (AR)	Annual	Regions 2,4,6	COE, BR	$10K	$10K	$10K
			1 (RE)	Annual	Regions 2,4	COE	$ 5K	$ 5K	$ 5K
			1 (RG)	Annual	Region 2	COE	$ 5K	$ 5K	$ 5K
I2	Identify essential breeding habitat	411-412	2 (MO)	Ongoing	Regions 3,6	SA			
			2 (MS)	Ongoing	Regions 3,4	SA			
			2 (AR)	Ongoing	Regions 2,4,6	SA			
			2 (RE)	Annual	Regions 2,4	SA			
			2 (RG)	Annual	Region 2	SA			
M3	Establish liaison to protect breeding habitat	413	3 (MO)	Annual	Regions 3,6	SA, COE, BR			
			3 (MS)	Annual	Regions 3,4	SA, COE			
			3 (AR)	Annual	Regions 2,4,6	SA, COE, BR			
			3 (RE)	Annual	Regions 2,4	SA, COE			
			3 (RG)	Annual	Region 2	SA			
M9	Revise or establish laws to protect breeding habitat	414	3 (MO)	Annual	Regions 3,6	SA			
			3 (MS)	Annual	Regions 3,4	SA			
			3 (AR)	Annual	Regions 2,4,6	SA			
			3 (RE)	Annual	Regions 2,4	SA			
			3 (RG)	Annual	Region 2	SA			

IMPLEMENTATION SCHEDULE

Complete Implementation Schedule for First Three Years of Recovery Effort

General Category	Task	Task #	Priority #	Task Duration	Responsibility: Region (USFWS)	Responsibility: Other Agencies	Fiscal Year Costs 1	Fiscal Year Costs 2	Fiscal Year Costs 3
R2, R3	Develop criteria and priorities for habitat protection	415	3 (MO)	1 year	Regions 3,6	SA			
			3 (MS)	1 year	Regions 3,4	SA			
			3 (AR)	1 year	Regions 2,4,6	SA			
			3 (RE)	1 year	Regions 2,4	SA			
			3 (RG)	1 year	Region 2	SA			
R3, M3	Develop river management plans	416	1 (MO)	Annual	Region 6	SA, COE, WCHT	$15K	$15K	$15K
			1 (MS)	Annual	Region 4	SA, COE	$10K	$10K	$10K
			1 (AR)	Annual	Regions 2,4,6	SA, COE, BR	$10K	$10K	$10K
			1 (RE)	Annual	Regions 2,4	SA, COE	$ 5K	$ 5K	$ 5K
			1 (RG)	Annual	Region 2	SA, COE, BR	$ 5K	$ 5K	$ 5K
R1, R2	Determine effects of river hydraulics and sediment discharge on breeding habitat; identify flow regimes to protect habitat	4161-4162	1 (MO)	Annual	Region 6	SA, COE, BR WCHT	$25K	$25K	$25K
			1 (MS)	Annual	Region 4	SA, COE	$20K	$20K	$20K
			1 (AR)	Annual	Region 2,6	SA, COE, BR	$20K	$20K	$20K
			1 (RE)	Annual	Region 2	SA, COE	$10K	$10K	$10K
			1 (RG)	Annual	Region 2	SA, COE	$10K	$10K	$10K
R3	Determine relationship of existing artificial breeding sites to riverine sites	4163	2 (MO)	2 years	Region 6	SA	$10K	$10K	$10K
			2 (MS)	3 years	Region 4	SA, COE	$10K	$10K	$10K
			2 (AR)	2 years	Regions 2,6	SA	$10K	$10K	$10K
			2 (RE)	2 years	Region 2	SA	$ 5K	$ 5K	$ 5K
			2 (RG)	2 years	Region 2	SA	$ 5K	$ 5K	$ 5K
M3	Modify and/or eliminate construction activities that impact breeding habitat	418	2 (MO)	Annual	Regions 3,6	SA, COE	$ 5K	$ 5K	$ 5K
			2 (MS)	Annual	Regions 3,4	SA, COE	$ 5K	$ 5K	$ 5K
			2 (AR)	Annual	Regions 2,4,6	SA, COE	$ 5K	$ 5K	$ 5K
			2 (RE)	Annual	Regions 2,4	SA, COE	$ 5K	$ 5K	$ 5K
			2 (RG)	Annual	Region 2	SA, COE	$ 5K	$ 5K	$ 5K

IMPLEMENTATION SCHEDULE

Complete Implementation Schedule for First Three Years of Recovery Effort

General Category	Task	Task #	Priority #	Task Duration	Responsibility: Region (USFWS)	Responsibility: Other Agencies	Fiscal Year Costs: 1	Fiscal Year Costs: 2	Fiscal Year Costs: 3
M8	Inform and educate the public	511-513	2 (MO)	Annual	Regions 3,6	SA, COE	$ 5K	$ 5K	$ 5K
			2 (MS)	Annual	Regions 3,4	SA, COE	$ 5K	$ 5K	$ 5K
			2 (AR)	Annual	Regions 2,4,6	SA, COE, BR	$ 5K	$ 5K	$ 5K
			2 (RE)	Annual	Regions 2,4	SA, COE	$ 5K	$ 5K	$ 5K
			2 (RG)	Annual	Region 2	SA, COE	$ 5K	$ 5K	$ 5K
M8, M9	Inform and educate public resource management agencies	52	3 (MO)	Annual	Regions 3,6	SA, COE			
			3 (MS)	Annual	Regions 3,4	SA, COE			
			3 (AR)	Annual	Regions 2,4,6	SA, COE			
			3 (RE)	Annual	Region 2	SA, COE			
			3 (RG)	Annual	Region 2	SA, COE			
M9	Coordinate recovery efforts	61	2	Annual	Regions 2,4,6	SA, COE			

APPENDIX 1

Contact People

The following individuals have offered to provide interested parties with information pertaining to interior least terns in their area.

Roger Boyd
Biology Department
Baker University
Baldwin City, Kansas
913/594-6451

Dennis Christopherson
U. S. Fish and Wildlife Service
1501 14 St. West, Suite 230
Billings, MT 59102
406/657-6028

Mark Dryer or Paul Mayer
U. S. Fish and Wildlife Service
1500 Capitol Avenue
Bismarck, North Dakota 58501
701/255-4491

Paul B. Hamel
Tennessee Department of Conservation
701 Broadway
Nashville, Tennessee 37219-5237
615/742-6546

Laura A. Hill
U. S. Fish and Wildlife Service
222 South Houston, Suite A
Tulsa, Oklahoma 74127
918/581-7458

Gary R. Lingle
Platte River Whooping Crane Habitat Maintenance Trust
2550 N. Diers Ave.
Grand Island, Nebraska 68803
308/384-4663

Ross Lock
Nebraska Game and Parks Commission
P. O. Box 30370
Lincoln, Nebraska 68503
402/471-5438

Ren Lohoefner
U. S. Fish and Wildlife Service
300 Woodrow Wilson, Suite 316
Jackson, MS 39213
601-965-4900

Elizabeth N. McPhillips
U. S. Fish and Wildlife Service
Federal Building, Room 227
225 South Pierre
Pierre, South Dakota 57501
605/224-8693

Rochelle B. Renken
Fish and Wildlife Research Center
Missouri Department of Conservation
1110 S. College Avenue
Columbia, Missouri 65201
314/882-9880

John P. Rumancik, Jr.
U. S. Army Corps of Engineers
B-202 Clifford Davis Federal Building
Memphis, Tennessee 38103-1894
901/521-3857

Marvin Schwilling
Kansas Department of Wildlife and Parks
1407 College Drive
Emporia, Kansas 66801
316/342-1985

Kenneth Smith
Arkansas Natural Heritage Inventory
225 East Markham, Suite 200
Little Rock, Arkansas 72201
501/371/1706

Sartor O. Williams, III
Endangered Species Program
New Mexico Department of Game and Fish
State Capitol, Santa Fe, New Mexico 87503
505/827-9914

APPENDIX 2

Agreements Necessary For Protection Of Essential Habitat

1. Memorandum of Understanding should be developed between the U. S. Army Corps of Engineers, National Park Service, U. S. Fish and Wildlife Service, and the State wildlife agency, for permanent protection and management (vegetation clearing, law enforcement, public relations, etc.) of all essential habitat on the Missouri River in North Dakota, South Dakota, and Nebraska.

2. U. S. Fish and Wildlife Service, National Park Service, and U. S. Army Corps of Engineers should acquire easements and/or fee title of essential interior least tern habitat on the Missouri River in North Dakota, South Dakota, and Nebraska.

3. Memorandum of Understanding should be developed between the U. S. Army Corps of Engineers, U. S. Bureau of Reclamation, U. S. Fish and Wildlife Service, Platte River Whooping Crane Habitat Maintenance Trust, and the state wildlife agency, for the permanent protection and management of all essential habitat on the Platte River system in Nebraska.

4. The U. S. Fish and Wildlife Service should provide land protection of essential interior least tern habitat on the Platte River system.

5. Memorandum of Understanding should be developed between the U. S. Army Corps of Engineers, State natural resource agency, and the U. S. Fish and Wildlife Service for the permanent protection and management of essential habitat on the Mississippi and Ohio Rivers.

6. Memorandum of Understanding should be developed between the U. S. Fish and Wildlife Service, State wildlife agency, and the U. S. Army Corps of Engineers governing the deposition of dredge spoils on the Mississippi and Ohio Rivers for purposes of enhancing or creating interior least tern habitat.

7. Memorandum of Understanding should be developed between the U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U. S. Section of the International Boundary and Water Commission, State wildlife agencies, and appropriate agencies in Mexico for permanent protection and management of all essential habitat in the Arkansas, Red, and Rio Grande Rivers basins in Kansas, Oklahoma, Arkansas, and Texas.

8. U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and The Nature Conservancy should acquire easements and/or fee title of essential interior least tern habitat in the Arkansas, Red, and Rio Grande river basins in Kansas, Oklahoma, Arkansas, and Texas.

9. Memorandum of Understanding should be developed between the U.S. Fish and Wildlife Service, State wildlife agencies, and the U.S. Army Corps of Engineers governing removal and deposition of dredge spoil from the McClellan-Kerr Arkansas River Navigation System, in Oklahoma and Arkansas, for purposes of enhancing or creating least tern habitat.

Appendix 3. Example of a memorandum of understanding

MEMORANDUM OF UNDERSTANDING

The Nature Conservancy
U.S. Army Corps of Engineers
Oklahoma Department of Wildlife Conservation
U.S. Fish and Wildlife Service
Tulsa Audubon Society
River Parks Authority

WHEREAS ____________________, an Oklahoma corporation, ("Owner") has acquired certain lands and riverbeds on the Arkansas River floodplain in Tulsa County, Oklahoma, as more particularly shown on the plat attached hereto as Exhibit A (the "Property"); and

WHEREAS said Property has special value for wildlife including nesting populations of the endangered Interior Least Tern, Stern antillarum athalassos; and

WHEREAS The Nature Conservancy ("Conservancy"), a private, nonprofit organization committed to the conservation and management of rare and endangered species, communities, and ecosystems, has expressed an interest to coordinate the efforts of local, state, and federal agencies in protecting the Least Tern; and

WHEREAS The United States Army Corps of Engineers ("Corps") has certain water management responsibilities on the Arkansas River that might affect the habitat of the Least Tern; and

WHEREAS the U.S. Fish and Wildlife Service ("USFWS") has federal management responsibilities over federally-listed endangered species such as the Least Tern, and the Oklahoma Department of Wildlife Conservation ("ODWC") has state management responsibilities over state-listed endangered species such as the Least Tern; and

WHEREAS the Tulsa Audubon Society ("TAS"), a private, nonprofit organization, has expertise in the preservation of birds such as the Least Tern; and

WHEREAS the River Parks Authority ("RPA") is a public trust charged with the responsibility of protecting and enhancing interalia, natural communities and species along the Arkansas River and its environment in Tulsa County, Oklahoma.

WHEREAS the Owner, ODWC, USFWS, Conservancy, TAS, the Corps and RPA all have an interest in protecting nesting populations of the rare and endangered Interior Least Tern on the Arkansas River; and

WHEREAS The Owner is agreeable to manage jointly these lands to protect the Least Tern.

NOW THEREFORE, the Owner hereby grants to The River Parks Authority, an exclusive license and permit, consisting of the following rights for the purposes described, in and to the lands described in Exhibit A attached hereto and made a part hereof, to-wit:

RIGHTS GRANTED TO THE RIVER PARKS AUTHORITY

1. The River Parks Authority shall have the right to enter upon and use said lands for the purpose of protecting all Least Tern nesting, fledging, feeding, resting and cover sites, located on said property. Said purposes shall include but not be limited to inspection, monitoring, research and, if deemed necessary, manipulation of the sites to enhance the Least Tern population. The River Parks Authority, upon consultation with the USFWS, may authorize personnel from the Corps, USFWS, ODWC, TAS, the Conservancy and others to enter said lands for the purposes described herein. Such consultation is necessary to alleviate potential for violations of the Endangered Species Act.

2. The River Parks Authority shall have the right to control and limit access to Least Tern nesting sites in breeding season, as necessary, and to erect and place any signs, posters, or other devices to identify the land as a protected area.

SAID RIGHTS ARE SUBJECT TO THE FOLLOWING LIMITATION, HOWEVER:

1. No one will construct facilities on said premises nor modify the land surface or habitat thereon until a proposal thereof has been reviewed and approved by USFWS and Owner.

2. All existing RPA regulations (e.g., no vehicle, dogs on leash, curfew clauses) will apply.

OBLIGATIONS OF RIVER PARKS AUTHORITY

AS PARTIAL CONSIDERATION for the rights hereby granted by the Owner, RPA agrees to:

Solicit expert advice regarding the protection, management and enhancement of the Least Tern population on the lands from the agencies and organizations that are party to this agreement and from other sources available to it, and shall exercise its best efforts to implement said recommendations consistent with the terms of this agreement.

OBLIGATIONS OF THE OWNER

THE OWNER agrees that:

1. In its planning and use of said lands, it shall, whenever practicable, take into consideration protection of said preserve area for endangered bird species.

2. It shall exercise its best efforts to implement recommendations of the River Parks Authority.

GENERAL PROVISIONS

1. Neither Owner nor any other party to this agreement is required to

obligate or spend funds under this agreement, it being the intent of the parties that staff time and expertise be the primary contribution of each party to the effective implementation of this Agreement.

2. This permit may be terminated, in whole or in part, by the Owner or by the River Parks Authority upon 90 days written notice to the other party.

3. All notices required under this agreement shall be effective when mailed to the following persons:

To Owner:

____
____
____
____

To River Parks Authority:

Jackie Bubenik, Executive Director
River Parks Authority
707 South Houston, Suite 202
Tulsa, Oklahoma 74127

4. By their signatures hereto, the Corps, USFWS, ODWC, TAS, and the Conservancy agree to assist the Owner and The River Parks Authority by providing expertise and assistance toward the common goal of protecting, managing, and enhancing the Least Tern population on the lands described.

IN WITNESS WHEREOF, the parties hereto have subscribed their names as of the dates indicated:

____

By: ______________________________ Dated: ____________________
______Its: ______________________________

THE NATURE CONSERVANCY Dated: ____________________

Attest:

By: ______________________________ By: ____________________
______Its Vice President Its Assistant Secretary

U.S. ARMY CORPS OF ENGINEERS Dated: ____________________

______
By: ______________________________
Its: ______________________________

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

By: ______________________________ Dated: ____________________
______Its: ______________________________

U.S. FISH AND WILDLIFE SERVICE

By: ______________________________ Dated: ____________________
______Its: ______________________________

TULSA AUDUBON SOCIETY Dated: ____________________

______

Attest:

By: ______________________________
_____Its: ______________________________

RIVER PARKS AUTHORITY

By: ______________________________
_____Its: ______________________________

By: ____________________
Its: ____________________

Dated: ____________________

Attest:

Dated: ____________________

APPENDIX 4

Essential Breeding Habitat for Interior Least Terns

Riverine sandbars, river channel environment including open channel area, channel width, and appropriate instream flows, and lake shorelines and other habitats provide essential habitat for the interior least tern. The interior least tern is completely dependent on these habitats for food and nesting sites. Therefore, destruction or adverse modification of remaining habitats will cause continued reduction of the species range and eventually a reduction in population numbers. The areas described and mapped herein as essential habitat will provide the space necessary for continued existence and growth of interior least tern populations required to meet the recovery objective. The following maps depict essential habitat for the interior least tern. Hatch marks along river segments and certain national wildlife refuges indicate the areas where essential habitat intermittently occurs depending on water conditions. For example, sandbars and interior least terns do not occur along every kilometer of the indicated segments of rivers. Locations of nesting birds may change from year to year within the indicated segment.

