VII. APPENDICES

Appendix A:
Implementation Subgroup Members

The following have participated in Implementation Subgroup meetings and/or
in the Southwestern Willow Flycatcher Implementation Subgroup Comment Forum
at http://ifw2es.fws.gov/swwf

Organization / Affiliation	Contact	Primary Recovery Unit Affiliation(s)
Arizona Cattle Growers	C. B. 'Doc' Lane	Gila, Lower Colorado River
Arizona Game and Fish Dept.	Dan Groebner	Gila
Arizona Game and Fish Dept.	Tracy McCarthey	Gila, Lower Colorado River
Arizona Game and Fish Dept.	William E. Werner	Lower Colorado River
Arizona Power Authority	Thomas A. Hine	Lower Colorado River
Arizona Met. Water Users Assoc.	V.C. Danos	Gila
Arizona Met. Water Users Assoc.	Kathy Ferris	Gila
Arizona State University	Jonathan Snyder	Gila
Arizona State University	Julie Stromberg	*All*
Arizona State University	Will Graf	*All*
Arizona Wildlife Federation	Randy Bonney	Gila, Lower Colorado River
Audubon	Bernard Foy	Rio Grande
Audubon	David Henderson	Rio Grande
Audubon	Reed Tollefson	Basin and Mojave
Audubon	Tom Jervis	Rio Grande
Budd-Falen Law Offices	Karen Budd-Falen	Gila
California Cattlemen's Assoc.	Patrick Blacklock	Basin and Mojave, Coastal California
California Dept. Fish and Game	Bob Allen	Basin and Mojave
California Dept. Fish and Game	Nancy G. Andrew	Lower Colorado River
California Dept. Fish and Game	Brad Valentine	*All*
California Dept. Fish and Game	Chris Hayes	Lower Colorado River
California Dept. Fish and Game	John Gustafson	Basin and Mojave, Coastal California

Organization / Affiliation	Contact	Primary Recovery Unit Affiliation(s)
California Dept. Fish and Game	Scott Clemons	Coastal California
California Dept. Fish and Game	David Mayer	Coastal California
California State University	Helen Bombay	Basin and Mohave
City of Albuquerque	Ondrea Linderoth-Hummel	Rio Grande
City of Albuquerque (PWD)	Susan Kelly	Rio Grande
City of Chandler	Doug Toy	Gila
City of Chandler	Cynthia Haglin	Gila
City of Mesa	Colette Moore	Gila
City of Peoria	Erik Dial	Gila
City of Phoenix	Tom Buschatzke	Gila
City of Phoenix	Jim Callahan	Gila
City of Phoenix	Bill Chase	Gila
City of Tucson	Dennis Rule	Gila
Clark County Conservation Dist.	John Hunt	Lower Colorado River
Clark County Env. Planning	Cynthia J. Truelove	Lower Colorado River
Coalition of AZ/NM Counties	Howard Hutchinson	Gila
Cocopah Tribe	John Swenson	Lower Colorado River
Colorado Dept. Water Resources	Mike Sullivan	Rio Grande, Upper Colorado River
Colorado River Board California	Christopher S. Harris	Lower Colorado River
Colorado River Board California	Fred Worthley	Lower Colorado River
Colorado River Comm. Nevada	Phillip Lehr	Lower Colorado River
Colorado River Indian Tribes	Michael Scott Francis	Lower Colorado River
Dairy Producers of New Mexico	Sharon Lombardi	Gila, Rio Grande
Defenders of Wildlife	John Fritschie	Lower Colorado River
Eagle Environmental, Inc.	Dale Stahlecker	Rio Grande