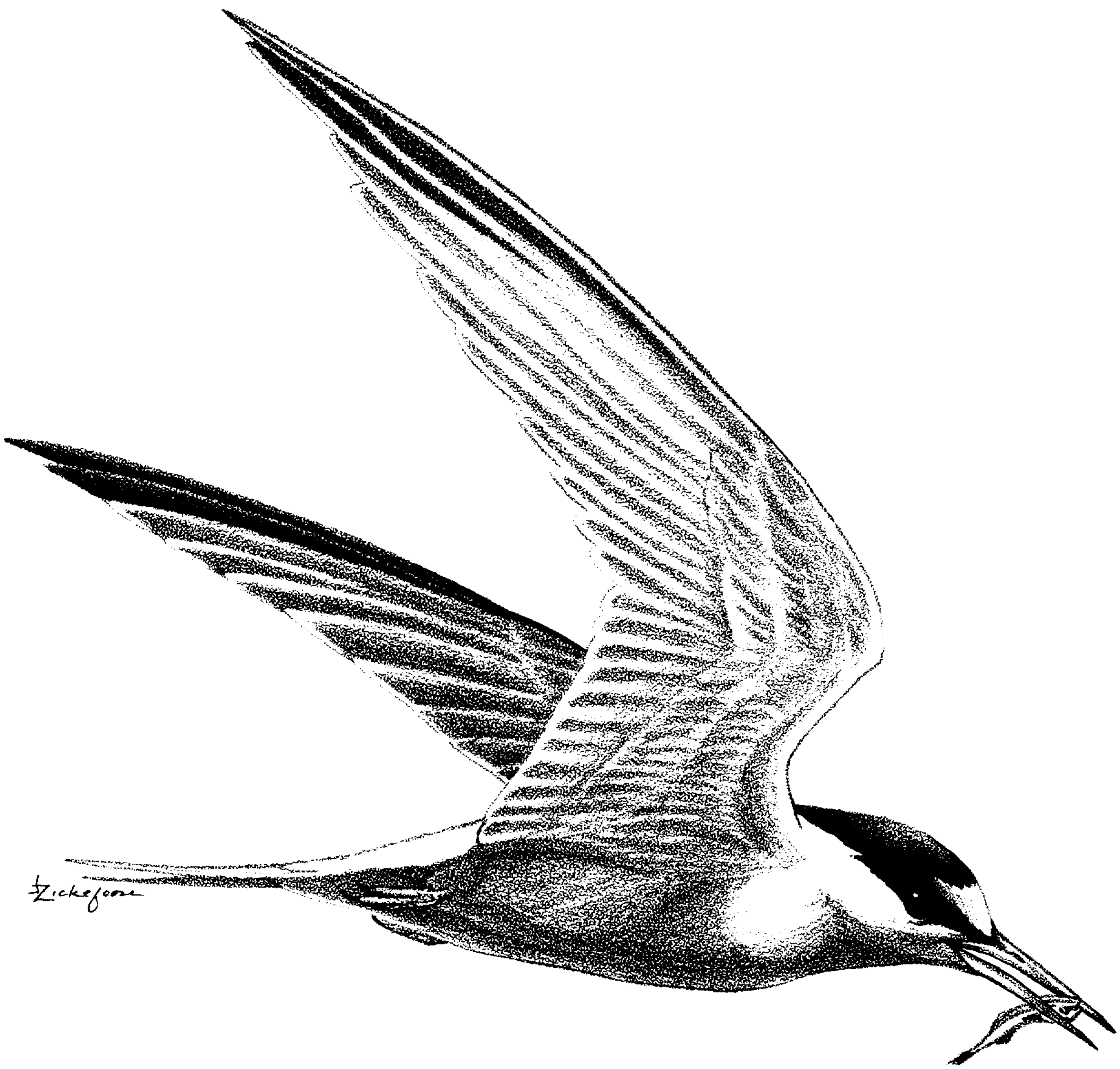
I. Missouri River System
   - Montana - Missouri River between Fort Peck Dam and North Dakota
   - North Dakota - Yellowstone River and Missouri River between Garrison Dam and the Cannonball River.
   - South Dakota - Cheyenne River from the Belle Fourche River to Lake Oahe; Missouri River from Ft. Randall Dam to mouth of the Niobrara River and from Gavin's Pt. Dam to Ponca, Nebraska.
   - Nebraska - Missouri River from South Dakota to mouth of the Niobrara River and from Gavin's Pt. Dam to Ponca; Niobrara River from Highway 183 bridge to Missouri River; Loup River from St. Paul to Platte River; Platte River from Lexington to Chapman and from Columbus (Highway 81 bridge to Missouri River.

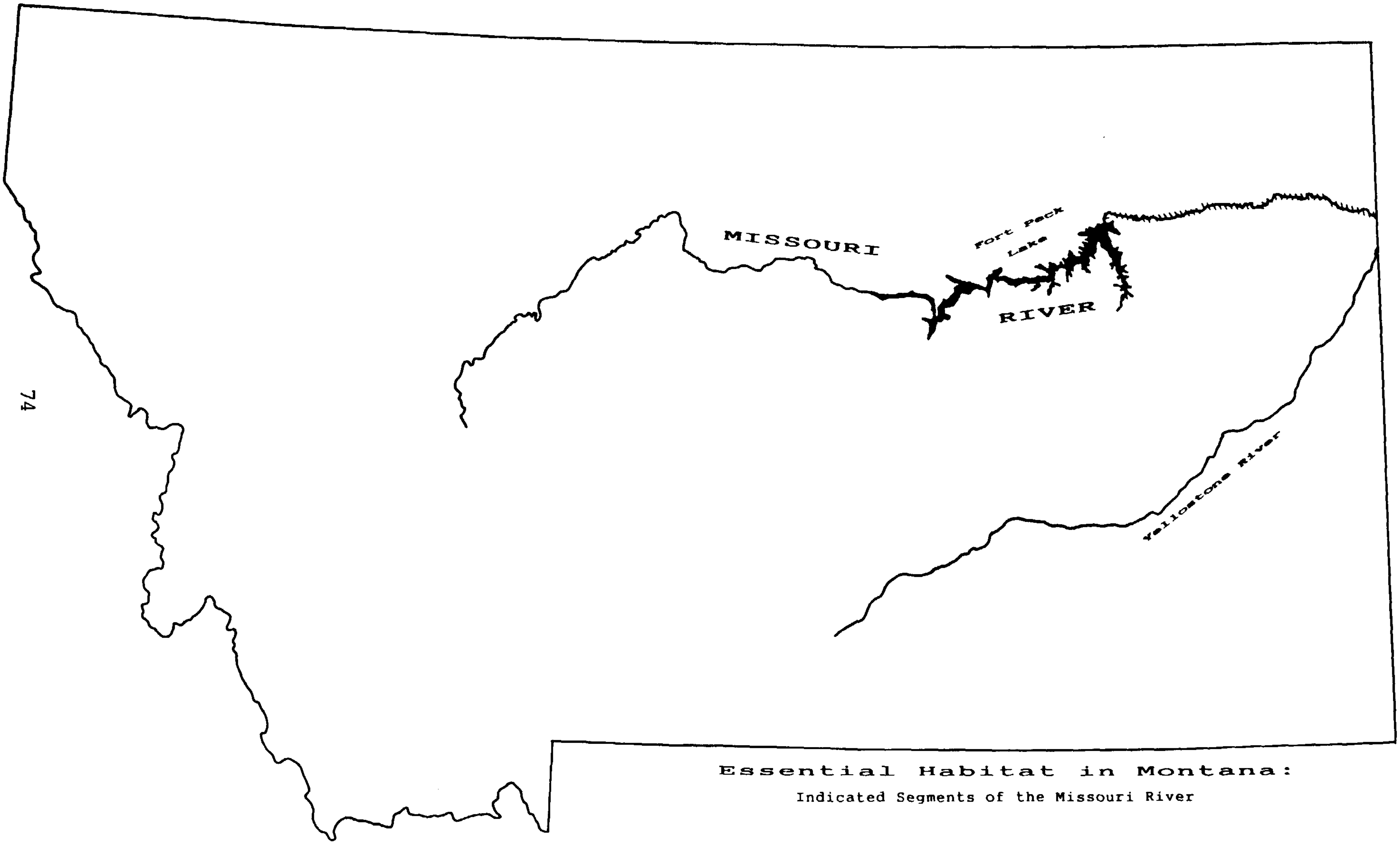
II. Mississippi River - From Highway 146 bridge, Missouri and Illinois to Vicksburg, Mississippi

III. Arkansas River system
   - Kansas - Quivira National Wildlife Refuge and Cimarron River
   - Oklahoma - Salt Plains National Wildlife Refuge; from below Kaw Dam to Arkansas River and Arkansas River from Tulsa to Muskogee; Cimarron River in Beaver, Harper, Woods, Woodward, Major, Kingfisher, Logan, and Payne counties; Canadian River in Ellis, Roger Mills, Dewey, Cleveland, McClain, Haskell, Pittsburgh, Hughes, Muskogee, and Sequoyah counties; Sequoyah National Wildlife Refuge;

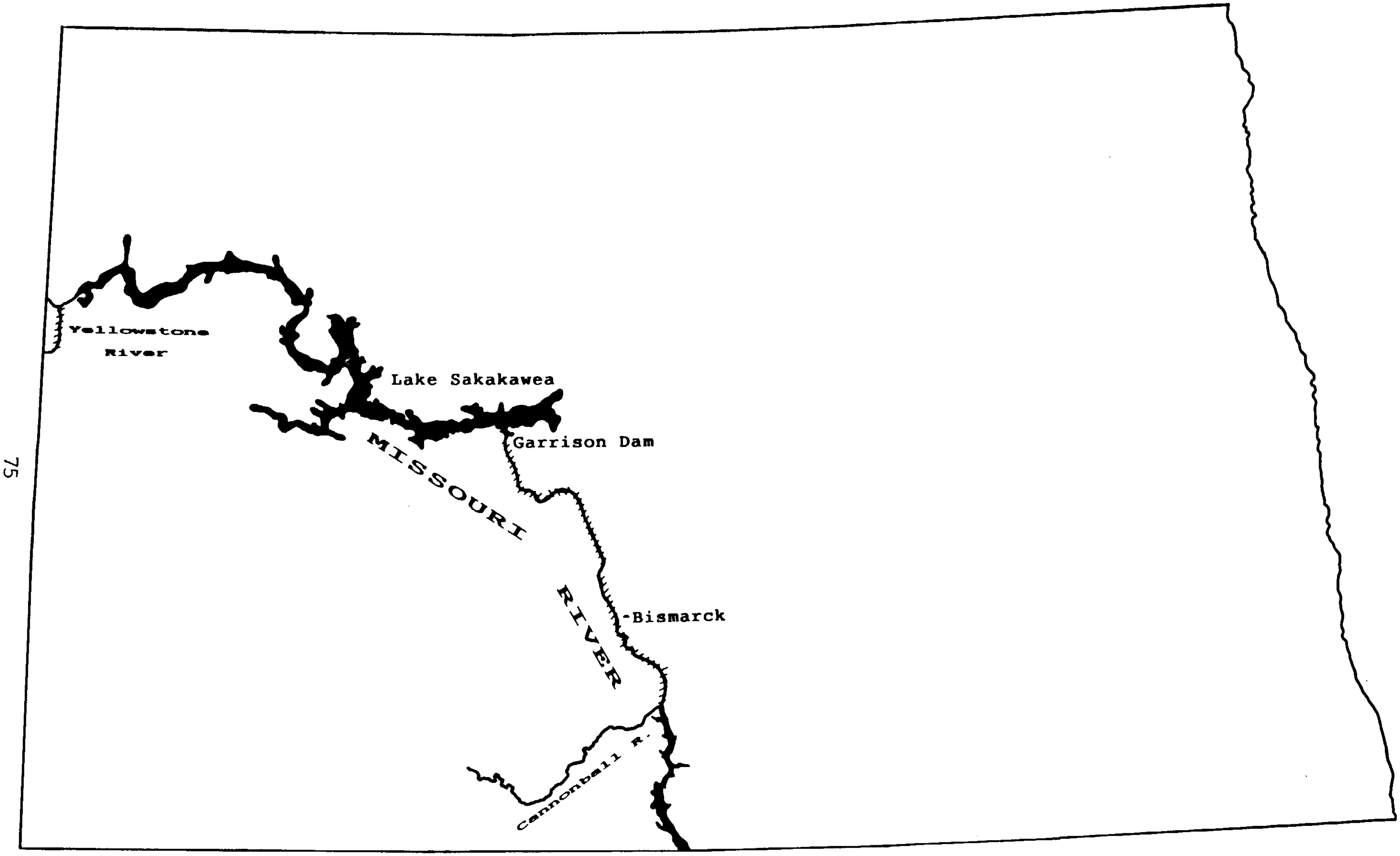
Red River from Harmon county to Highway 277/281 bridge.
Texas - Canadian River from Sanford Dam to Oklahoma; Prairie Dog Town Fork/Red River from Briscoe/Armstrong county boundary to Burkburnett, Texas.

IV. Pecos River - Bitter Lake National Wildlife Refuge, New Mexico.

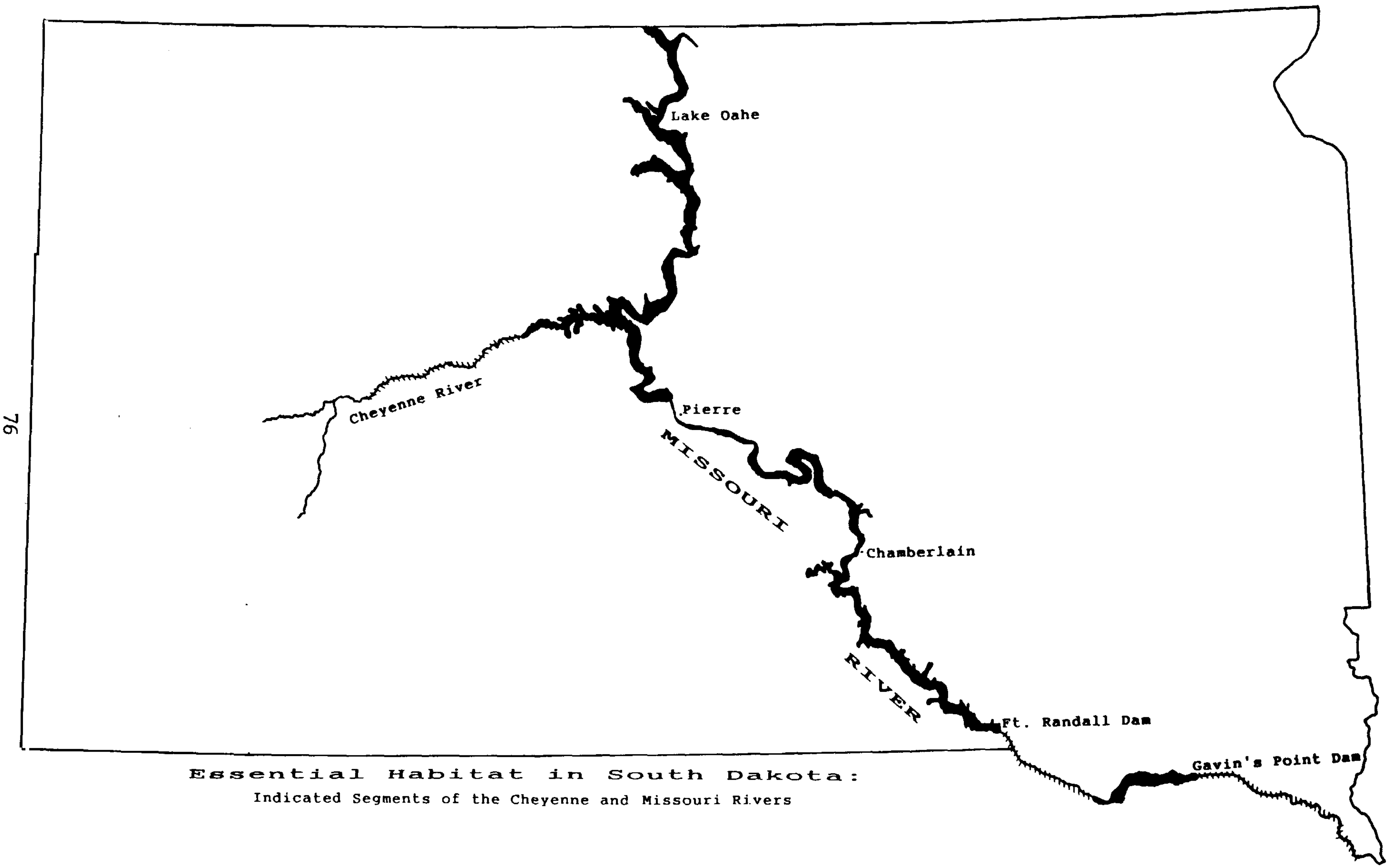




Essential Habitat in Montana:
Indicated Segments of the Missouri River

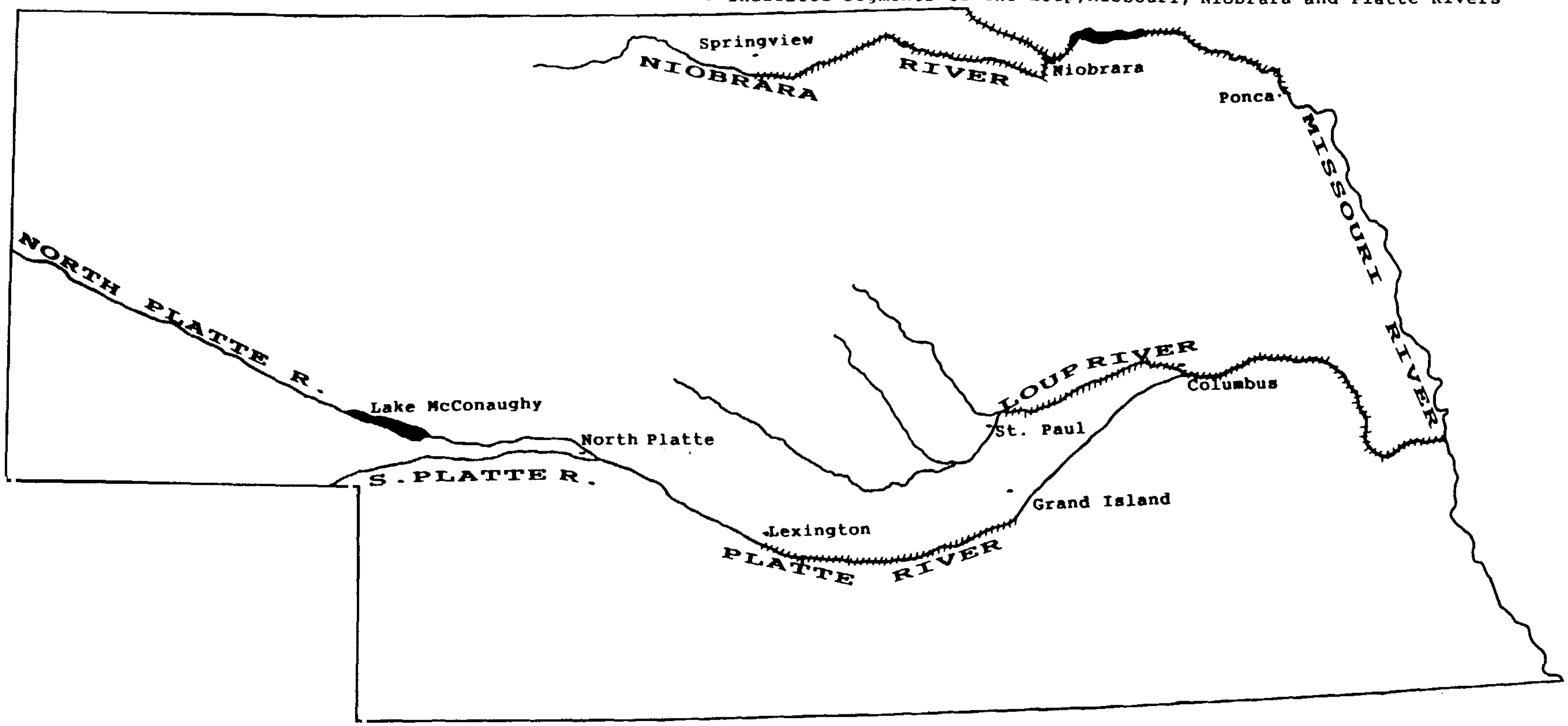


Essential Habitat in North Dakota:
Indicated Segments of the Missouri and Yellowstone Rivers



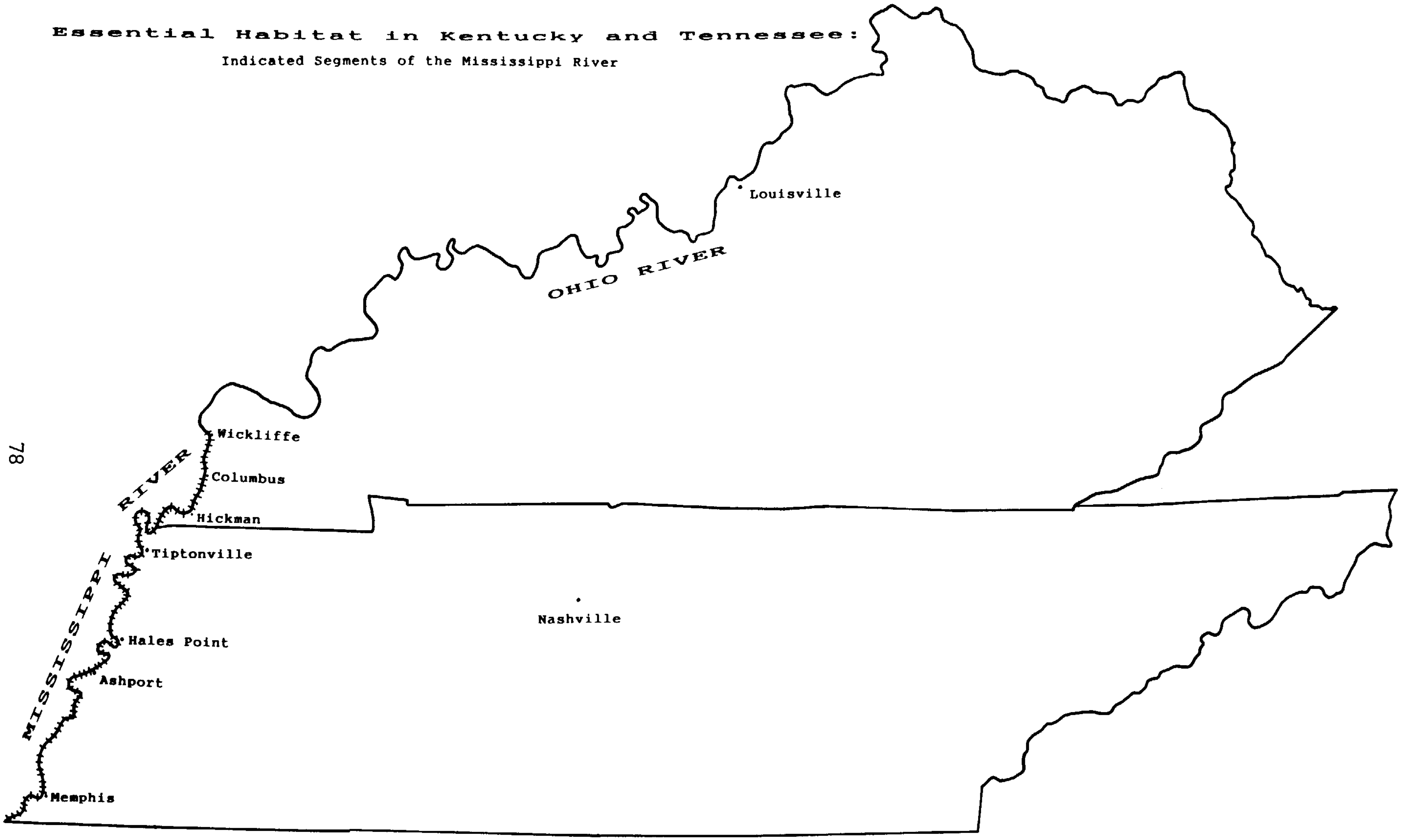
Essential Habitat in South Dakota:
Indicated Segments of the Cheyenne and Missouri Rivers

Essential Habitat in Nebraska: Indicated Segments of the Loup, Missouri, Niobrara and Platte Rivers



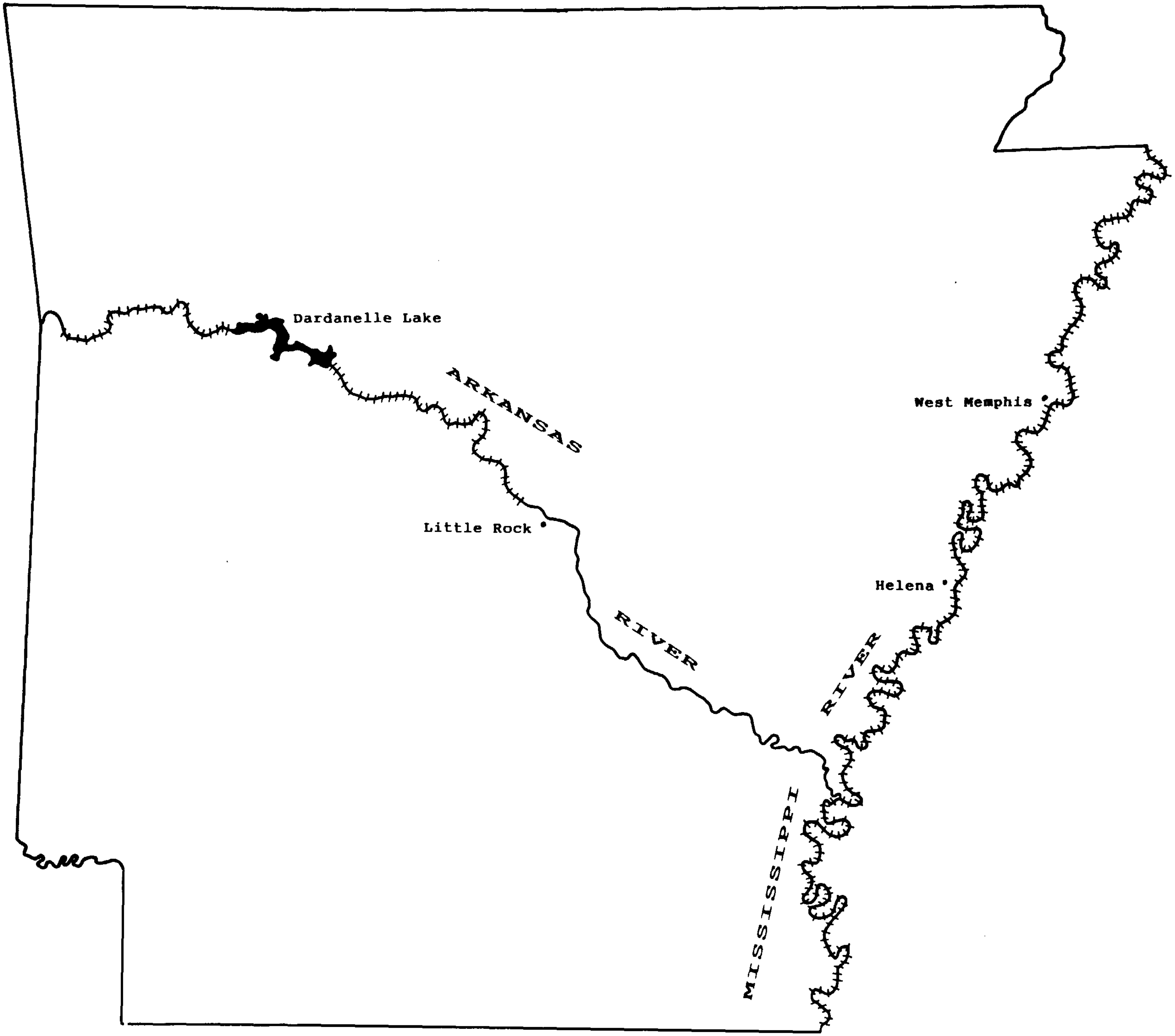
Essential Habitat in Kentucky and Tennessee:

Indicated Segments of the Mississippi River



Essential Habitat in Missouri:

Indicated Segment of the Mississippi River

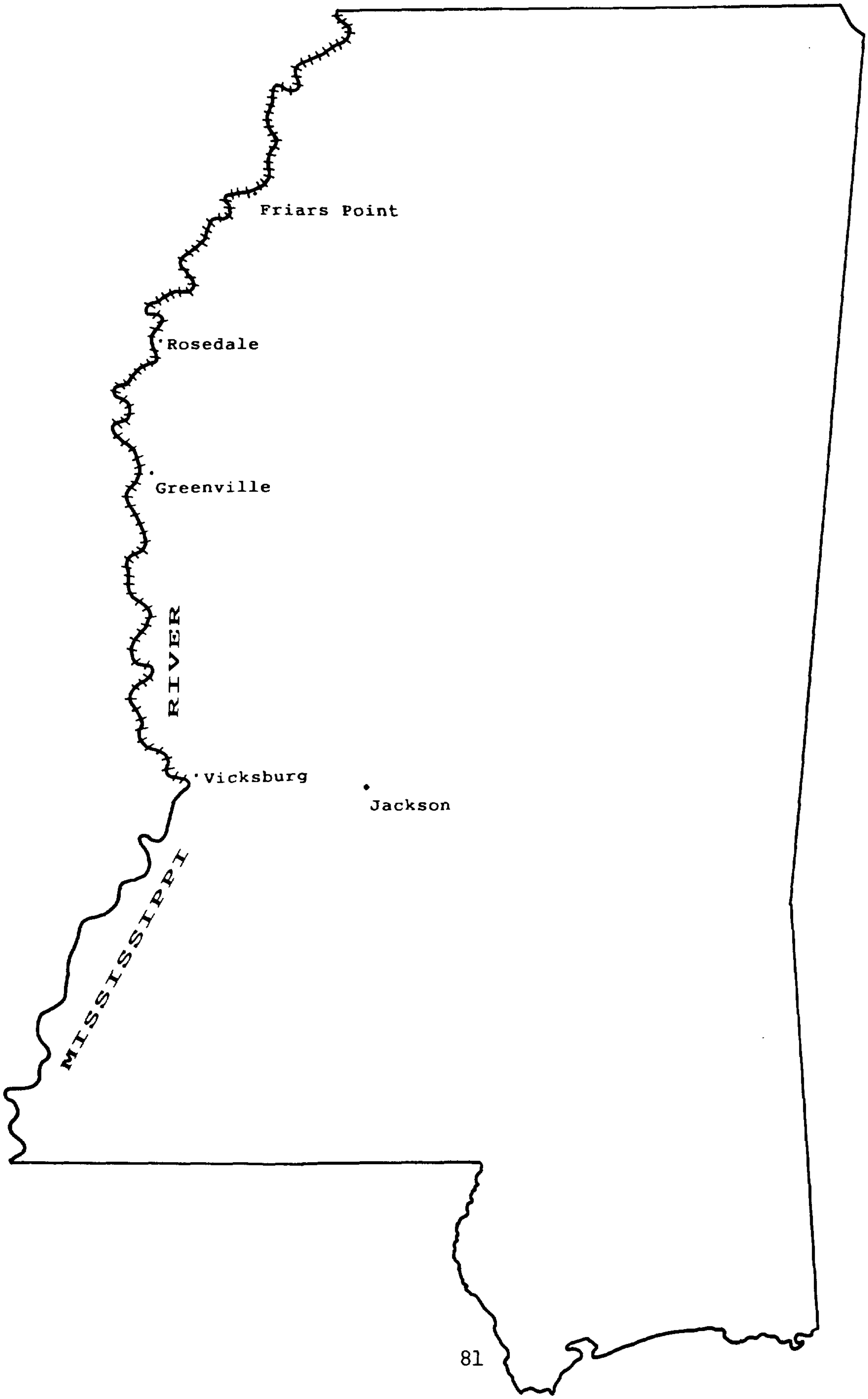


Essential Habitat in Arkansas:

Indicated Segments of the Arkansas and Mississippi Rivers

Essential Habitat in Mississippi

Indicated Segment of the Mississippi River



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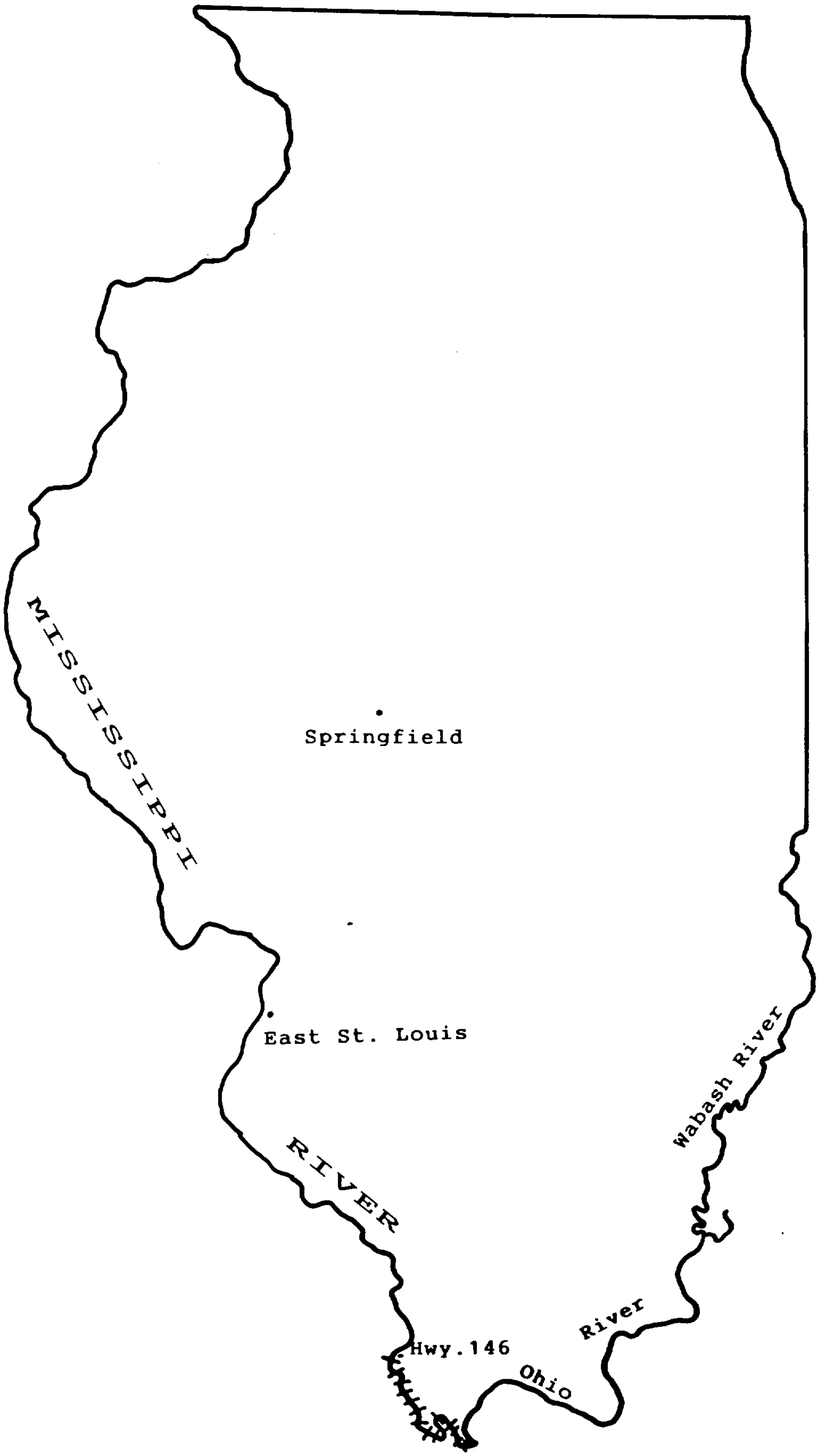
Indicated Segment of the Mississippi River



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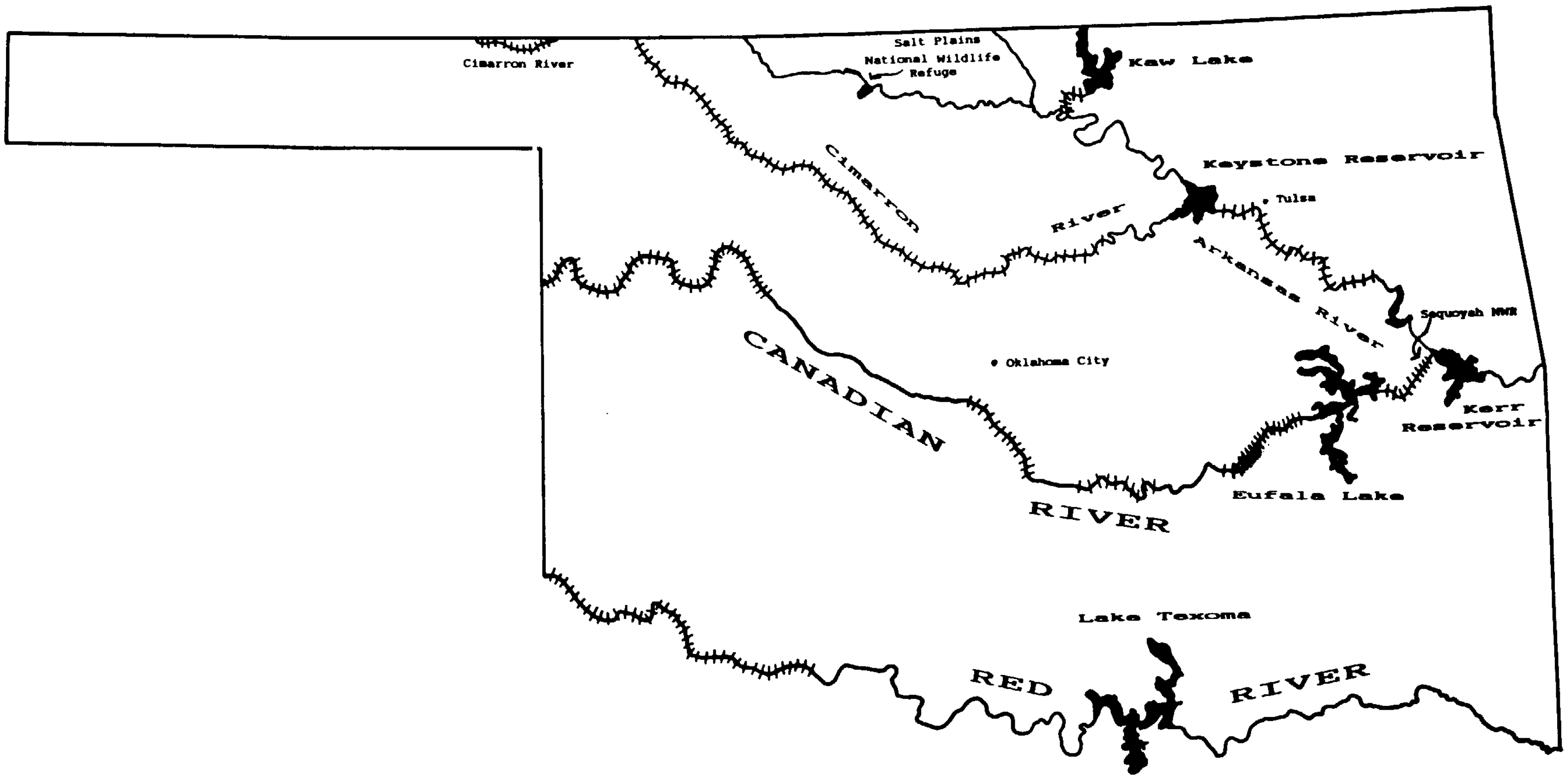
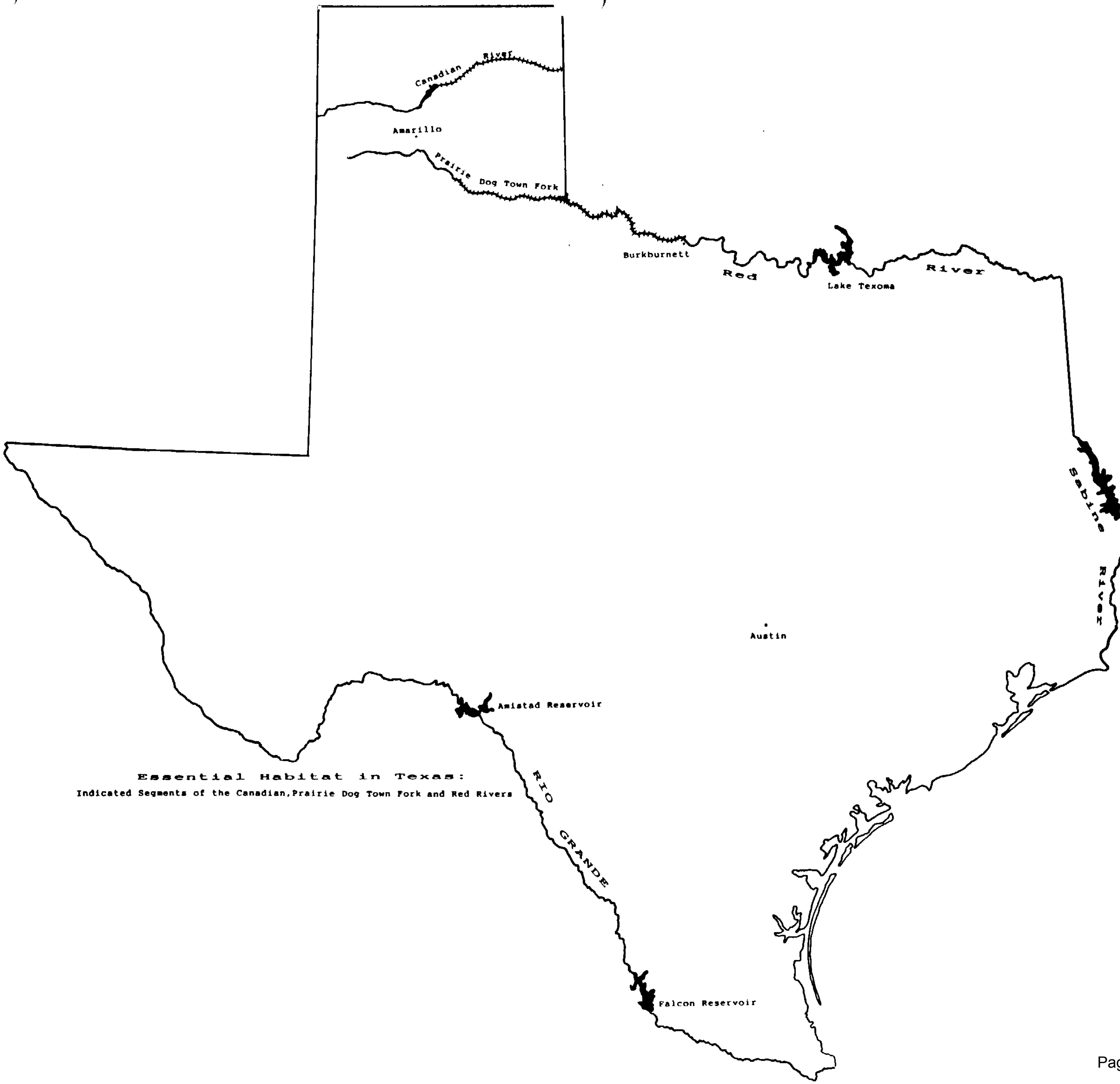
Indicated Segment of the Mississippi River



Essential Habitat in Oklahoma:

Sequoyah & Salt Plains National Wildlife Refuge

Indicated Segments of the Arkansas, Canadian, Cimarron and Red Rivers



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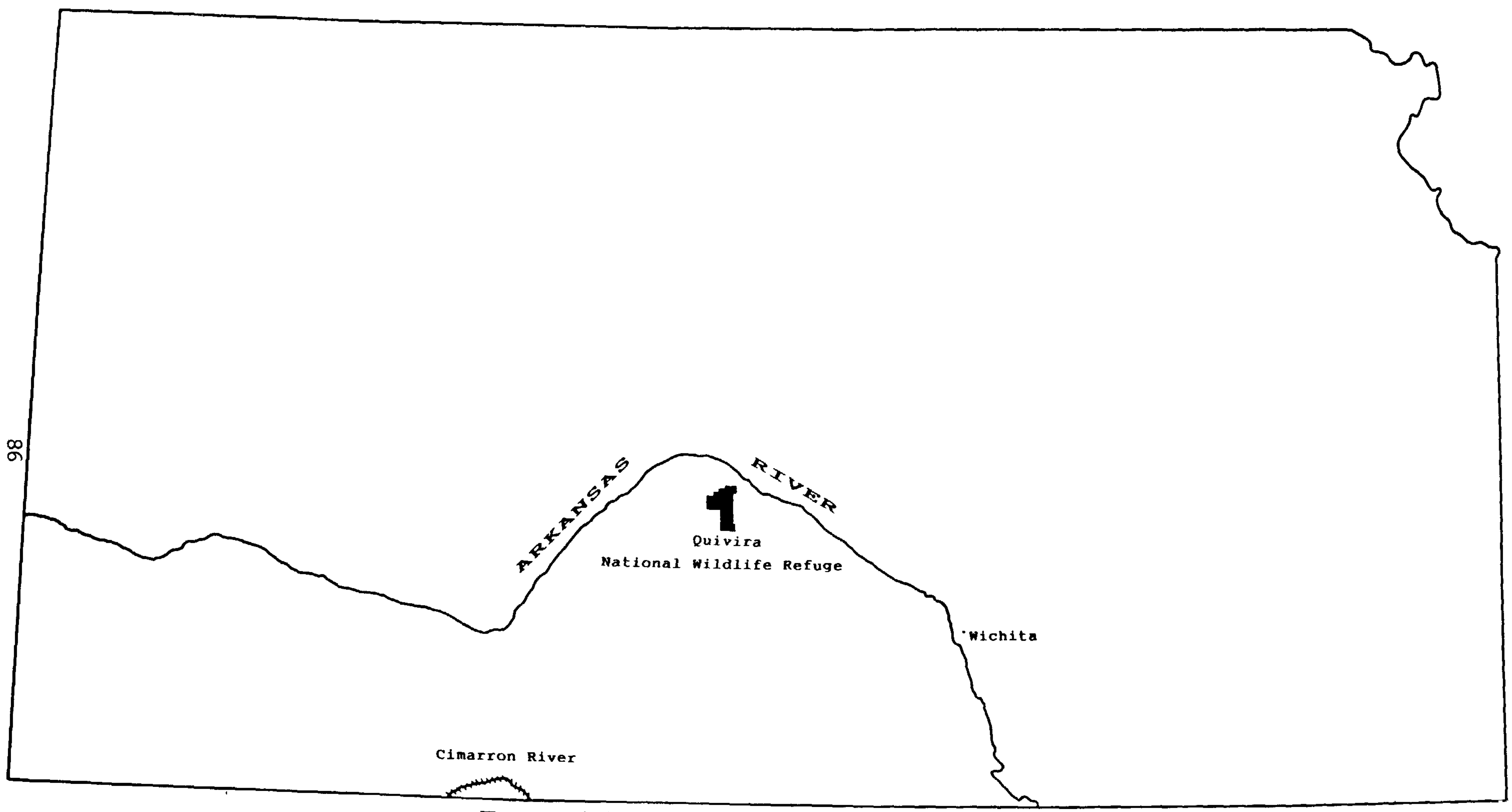
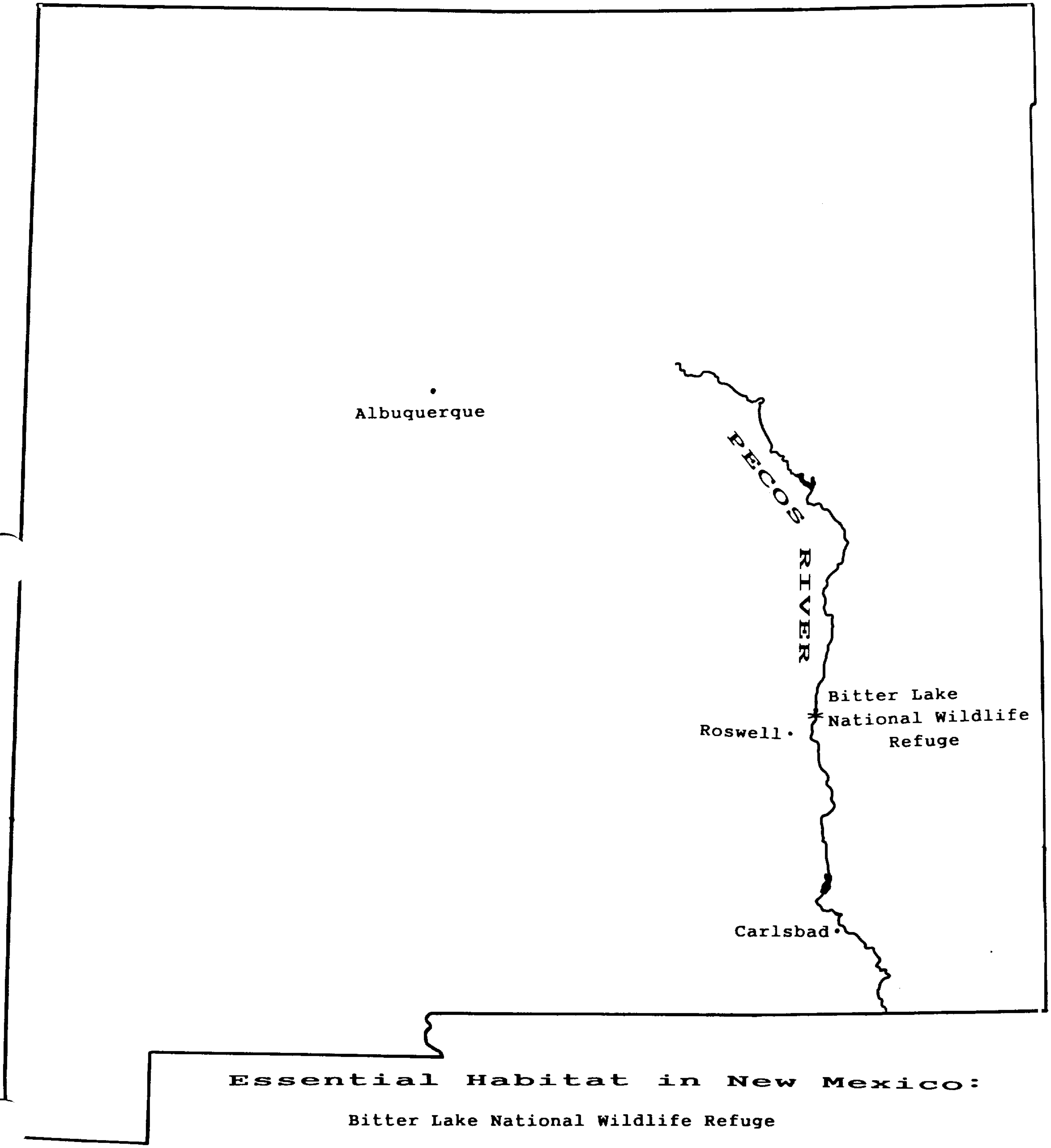
Indicated Segments of the Canadian, Prairie Dog Town Fork and Red Rivers



Essential Habitat in Kansas:
Quivira National Wildlife Refuge and Cimarron River



Essential Habitat in New Mexico:

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BIOLOGICAL REPORT 82(10.103)
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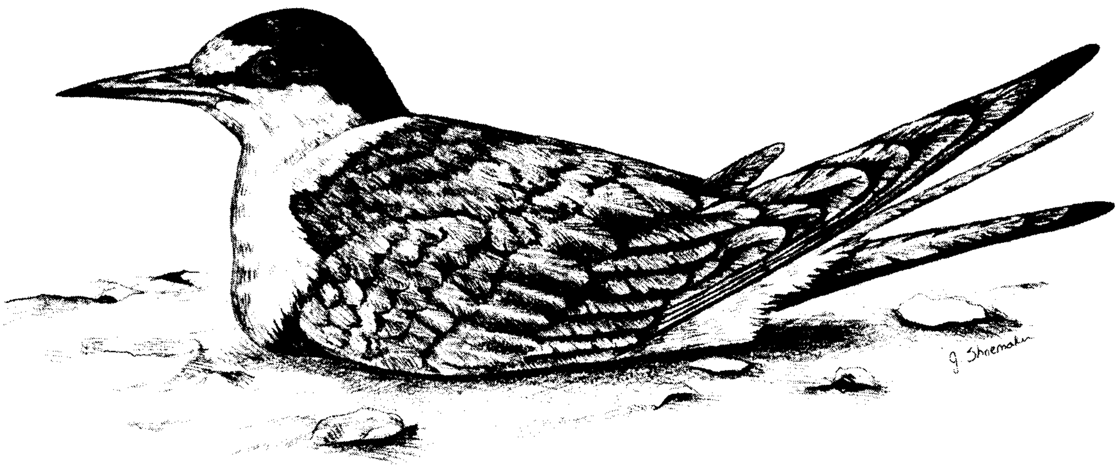
HABITAT SUITABILITY INDEX MODELS: LEAST TERN



Fish and Wildlife Service

U.S. Department of the Interior

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HABITAT SUITABILITY INDEX MODELS: LEAST TERN

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PREFACE

This document is part of the Habitat Suitability Index (HSI) Model Series [Biological Report 82(10)] which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information Section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. This information provides the foundation for the HSI model and may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model Section documents the habitat model and includes information pertinent to its application. The model synthesizes the habitat use information into a framework appropriate for field application and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). The HSI Model Section includes information about the geographic range and seasonal application of the model, its current verification status, and a list of the model variables with recommended measurement techniques for each variable.

The model is a formalized synthesis of biological and habitat information published in the scientific literature and may include unpublished information reflecting the opinions of identified experts. Habitat information about wildlife species frequently is represented by scattered data sets collected during different seasons and years and from different sites throughout the range of a species. The model presents this broad data base in a formal, logical, and simplified manner. The assumptions necessary for organizing and synthesizing the species-habitat information into the model are discussed. The model should be regarded as a hypothesis of species-habitat relationships and not as a statement of proven cause and effect relationships. The model may have merit in planning wildlife habitat research studies about a species, as well as in providing an estimate of the relative suitability of habitat for that species. User feedback concerning model improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning are encouraged. Please send suggestions to:

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CONTENTS

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Word processing was provided by Elizabeth Graf, Carolyn Gulzow and Dora Ibarra. The cover was illustrated by Jennifer Shoemaker. Kay Lindgren assisted with the literature search and document acquisition for this project.

LEAST TERN (*Sterna antillarum*)

HABITAT USE INFORMATION

General

The least tern (*Sterna antillarum*) breeds along coastal and freshwater habitats of North, Central, and South America and the Caribbean Islands (American Ornithologists' Union 1983). Three subspecies breed in the continental United States. The eastern least tern (*S. a. antillarum*) breeds along the Atlantic-Gulf coast from the southern tip of Texas (American Ornithologists' Union 1983) to southern Maine (Hunter 1975). The interior least tern (*S. a. athalassos*) breeds sporadically along the major tributaries of the Mississippi River drainage basin (Ducey 1981) and the Rio Grande (Downing 1980). The California least tern (*S. a. browni*) breeds from southern Baja California, Mexico, north to the San Francisco Bay (California Least Tern Recovery Team 1980). Least terns seen along the southern Colorado River and Salton Sea area of southern California may be wanderers from the *mexicanus* subspecies of the nearby Gulf of California (Wilbur 1974). No breeding populations of this subspecies in the continental United States were cited in the literature.

Breeding habitat is generally characterized as open sand, soil, or dried mud in the proximity of a lagoon, estuary, or river (Hardy 1957; Craig 1971; Massey 1971). The least tern has suffered a significant loss of nesting and feeding habitat from human activities, including recreational use and habitat modification due to development (Wilbur 1974; Buckley and Buckley 1976; California Least Tern Recovery Team 1980; Ducey 1981).

Food

Least terns consume small fish that swim near the surface (Tomkins 1959). The method of hunting consists of hovering and diving from a height of "a few feet" (Hardy 1957:50) to 10 m (Moseley 1976) above the surface. Least terns also skim the water for surface-dwelling prey (Bent 1921; Oberholser 1974) and feed on insects on land (Bent 1921; McDaniel and McDaniel 1963; Schulenberg et al. 1980). However, feeding over land is considered rare for least terns (Moseley 1976).

Least terns employ an opportunistic foraging strategy (Atwood and Minsky 1983) and probably exploit any fish species within a certain size range (Moseley 1976). The stomach contents of 49 least terns collected in New Jersey, Florida, and Louisiana consisted of 43.1% silver anchovy (*Engraulis eurystole*), 6.8% menhaden (*Brevoortia tyrannus*), 6.3% mummichogs (*Fundulus heteroclitus*), 5.0% Crustacea, 1.1% silversides (*Menidia* spp.), and 37.7% unidentified items (McAtee and Beal 1912).

Species of fish dropped or discarded by adults in nesting colonies appear to correlate roughly with species actually consumed (Massey and Atwood 1980; Atwood and Kelly 1984). In California, northern anchovy (Engraulis mordax) usually was the most commonly dropped fish followed by topsmelt (Atherinops affinis), jacksmelt (Atherinopsis californiensis), and deepbody or slough anchovies (Anchoa compressa, A. delicatissima) (Atwood and Kelly 1984). In Mississippi, Hays (1980) found Gulf menhaden (Brevoortia patronus) and bay anchovy (Anchoa mitchilli) most frequently dropped at a least tern colony. In addition to these two species, emerald sleeper (Erotelis smaragdus) and rough silverside (Membras martinica) were dropped at colony sites in Texas (B. C. Thompson, Texas Parks and Wildlife Department, Austin; letter dated 9 August 1984). Burroughs (1966) found sand lance (Ammodytes spp.), herring (Clupea spp.), and hake (Urophycis spp.) dropped in least tern colonies in Massachusetts. Hardy (1957) found dropped river shiner (Notropis blennius) on the lower Ohio River and determined this species to be the dominant food of least terns in that area. Schulenberg et al. (1980) collected plains killifish (Fundulus kansae) most often at colony sites in Kansas.

Fish 2.5 to 7.5 cm long were caught and eaten by adult least terns and fed to young in Kansas (Schulenberg et al. 1980). Moseley (1976) found that adult birds in North Carolina ate fish 5 to 8 cm long and fed newly-hatched chicks fish 2 to 4 cm long. In California, adult terns fed on fish from 4 to 9 cm long (Massey 1974) and seemed barely able to swallow northern anchovies 9.5 to 10 cm long, and surfperches (Embiotocidae) 2 cm deep vertically (Massey and Atwood 1980). Eighty-four percent of fish eaten during courtship were < 5 cm long with 50% between 2.5 and 5 cm. Dropped fish collected in California terneries ranged from 3.5 to 9.5 cm long. Chicks < 10 days of age were fed fish < 2.5 cm, whereas chicks older than 10 days and fledglings were fed a broad range of sizes (Massey and Atwood 1980). Massey and Atwood (1981a) concluded that suitable fish for young chicks were nonspiny species < 1.5 cm long. Atwood and Kelly (1984) considered spiny fish and fish with a body depth or rotundity diameter > 1.5 cm as generally unsuitable food items for adult least terns.

Water

No information on least tern drinking water requirements was found in the literature. Food and cover requirements associated with water are discussed under the appropriate sections.

Cover

Adult least terns require no cover during the breeding season. Areas used for mating, nesting, and feeding young have been described as bare (Jernigan et al. 1978). Massey and Atwood (1982) described a night roosting site as a wide stretch of sandy beach.

Least tern chicks abandon the nest within a few days after hatching (Massey 1974). Parent birds tend to lead the chicks toward the colony's periphery (Akers 1975) into more heavily vegetated areas (Moseley 1976). Chicks can wander widely within and outside of the colony (Massey 1974; Akers 1975). Chicks use sparse vegetation and water deposited debris for shade and protection (Hardy 1957; Jernigan et al. 1978; Minsky et al. 1984; Schulenberg and Ptacek 1984).

Reproduction

Least terns generally nest on a flat, unvegetated substrate near a good feeding area (Portnoy 1977) (Fig. 1a), but also can nest successfully on less characteristic sites (Figs. 1b and 1c). Least terns in marine environments nest on islands, peninsulas, beaches, sandbars, and isolated sandpits (Moseley 1976), usually between the high tide line and the area of dune formation (Akers 1975; Hunter 1975; Dorr 1976; Blodget 1978). Most inland least tern nesting occurs along the larger rivers with broad expanses and braided water channels (Ducey 1981), specifically on saltflats and sandbars that become exposed during periods of low water (Stiles 1939; Hardy 1957; Schulenberg and Schulenberg 1982). However, nests also are found in salt marshes (Parmelee et al. 1969) and along lakes (Schulenberg et al. 1980).

Least terns scrape out shallow nests on unconsolidated substrates such as sand, soil, shell, or gravel. Least terns in North Carolina (Jernigan et al. 1978) and in New York (Gochfeld 1983) preferred a coarse sand-shell substrate. Craig (1971) stated that a sand-shell mix provided the best background for the cryptically colored eggs and chicks of least terns in California. Areas of sand-pebble substrate that provide camouflage (Burroughs 1966) are also preferred as nesting sites by least terns (Hardy 1957).

Successful tern colonies have been found on fine-grained substrates (Wycoff 1950; Hays 1980). However, studies in California (Swickard 1972), Oklahoma (Grover and Knopf 1982), Texas (Thompson and Slack 1982), and Kansas (Schulenberg and Ptacek 1984) have associated high egg loss during heavy rains with the poor water permeability of finer grained substrates. Finer materials also are more prone to wind-drifting (Downing 1980; Gochfeld 1983), which can destroy eggs (Burroughs 1966) and possibly young (Ganier 1930). Soots and Parnell (1975) found that shell material helped stabilize nesting substrate in North Carolina. When little or no shell was present, winds caused erosion and shifting sand dunes. On a saltflat in California, least terns apparently avoided nesting on sites containing high amounts of silt and clay (Minsky et al. 1984).

Least tern nesting habitat is generally characterized as ephemeral (Gochfeld 1983), being represented vegetatively by pioneering plant species that are low-growing, scattered, or form dispersed clumps (Jernigan et al. 1978; Thompson and Slack 1982). Total vegetation cover rarely exceeded 20% at colony sites in California (Craig 1971), Kansas (Schulenberg et al. 1980), and Texas (Thompson and Slack 1982). In New York, most nesting sites were in areas of 5 to 25% cover, although sites with > 20% cover were seldom occupied (Gochfeld 1983). Nest sites in North Carolina (Jernigan et al. 1978) and Nebraska (Faanes 1983) were generally located in areas of < 10% cover.

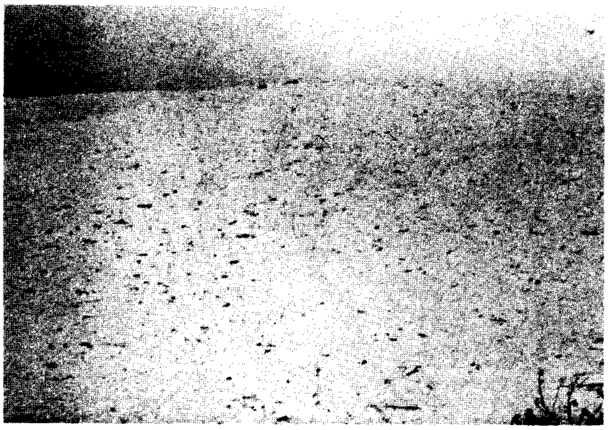

Figure 1a. Preferred least tern nesting habitat consists of flat, open, unconsolidated sites such as this North Carolina coast beach (photo by R. F. Soots, Jr.).

Figure 1b. Least terns can nest in topographically diverse upland habitat. Some least terns in southern California nest on flat areas between 2 m high sand dunes (photo by L. R. Bevier).

Figure 1c. Established least tern colonies can persist in areas of encroaching vegetation and human disturbance such as this site on a Texas Gulf coast island (photo by B. C. Thompson).

Figure 1. Examples of least tern nesting habitat in marine environments.

Jernigan et al. (1978) reported that vegetation height ranged from 0 to 40 cm with a mean of 7 cm in natural sites. Least terns in Kansas nested among 0.6 to 0.9 m tall plants when more favorable habitat was flooded (Schulenberg and Schulenberg 1981). Nests in Mississippi tended to be located among sparse vegetation more often than on open beach (Jackson 1976). Other authors (Akers 1975; Blodget 1978; Grover and Knopf 1982) have noted that least terns tend to nest in close proximity to debris. Occasionally, least tern colonies are found in relatively densely vegetated areas, although some workers attribute this to possible site tenacity (i.e., the tendency of birds to return to the same site year after year) (Downing 1973; Jernigan et al. 1978; Thompson and Slack 1982; Gochfeld 1983) or a response to habitat loss (Moseley 1976) rather than preferential habitat selection. Other authors have stated that least terns move to new habitat when vegetation encroachment occurs (Wycoff 1960; Downing 1973; Buckley and Buckley 1980). Vegetation encroachment on sandbar nesting habitat is a major cause of habitat loss for least terns in the interior (Ducey 1981).

By nature of their close proximity to water, least tern colonies are often threatened by inundation. Flooding by high tides and stream flows can be a major cause of reproductive failure for the least tern (Paige 1968; Blodget 1978; Loftin and Thomson 1979; Ducey 1981; Grover and Knopf 1982; Faanes 1983; Schulenberg and Ptacek 1984). Least terns in marine environments often avoid inundation by selecting the more elevated portions of a breeding site (Akers 1975; Thompson and Slack 1982; Gochfeld 1983), such as lumps and ridges as opposed to flats (Jernigan et al. 1978). Loftin and Thomson (1979) concluded that nests elevated "a few inches" by transplanting an automobile tire over them would stand a better chance of survival from high water. Least terns also can escape flooding by avoiding narrow beaches and by nesting some distance from the high tide line (Gochfeld 1983). Least terns in Long Island, New York avoided beaches < 10 m wide above the high tide line. Similarly, least tern nests in riverine environments often are situated on less vulnerable sites. At a colony site on the lower Ohio River, most nests were located on accumulations of gravel and usually were located well back from the water (Hardy 1957). Wycoff (1960) also noted least terns nesting on relatively higher ridges of gravelly mud in Nebraska. Least terns inhabiting river systems can delay reproduction until after the period of peak river flooding, when suitable nesting sites become available (Bent 1921; Ganier 1930; Stiles 1939; Hardy 1957; Wycoff 1960).

Predation also can be a major cause of nesting failure (Paige 1968; Akers 1975; Blodget 1978; Massey and Atwood 1979). The presence of predators can prevent least terns from nesting (Massey 1971) and cause them to abandon previously occupied sites (Massey and Atwood 1981a). Barriers to mammalian predators include fencing (Massey 1971; Minsky 1980) and the isolation of a colony site by water (Hardy 1957; Swickard 1972, 1974; Faanes 1983). Landin and Soots (1977) noted that dredged material deposits that were used for nesting allowed access to colonies at low tide when located too close to the mainland. They also found that islands > 8 ha were rarely used because predators could inhabit them year-round. Dredge-spoil islands that lack dense vegetation and are not located adjacent to large marshes are less likely to support mammalian predators than are naturally occurring barrier islands (Soots and Parnell 1975). Some terrestrial predators on least tern eggs and chicks include Norway rats (Rattus norvegicus), house cats (Felis catus), skunks (Mustelidae) (Massey and Atwood 1979), foxes (Vulpes fulva) (Minsky 1980), and coyotes (Canis latrans) (Grover and Knopf 1982). Least tern eggs and chicks also are preyed on by many avian species. Clumps of vegetation or debris used as cover by chicks can provide little protection from avian predation (Jenks-Jay 1982). In Massachusetts, however, the erection of wood and metal shelters provided protection from avian predators (Jenks-Jay 1982). Clay roofing tiles were used to provide hiding places for chicks from predatory birds in California (Massey and Atwood 1979). Avian predators include several species of raptors, gulls, and corvids.

Interspersion and Composition

Least terns hunt in shallow water areas such as nearshore ocean (Collins et al. 1979; Atwood and Minsky 1983), estuaries, lagoons (Wilbur 1974), rivers, streams, lakes, ponds (Hardy 1957), channels (Collins et al. 1979; Atwood and Minsky 1983), and canals (Fisk 1975). In marine environments, offshore foraging can occur in areas of floating seaweed that provide conditions normally found only in shallow water areas (e.g., minimum surface chop and small fish near the surface) (Massey and Atwood 1979). The movements of prey species tend to make specific foraging localities difficult to delimit (Massey and Atwood 1981a; Atwood and Minsky 1983).

In North Carolina, Jernigan et al. (1978) found that colony sites were in the vicinity of shallow, open water and tidal marshes with ample food supplies. In California, Atwood and Minsky (1983) observed that foraging activities were consistently high in nearshore ocean waters near major river mouths, possibly as a result of ecological conditions such as water depth, salinity, or nutrient supply that favored concentrations of prey species. Massey and Atwood (1980) noted that 75 to 90% of observed feeding activity during courtship, incubation, and feeding of young occurred in the nearshore ocean. Along rivers, shallow water areas formed by meanders or alterations in current flow are favorable sites for nesting and are the areas most frequently fished (Hardy 1957). Of 49 species of dropped fish listed by Atwood and Kelly (1984) in California, all primarily inhabited shallow water areas.

Least tern colonies need to be located close to feeding areas (i.e., extensive areas of shallow water) (Craig 1971). An ideal nesting substrate will not attract nor support breeding pairs if suitable feeding conditions are not present within a reasonable distance (California Least Tern Recovery Team 1980). Coastal least terns commonly breed in close proximity to shallow water areas such as nearshore ocean (Collins et al. 1979; Massey and Atwood 1980), estuaries (Massey 1971; Dorr 1976), and bays (Erwin 1978; Thompson 1982). In North Carolina, Jernigan et al. (1978) found all of 61 observed colonies within 250 m of a large expanse of shallow water. Least terns in Nebraska generally foraged within 100 m of nest sites (Faanes 1983). Although least terns in Kansas occasionally flew 3.2 to 4.8 km from colony sites to feed, birds usually foraged within 1.6 km of colony sites (J. H. Schulenberg, contractor with Kansas Fish and Game Commission, Pratt; pers. comm.). In California, most foraging occurred within 3.2 km of nesting sites (Atwood and Minsky 1983). Massey and Atwood (1980) saw many birds foraging 6.4 km or more from the colony; however, birds found foraging farther than 4 km from the nesting site were suspected to be nonbreeders (Massey and Atwood 1981a). In Mississippi, Hays (1980) noted that although least terns commonly fished in shallow water, they also foraged in deeper water 4.8 to 8 km from shore in the Gulf of Mexico.

Least terns use a variety of aquatic habitats when available. Least terns in the interior have been seen foraging in rivers, lakes, ponds, sloughs, and borrow pits (Ganier 1930). Similarly, the least terns in a colony on the San Gabriel River in California were seen foraging in the river, at the mouth of the river, in a marina, in a flood control canal, in a marsh, and offshore (Massey and Atwood 1979). After fledging, terns in California shifted to quiet, shallow areas such as freshwater lakes and ponds, flood control channels, and saltmarsh channels where the young appeared to be perfecting their foraging skills (Massey and Atwood 1980; Atwood and Minsky 1983). The authors suggested that such areas were critical to the survival of fledglings, and were therefore of major importance to the reproductive biology of the least tern. The authors further suggested that disturbance of nearshore ocean areas and river systems within 3.2 to 4.8 km of active nesting sites should be avoided, and that freshwater habitat within 8 km of the coast as well as salt marshes should be assessed for use by least terns.

Special Considerations

Nesting sites generally are characterized as unstable areas created and maintained by tidal action or flooding. Due to the sometimes transitory nature of nesting habitat, least terns have been described as having strong group adherence and weak site tenacity, which may aid in discovering recently created habitat (McNicholl 1975). In some cases, however, site tenacity can be a more important determinant of site selection than the physical characteristics of an area (Gochfeld 1983; J. L. Atwood, Department of Biology, University of California, Los Angeles; unpubl.). Least tern colonies can display high site fidelity by continuing to use an area year after year for as long as the site remains suitable (Burger 1984), including marginal sites where successful reproduction has occurred previously (Massey and Atwood 1979). In New Jersey, colony sites were abandoned only when predation, human disturbance, or vegetation encroachment reached intolerable levels (Burger 1984). Terns returned to and nested at sites where colonies were completely wiped out the previous year when such sites had been in use for several years. Year-to-year fidelity has been documented for least terns in California by Atwood (unpubl.), who also found that least terns tended to nest in the general vicinity of their natal colonies. Of 190 banded birds studied, approximately 50% nested within 25 km of where they were hatched, and over 80% nested within 50 km of their natal site.

Least tern nesting and feeding habitat has undergone a significant decrease as a result of beach erosion (Downing 1973) and various human activities such as recreational use of beaches (Gochfeld 1983), the development of beach homes (Chambers 1908) and marinas (Massey and Atwood 1980), dam construction (Ducey 1981), channel deepening (Downing 1980), and agricultural drawdown (Schulenburg and Ptacek 1984). Least terns partially compensate for the loss of natural habitat by successfully nesting in marginal areas quite unlike former sites (Craig 1971; Massey and Atwood 1979), although reproductive success in such areas often can be reduced (Atwood, pers. comm.). In California, least terns historically nested on beaches near the mouths of major rivers, bays, and estuaries (Massey and Atwood 1981a). Due to displacement, birds also now nest in areas such as mudflats and landfill sites back from the ocean (Craig 1971; Massey 1974; California Least Tern Recovery Team 1980). On the Atlantic-Gulf coast, least terns commonly nest on dredge and development spoil (Downing 1973; Soots and Parnell 1975; Buckley 1978) and on flat rooftops (Downing 1973; Fisk 1975, 1978a, b). Least terns also have been reported nesting on dredge material (Moser 1940; Wycoff 1950) and sandpits (Swanson 1956; Wycoff 1960) near rivers and lakes in the interior. Other unnatural nesting areas used by least terns include airports (Anderson 1972; Atwood et al. 1979), old parking lots (Texas Waterbird Society 1982; Gochfeld 1983), road shoulders (Texas Waterbird Society 1982), and cultivated fields (Nugent 1974).

Human-related disturbance to least tern colonies occurs in the form of foot traffic, pets, off-road vehicles (Dorr 1976; Blodget 1978), and livestock (Schulenberg and Ptacek 1984). Least terns can successfully nest close to human activity if the nest itself is not disturbed (Craig 1971; Thompson 1982). Brubeck et al. (1981) found a colony of least terns within 5 m of a heavily traveled highway in Texas, and Davis (1968) noted that the daily passing of a train approximately 3 m away from a colony in California did not displace incubating birds. Where human disturbance to the nests is a problem, fencing has been shown in some cases to be an effective means of protecting colonies (Blodget 1978; Massey and Atwood 1979, 1981a). Protection provided by fencing allowed least tern colonies in Massachusetts to become accustomed to vehicles and people (Blodget 1978). Fencing of a colony of three least tern nests in California resulted in an increase to 35 nesting pairs during the same year, and 80 to 95 pairs the following year (Massey and Atwood 1979).

Least tern nesting habitat can be enhanced by the improvement of marginal sites. In California, Swickard (1974) found that poorly drained and camouflaged substrates such as saltflats could be improved by the addition of highly disturbed and displaced sand. Schulenberg and Schulenberg (1982) reported similar results for least tern nesting habitat in Kansas. Swickard (1972) also stressed the importance of vegetation removal, which must be repeated periodically to prevent encroachment (Downing 1973; Massey and Atwood 1979; Schulenberg and Ptacek 1984).

The size of least tern colonies can range from a few to several hundred nesting pairs, and a colony can be divided into subcolonies (Massey 1974). The loss of nesting habitat can either lead to a decrease in colony size (Varza 1975) or complete abandonment of a site (Burger 1984). Erwin (1977) suggested that, because least terns frequently shift nesting sites, a larger amount of habitat than is being used at a given time should be protected in order to accomodate future needs.

The California and interior subspecies of the least tern are listed as endangered (California Least Tern Recovery Team 1980; U.S. Fish and Wildlife Service 1985a). All three subspecies are designated as national species of special emphasis (U.S. Fish and Wildlife Service 1985b).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model was developed for application within the entire breeding range of the least tern in the continental United States (Fig. 2). A review of literature pertaining to the least tern indicated that habitat for the three subspecies can be characterized by the same environmental variables. This model was constructed to evaluate the various habitat types inhabited by all of the subspecies and the various habitat types available to a potential population within a subspecies, unless otherwise indicated (see Cover types).

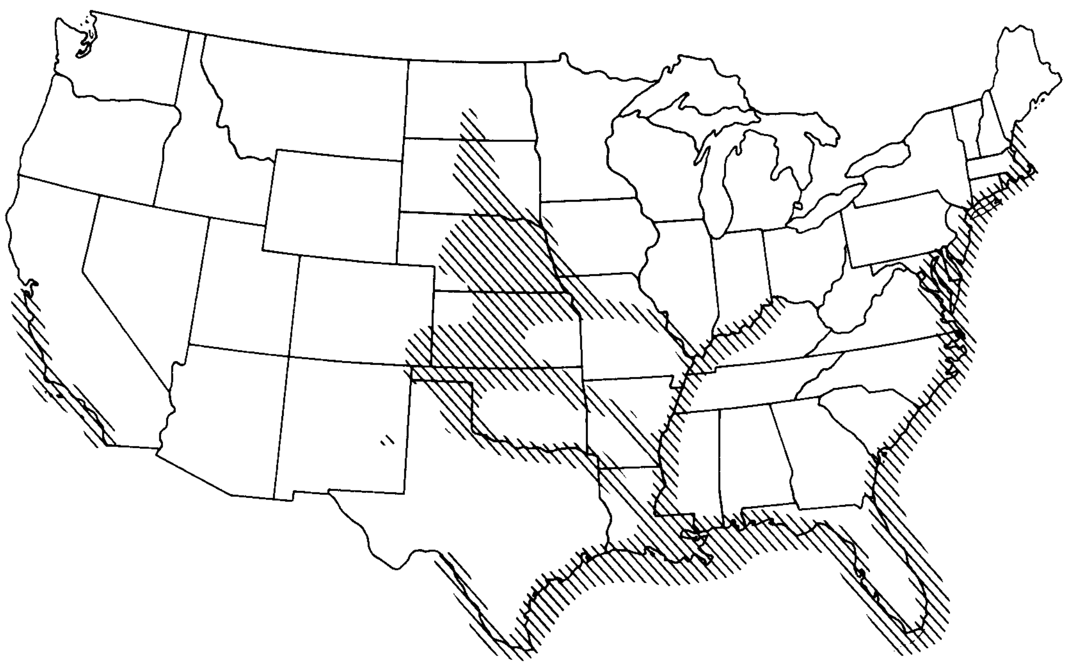

Figure 2. Approximate breeding range of the least tern in the United States (developed from various sources).

Season. This model was developed to evaluate the breeding season habitat of the least tern, specifically during May and June, which are generally the months of peak reproductive effort by the species (Hardy 1957; Downing 1973; Massey and Atwood 1981b). In riverine habitat, extensive flooding can cause reproduction to be delayed into July and August. See Application of the Model for guidance towards the evaluation of habitat that experiences extensive flooding during May and June.

Cover types. This model was developed to evaluate habitat in shore and bottom wetland (SBW), barren land (BL), and desertic herbland (DH) cover types

(U.S. Fish and Wildlife Service 1981), and marine (M), estuarine (E), riverine (R), lacustrine (L), and palustrine (P) aquatic systems (Cowardin et al. 1979). This model also is applicable to unnatural areas of unconsolidated substrate such as dredge material and sandpits, that may simulate natural substrate. Highly unnatural areas such as rooftops, airports, and roads are not considered acceptable areas for evaluation using this model.

It is believed that least terns require large expanses of relatively shallow water for foraging. However, a wide variety of aquatic habitats can contain fish of suitable size for least terns. Due to the opportunistic foraging behavior of least terns, it is assumed that potential least tern foraging habitat is any open body or channel of water, natural or constructed, known to contain or suspected of containing fish < 10 cm long that swim near the surface.

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before a species will live and reproduce in an area. The larger least tern colonies typically are found on broad, open nesting sites. However, small or narrow sites of adequate suitability also support some nests. The minimum area to be evaluated is left to the discretion of the user of this model. Some examples of least tern colonies on limited and restricted area sites are presented in Table 1. The relationship between aquatic habitat area and suitability is discussed under Food component.

Table 1. Examples of least tern colony sizes on limited and restricted area sites.

Subspecies	Area	# of nests	Reference
S. a. antillarum	5 m wide beach	6	Hunter (1975)
S. a. antillarum	64.2 m x 18.3 m island	300	Anderson (1977)
S. a. athalassos	38.1 m x 22.9 m island	6	Wycoff (1950)
S. a. athalassos	91.5 m x 20.1 m sandbar	6	Schulenberg and Schulenberg (1982)
S. a. browni	99 m x 122 m fenced enclosure	140-160	Massey and Atwood (1981)
S. a. browni	24.4 m x 54.9 m area of improved substrate	34	Swickard (1974)

Verification level. Previous drafts of this model were critiqued by Jonathan L. Atwood, Jean H. Schulenberg, and Bruce C. Thompson. Comments from these reviewers have been incorporated into the current model. Michael L. Peterson, Robert F. Soots, Jr., and Bruce C. Thompson assisted in the construction of the substrate textural triangle used in the model.

Model Description

Overview. The least tern habitat model considers the ability of the habitat to meet the food and nesting needs of the species as an indication of overall breeding season habitat suitability. The literature indicates that site tenacity plays a major role in least tern habitat use. Due to this behavioral trait, least terns may often nest in areas of relatively low suitability, as defined by this model. It is not recommended that this model be used to determine the value of sites with existing breeding populations of least terns or sites with a history of breeding activity within the past 5 years. This recommendation is made because occupancy can be a function of site tenacity in addition to, and possibly irrespective of, the physical habitat parameters addressed by this model. Due to the threatened and endangered status of the least tern throughout its range, habitats with a history of supporting populations of breeding least terns within the past 5 years should be assumed to have high value even if the model indicates low suitability. However, this model can be used to assess suitability and, subsequently, identify those habitat parameters that can limit the reproductive potential of an existing breeding population. With the distinction between habitat value and habitat suitability in mind, the model can be used as a tool for management.

The following sections provide a written documentation of the logic and assumptions used to interpret the habitat information for the least tern and to explain and justify the variables and equations used in the HSI model. Specifically, these sections identify variables that are used in the model, define and justify the suitability levels of each variable, and describe the assumed relationships between variables.

Food component. Least tern food requirements are related to the abundance and accessibility of small fish. Least terns feed on a variety of small fish species. A discussion of some fish species and size classes commonly foraged by least terns was presented under Food, the habitats used for foraging were discussed under Interspersion and Composition, and the assumptions concerning least tern foraging habitat were discussed under Cover types. The user of this model should use this information and, possibly, the advice of a fisheries authority, as guides to the determination of what aquatic habitats can be considered as foraging habitat.

Least terns will not use an optimum nesting site if the surrounding area does not contain adequate food resources. It is therefore important that the availability of food resources be addressed. This model does not directly measure the availability of fish. As an alternative, it is assumed that a suitable nesting habitat in close proximity to abundant and/or diverse aquatic habitat is a desirable nesting site for least terns. The maximum distance that breeding birds will fly to forage is not known. However, because of the care required by the progeny, it is probable that parent birds will not fly as far as nonbreeding birds during the incubation and chick-rearing period. It is assumed in this model that an area composed of ≥ 50% water within the average maximum flight distance from the potential nesting habitat will provide optimum foraging habitat area (Fig. 3). This is based on the assumption that a nesting habitat that borders an expansive aquatic system (e.g., the ocean or a large river and floodplain) will provide a potential nesting population with ample foraging habitat. It is assumed that the average maximum flight distance for coastal least terns is 3.2 km, based on the observations of Atwood and Minsky (1983) in California. It also is assumed the average maximum flight distance for interior least terns is 1.6 km, based on the observations of Schulenberg (pers. comm.) in Kansas. If breeding least terns behave differently in other areas, these distances should be modified accordingly.

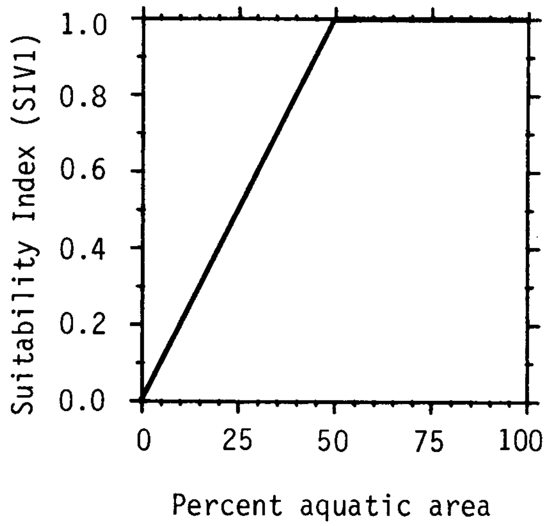

Figure 3. The relationship between the percent of the area within the average maximum flight distance from the potential nesting habitat that is aquatic habitat and the suitability index value for least tern food.

Least terns use and, at times, depend on a variety of foraging habitats. It is assumed that an area that contains a diversity of aquatic habitat types will be: (1) more productive than less diverse areas; (2) more likely to continue to provide food during the incubation and chick-rearing period if one of the aquatic habitat types fails to provide sufficient food supplies; and (3) able to adequately accommodate any possible change in foraging habitat use as the breeding season progresses. Habitat with two or more disparate aquatic systems (M, E, R, L, and P) within the average maximum flight distance is assumed to provide optimum diversity. However, a single, diverse aquatic system such as an estuary (E) or large riverine floodplain (P) can also be highly productive. Therefore, it is assumed that an area composed of a single aquatic system will provide optimum diversity of foraging habitat when it

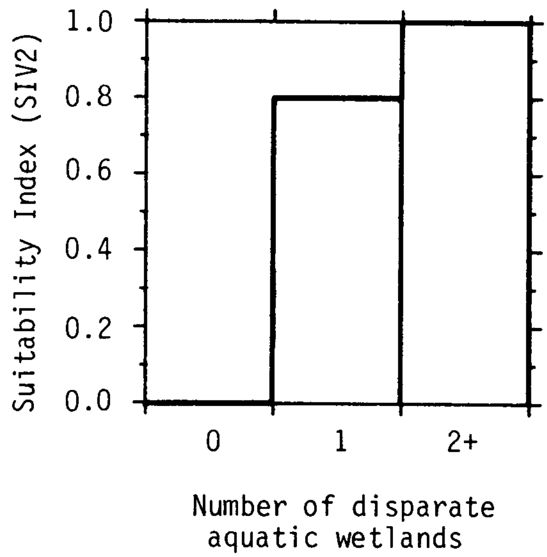

Figure 4. The relationship between the number of disparate aquatic wetlands within the average maximum flight distance from the potential nesting habitat and the suitability index value for least tern food.

contains two or more disparate aquatic (i.e., flooded) wetlands (Cowardin et al. 1979, Table 4) within the average maximum flight distance from the potential nesting habitat (Fig. 4). Again, this distance should be modified if breeding least terns are known to concentrate their feeding activity within a different radial distance. The user is referred to Cowardin et al. (1979) as a guide for the designation and delineation of aquatic systems and aquatic wetlands.

The formulation of SIV1 and SIV2 was based on the assumption that least terns prefer to nest in areas containing extensive areas of water and diverse aquatic habitat. The assumption that extensive and diverse aquatic habitat benefits least tern populations is based on the facts that: (1) most large populations are found along the coast, particularly in the vicinity of inlets; and (2) interior populations of least terns have declined drastically (Ducey 1981) concurrent with a significant decrease in aquatic habitat (i.e., areal extent and, correspondingly, diversity) throughout much of their range (Williams 1978a; Burke and Robinson 1979; Schulenberg and Ptacek 1984).

The suitability index value for food (SIF) is assumed to be a function of the areal extent of surface water and diversity of foraging habitat within the average maximum flight distance from the potental nesting habitat. The relationship between suitability values calculated using Figures 3 and 4 is illustrated in Equation 1. SIV1 is weighted to reflect the assumed greater relative significance of the quantity of foraging habitat.

$$SIF = \frac{2(SIV1) + SIV2}{3} \qquad (1)$$

Reproduction component. Reproductive (i.e., nesting) habitat suitability for the least tern is related to a combination of several factors; percent vegetation cover, average height of vegetation cover, type of substrate, susceptibility to flooding, and the amount of predation and human-related disturbance. The first three variables are presented in the following discussions. The latter two factors are addressed under Application of the Model.

Dense, tall vegetation on a potential nesting site can provide cover or convenient perches for predators. Least terns generally nest in areas of sparse vegetation and usually will not nest in areas with > 20% vegetation cover or in areas of tall vegetation. In some cases, sparse vegetation is necessary to protect chicks from exposure to the sun and predators. However, least terns commonly nest successfully in habitats with no vegetation and thus such habitats are considered to be highly suitable. It is assumed that habitats with vegetation between 0% and 15% coverage provide optimum cover suitability (Fig. 5a), and in habitats with 0% vegetation other materials such as water-deposited debris can serve the same purpose as vegetation. It also is assumed that an area will have no suitability as nesting habitat when vegetation exceeds 25% coverage. When percent vegetation cover is < 15% or > 25%, the suitability index for vegetation cover (SIC) is assumed to be determined solely by SIV3 (Fig. 5a).

When percent vegetation cover is ≥ 15% and ≤ 25%, suitability is determined by an assumed synergistic relationship between percent vegetation cover and the average height of vegetation (Fig. 5b). In such cases, it is assumed that an area has no suitability as potential nesting habitat when the average height of vegetation is ≥ 40 cm. When percent vegetation cover is ≥ 15% and ≤ 25%, the SIC is assumed to equal the value obtained using Equation 2.

$$SIC = (SIV3 \times SIV4)^{1/2} \qquad (2)$$

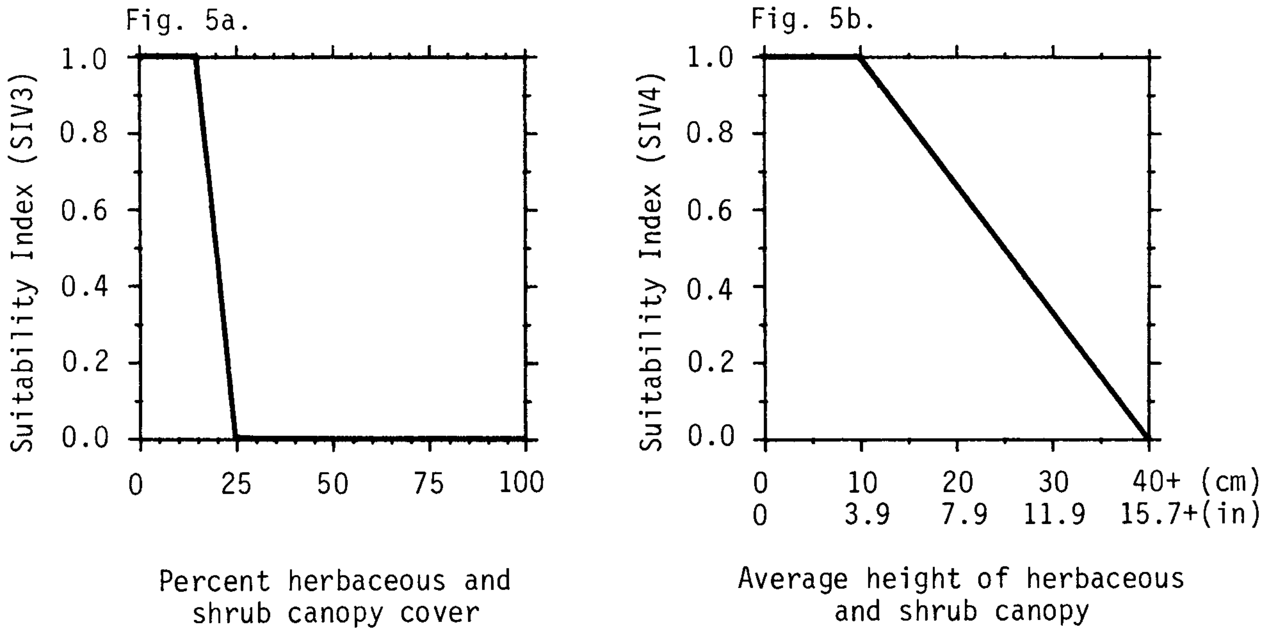

Figure 5. The relationships between vegetation cover and the suitability index values for least tern reproduction.

Least terns generally nest on unconsolidated substrate. Nesting success often is influenced by the type of substrate used. Figure 6 ranks the various mixtures of possible substrates of least tern nesting habitat. The bold lines within the triangle were delineated by a soil scientist (M. L. Peterson, U.S. Soil Conservation Service, Greeley, CO; unpubl.) and divide the triangle into three areas based on perculation characteristics. The upper right area of the triangle represents well-drained substrate, the lower left area represents poorly drained substrate, and the area between these two represents moderately well-drained substrate. Superimposed on the three areas are six shaded categories which were delineated by biologists (R. F. Soots, Department of the Army, Board of Engineers for Rivers and Harbors, Fort Belvoir, VA; pers. comm.; Thompson, pers. comm.) familiar with the requirements of least terns with respect to nesting substrate. These categories represent three classes of nesting substrate described as excellent, good, and poor. The triangle is used to evaluate substrate samples obtained from the potential nesting habitat. The triangle is read in the following manner: (1) locate the percentages of sand, fragmentary material, and silt/clay on their respective sides of the triangle; (2) follow the percentages inward on the triangle parallel with the labeled percentage lines; and (3) the shaded portion in which the three percentages intercept is the quality class into which the sample falls. Each quality class is assigned a corresponding suitability value (SIV5). The suitability values derived from the triangle are based on the following assumptions: (1) the presence of sandy areas is a proximate factor controlling nest site selection; (2) the presence of fragmentary material (e.g., pebbles,

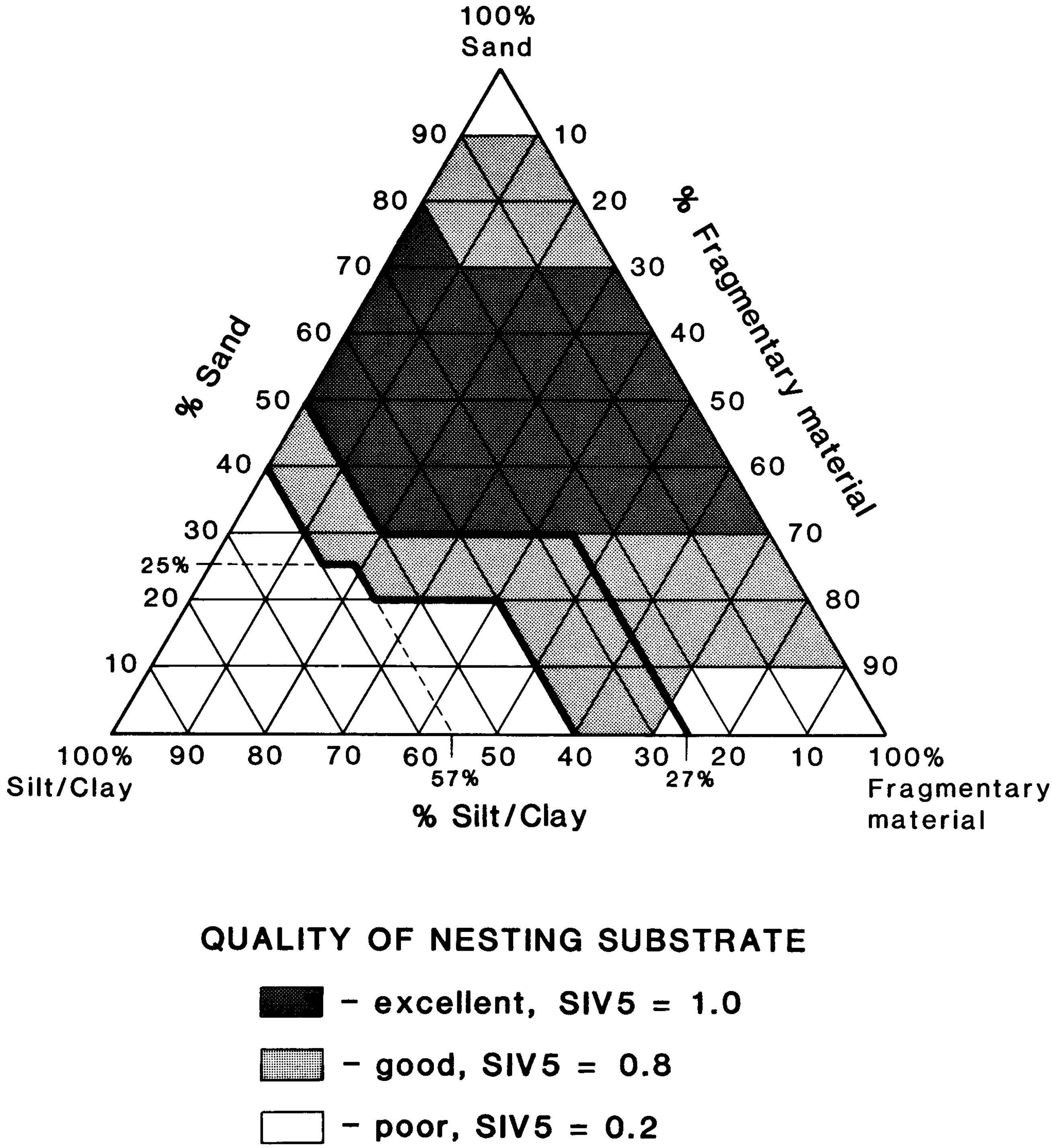

Figure 6. The relationship between substrate composition and the suitability index value for least tern reproduction.

gravel, shell, coral) enhances drainage of the nest site and stabilizes the substrate; (3) large amounts of silt and clay inhibit drainage; (4) least terns prefer not to nest on substrate composed almost entirely of fragmentary material; and (5) consolidated substrate has no suitability for nesting.

The suitability index value for reproduction (SIR) is assumed to equal the lower of the values obtained from an evaluation of vegetation cover (SIC) and substrate composition (SIV5).

HSI determination. Habitat suitability for the least tern is determined by the quality of foraging habitat (SIF) and the quality of nesting habitat (SIR). The HSI for the least tern is equal to the lower of these two values.

Application of the Model

Application procedure. This model was designed to address the major habitat variables that affect the occupancy of potential nesting sites by least terns throughout their range, as indicated by the literature. Due to the wide distribution of the least tern, different subspecies or different potential populations within a subspecies may not be affected by all habitat variables included in the model. Consequently, the user should apply only those variables and procedures that pertain to the geographic area under evaluation. The following methodology is recommended for determining when certain variables apply and how they should be implemented:

SIV1 and SIV2 — Apply to all areas. It is recommended that an average maximum flight distance of 3.2 km be used in marine habitats and 1.6 km in inland habitats.

SIV3 and SIV4 — Apply to all areas.

SIV5 — Applies to the following:

(1) Areas that are dominated by a silt/clay substrate and experience frequent and/or torrential precipitation during May and June. The assumption is that potential nest sites would be threatened by washout.

(2) Areas that are dominated by a sand substrate and experience frequent high winds during May and June. The assumption is that potential nest sites would be threatened by an unstable substrate.

(3) Areas that are dominated by a fragmentary material substrate. The assumption is that such areas would be unattractive to nesting least terns.

If the area of evaluation does not fall into either of the three categories listed above, SIV5 can be excluded as a variable in the model.

Predation and human disturbance, variables not included in this model, can significantly influence the suitability of potential nesting habitat. At this time, no recommendations can be made for measuring and quantifying these variables. If significant predation and human disturbance occur on a potential nesting site, this model may not provide an accurate measure of breeding habitat suitability. The literature shows that these categories of disturbance can be partially or totally controlled by various management techniques (see Reproduction and Special Considerations). This model can be used to identify areas that are more promising candidates for the implementation of management efforts. It should be realized, however, that the control of predation often is quite difficult and many times unsuccessful (B. W. Massey, contractor with U.S. Fish and Wildlife Service, Laguna Niguel, CA; letter dated 17 July 1984).

The periodic processes of inundation, erosion, and deposition associated with flood disturbances are generally necessary for the establishment and perpetuation of least tern nesting habitat. However, such occurrences during the nesting period eliminate potential breeding habitat and are a direct cause of mortality for existing breeding populations (i.e., nests). The threat of flooding as a direct result of precipitation can be mitigated by the composition of the substrate (SIV5). Protection from flooding by high tides or high stream flows, however, can be assumed only if the habitat is located at a higher elevation than the floodwater. It is assumed in this model that only habitat that is at a higher elevation than a prescribed floodwater elevation has potential as nesting habitat. Habitat that is at a lower elevation than the prescribed floodwater elevation is assumed to have a high probability of inundation during the nesting period and, therefore, has no suitability as nesting habitat. The following methodology is recommended for selecting that portion of the habitat that has a low probability of inundation during the nesting period.

In marine systems, potential least tern nesting habitat is subject to inundation by variations in sea level. Records of sea-level variations based on tide stations located throughout the nesting range of the least tern in the United States are maintained by the National Ocean Service (Hicks et al. 1983). It is recommended that the mean high water (MHW) tidal datum (Hicks 1984) be used to represent the floodwater elevation. The mean high water line (MHWL) is used to represent the interface of the land with the water surface at the elevation of MHW. Habitat that is located at a lower elevation than the MHWL is presumed to have a higher probability of inundation than habitat located at a higher elevation than the MHWL. Consequently, only habitat at a higher elevation than the MHWL should be considered and evaluated as potential nesting habitat. The designated MHWL should correspond to the highest single elevation recorded for the combined months of May and June, based on the tide station(s) in closest proximity to the area under evaluation (National Oceanic and Atmospheric Administration 1984). Information on the MHWL can be obtained by contacting:

Tidal Datum Section
NOAA/National Ocean Service
6001 Executive Boulevard
Rockville, MD 20852
(301) 443-8467

In riverine systems, potential least tern nesting habitat is subject to inundation by periodic increases in stream discharge. Each river presents a unique hydrologic problem due to site-specific geomorphology and lateral inflow conditions. Therefore, when attempting to determine the floodwater elevation, users of this model are strongly urged to consult with professionals who are familiar with streamflow conditions in the area under evaluation. Many river systems display irregular flood frequencies, making a concrete definition of a flood regime difficult, if not impossible. The objective is to determine and delineate that portion of the habitat that is least likely to be flooded during the months of May and June.

A determination of the potential nesting habitat's spatial relationship to the floodplain should first be made. A floodplain is defined as that portion of the river drainage that is inundated during a flood (Williams 1978b). A floodplain can be subdivided into an inactive floodplain (i.e., terrace) and an active floodplain (i.e., floodplain). An inactive floodplain is rarely inundated resulting in an insignificant amount of erosion and deposition. An active floodplain is that portion of the floodplain where significant amounts of erosion and deposition have occurred in the recent past (e.g., 10 years). Some river reaches do not have an active floodplain. If a potential site is determined to lie wholly within the inactive floodplain, it can be assumed that the probability of inundation is so low that 100% of the area has potential as nesting habitat. If all or part of the habitat lies within the active floodplain, however, the floodwater elevation should be determined. Since the intensity and time of flooding can be subject to wide variations within and among years, it is recommended that a mean river stage elevation for the combined months of May and June be used to represent the average elevation of flood waters during the nesting period. This elevation would then be designated as the floodwater elevation for May and June. Gaging stations (where maintained) record the river stage discharge data used for obtaining the floodwater elevation. This information can be obtained from several agencies which participate in the National Flood Insurance Program. These include the Federal Emergency Management Agency, U.S. Army Corps of Engineers, U.S. Geological Survey, U.S. Soil Conservation Service, U.S. Bureau of Reclamation, and State water resources agencies. Information also may be available at private consulting firms. In ungaged areas, the user must determine the feasibility of extrapolating river stage discharge data from a gaged site. If extrapolation is judged to be infeasible, the user is advised to attempt to estimate which fraction of the habitat has a high probability of flooding during May and June. The designated area should then be omitted when identifying cover types of potential nesting habitat.

In riverine systems that experience extensive flooding during May and June, least terns may occasionally nest on whatever nonflooded habitat that is available. However, nonflooded habitat during May and June is often covered by dense vegetation due to the lack of frequent flooding that controls vegetation encroachment. For management purposes, potential nesting habitat during May and June can be delineated using the procedure discussed above. Methods of nesting site improvement discussed under Reproduction and Special Considerations can then be implemented on the delineated habitat in order to increase the suitability of the potential nesting habitat during May and June when least terns are prepared to reproduce.

Least terns also can delay reproduction until suitable nesting habitat is exposed by receding floodwater. In areas where delayed reproduction is known to occur on a regular basis, or in areas where little or no potential nesting habitat is exposed during May and June, potential nesting habitat can be delineated using the procedure discussed previously. In these areas, however, a mean river stage elevation for the months of July and August should be used. This alternate method of evaluation is recommended for areas where least terns must delay reproduction into the summer months because it is believed that habitat should be assessed during the period of potential use. However, the user should be aware that, in some cases, potential foraging habitat can be less suitable for least terns during summer months when some aquatic habitat may dry up (Downing 1980).

It is recommended that the model be applied in the following manner:

1. Delineate the potential nesting habitat and evaluate its suitability (SIR) using SIV3, SIV4, and SIV5. For management purposes, special emphasis should be given to island habitat that is less subject to mammalian predation and human disturbance.

2. Using a map or aerial photograph, delineate the average maximum flight distance zone around the perimeter of the potential nesting habitat. On expansive areas of potential nesting habitat, radial distances equal to the average maximum flight distance should be delineated from random points within the habitat. Delineate cover types of all aquatic habitat within the average maximum flight distance that can be considered as foraging habitat (see Cover types). The map or photograph should accurately represent aquatic conditions as they occur during May and June or July and August. This is crucial for an accurate evaluation of a riverine system with an active floodplain.

3. Determine the total aquatic area (SIV1) and number of disparate aquatic systems or wetlands (SIV2) that constitute foraging habitat within the average maximum flight distance zone. Determine the suitability of foraging habitat (SIF) based on SIV1 and SIV2.

If an evaluation of a particular aquatic habitat is desired, potential nesting habitats within the average maximum flight distance of the aquatic habitat should be located. The above procedure should then be applied to the potential nesting habitats. Using this method, the aquatic habitat's relative contribution to the overall reproductive habitat can be determined.

Summary of model variables. The relationships between habitat variables, life requisites, cover types, and the HSI value are summarized in Figure 7. Figure 8 provides variable definitions and suggested measurement techniques (Hays et al. 1981).

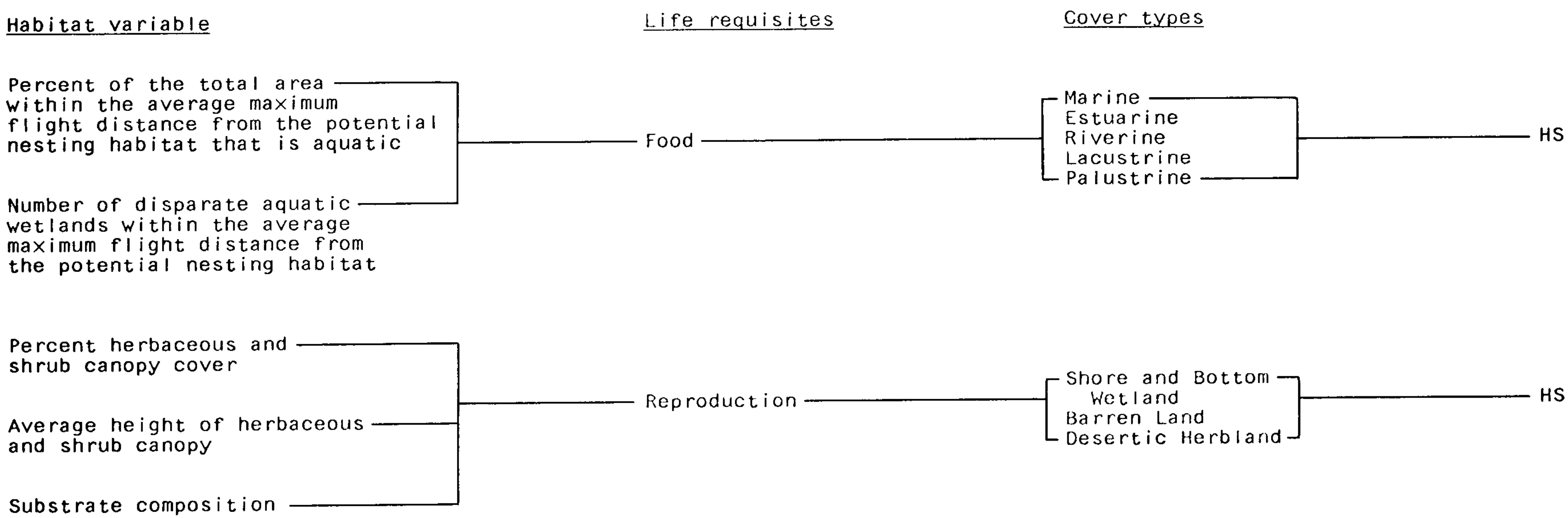

Figure 7. Relationships between habitat variables, life requisites, cover types, and the HSI for the least tern.

Variable (definition)	Cover types	Suggested techniques
Percent of the total area within the average maximum flight distance from the potential nesting habitat that is aquatic.	M,E,R,L,P	Remote sensing, mapping
Number of disparate aquatic wetlands within the average maximum flight distance from the potential nesting habitat.	M,E,R,L,P	Remote sensing, mapping
Percent herbaceous and shrub canopy cover [the percent of the ground surface that is shaded by a vertical projection of nonwoody vegetation and woody vegetation < 5 m (16.4 ft) tall].	SBW,DH,BL	Remote sensing, line intercept
Average height of herbaceous and shrub canopy [the average height from the ground surface to the dominant height stratum of the herbaceous or shrub (woody vegetation < 5 m tall) canopy].	SBW,DH,BL	Line intercept, graduated rod
Substrate composition (the relative proportions of sand, fragmentary material, and silt/clay in the substrate).	SBW,DH,BL	Sieve and hydrometer analysis (American Society for Testing and Materials 1967)

Figure 8. Definitions of variables and suggested measurement techniques.

Model assumptions. This model was developed with information obtained from the published literature and communications with professional biologists familiar with the species and its habitat requirements. It attempts to identify those physical parameters assumed most important in explaining habitat potential, and then attempts to combine those parameters into simple algorithms that yield an index value between 0.0 and 1.0. The major assumptions in this model are:

1. Overall reproductive habitat quality can be assessed by evaluating nesting and foraging habitat quality.

2. Reproductive habitat quality is equal to the lower of the life requisite values. The lower life requisite value is assumed to be the major limiting factor for reproductive potential.

3. The quantity and diversity of aquatic habitat are used as surrogate measures of food abundance. This is based on: (a) the assumption that the abundance and availability of small fish is directly related to these two variables; (b) the suggestion in the literature that least terns prefer abundant and diverse foraging habitat; and (c) the absence of quantitative data that would establish a relationship between fish biomass and least tern abundance.

SOURCES OF OTHER MODELS

Gochfeld (1983) developed a quantitative model of least tern nest site suitability in Long Island, New York. He examined site quality based on width of sites above the high tide line, slope, substrate, and vegetation cover, and site availability based on proximity to potential human disturbance and extent of off-road vehicle tracks. Quality and disturbance criteria were assigned scores of excellent, good, fair, or poor. The quality and disturbance scores were multiplied to obtain a composite habitat suitability score for each site. The composite score was used to classify sites as highly suitable, moderately suitable, or poor. It was found that 98% of colonies were on sites that had been graded excellent or good quality and that 48% of colonies were on sites more or less free from human disturbance. Least terns nested on 67% of the highly suitable sites and 17% of the poorly suited sites. Site tenacity was believed to be at least as important as physical habitat characteristics in determining occupancy.

Gochfeld's model was constructed based on data collected over a two year period in Long Island. His model can be considered to be specific to that area, and may provide more accurate results for habitat in Long Island than would the HSI model in this document. The HSI model was constructed from data collected throughout the breeding range of the least tern in the United States and is assumed to provide a general index of breeding habitat suitability throughout the range of the species.

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A review and synthesis of existing information were used to develop a Habitat Suitability Index (HSI) model for the least tern (*Sterna antillarum*). The model consolidates habitat use information into a framework appropriate for field application, and is scaled to produce an index between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). HSI models are designed to be used with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

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