Organization / Affiliation	Contact	Primary Recovery Unit Affiliation(s)
EcoPlan Associates, Inc.	Bill Davis	Lower Colorado River
EcoPlan Associates, Inc.	George A. Ruffner	Lower Colorado River
Elephant Butte Irrigation Dist.	Gary Esslinger	Rio Grande
Environmental Consulting	Jim Greaves	Coastal California
Forest Guardians	John Horning	Gila, Rio Grande
Fort Huachuca Military	H. Sheridan Stone	Gila
Fort Mojave Tribe	John Algots	Lower Colorado River
Fort West Ditch Association	Linda Stailey	Gila
Gila Hotsprings Ranch	David and Becky Campbell	Gila
Hatch and Parent	Susan F. Petrovich	Coastal California
Hopi Tribe	Charles R. Mahkewa	Lower Colorado River
Hualapai Tribe	Kerry Christensen	Lower Colorado River
Imperial Irrigation District	Michel Remington	Lower Colorado River
ISDA	Robert S. Lynch	Gila, Lower Colorado River
Kern County Farm Bureau	Loron Hodge	Basin and Mojave
Kern County Planning Dept.		Basin and Mojave
Lincoln County Public Lands	Shelley Wadsworth	Lower Colorado River
Los Alamos National Laboratory	David Keller	Rio Grande
Metropolitan Water District	Marty Meisler	Lower Colorado River
Middle Rio Grande Cons. Dist.	Sterling Grogan	Rio Grande
Middle Rio Grande Cons. Dist.	Yasmeen Najmi	Rio Grande
National Park Service	Curtis Deuser	Lower Colorado River
National Park Service	Kent Turner	Lower Colorado River
National Park Service	Ross D. Haley	Lower Colorado River
National Park Service	Tim Tibbitts	*All*

Organization / Affiliation	Contact	Primary Recovery Unit Affiliation(s)
Nature Conservancy	Jim Moore	Lower Colorado River
Nature Conservancy	Patrick McCarthy	Gila
Nature Conservancy	Peter L. Warren	Lower Colorado River
Nature Conservancy	Rob Marshall	*All*
Nevada Department of Wildlife	Cris Tomlinson	Lower Colorado River
Nevada Department of Wildlife	Jon Sjoberg	Lower Colorado River
New Mexico Cattle Growers	Caren Cowan	Gila, Rio Grande
New Mexico Dept. Agriculture	Bill Moore	Rio Grande
New Mexico Dept. Agriculture	George Douds	Rio Grande
New Mexico Dept. Game & Fish	Chuck Hayes	Gila, Rio Grande
New Mexico Dept. Game & Fish	Sartor O. Williams	*All*
New Mexico Farm Bureau	Joel Alderete	Gila, Rio Grande
NM Interstate Stream Comm.	John Whipple	Gila, Rio Grande
NM Interstate Stream Comm.	Rhea Graham	Rio Grande
NM Interstate Stream Comm.	Rolf Schmidt-Petersen	Rio Grande
New Mexico State Government	Cecilia Abeyta	Rio Grande
New Mexico State University	Jerry Holechek	*All*
New Mexico State University	Jon Boren	*All*
New Mexico State University	Terrell Baker	Gila, Rio Grande
Northern Pueblo Agency (BIA)	Norman Jojola	Rio Grande, Lower Colorado River
NRCD - Redington	Johnny Lavin	Gila
NRCD - Verde	John Parsons	Gila
NRCD - Winkelman	Jean Schwennesen	Gila
NRCS - High Desert	Jim Neveu	Lower Colorado River
NRCS	Dave Seery	Rio Grande

Organization / Affiliation	Contact	Primary Recovery Unit Affiliation(s)
Ogden Environmental	Kristie Klose	Lower Colorado River
Palo Verde Irrigation District	Gerry Davisson	Lower Colorado River
Parsons Engineering Sci., Inc.	David Connally	Rio Grande
People for the USA	Shauna Johnson	Upper & Lower Colorado River
Phelps Dodge Corporation	Dawn Meidinger	Gila
Phelps Dodge Corporation	Ty Bays	Gila
Private Consultant	Helen Yard	Gila, Lower Colorado River
Production Credit Assoc. NM	Jimmie C. Hall	Gila, Rio Grande
Pueblo of Zuni	Steven Albert	*All*
Ranching Industry	Bruce Hafenfeld	Basin and Mojave
Ranching Industry	David Ogilvie	Gila
Ranching Industry	Joe A. Romero	Rio Grande
Ranching Industry	Kenneth Zimmerman	Basin and Mojave
Ranching Industry	Walt Anderson	Gila
Rio Grande Compact Comm.	Jack Hammond	Rio Grande
Salmon, Lewis, & Weldon	Lisa McKnight	Gila
Salt River Pima-Maricopa Tribe	Morris Pankgana	Gila
Salt River Pima-Maricopa Tribe	Steve Parker	Gila
Salt River Project	Charlie Ester	Gila
Salt River Project	Craig Sommers	Gila
San Carlos Apache Tribe	Matt Hopkins, Jr.	Gila
San Diego County Water Auth.	Larry Purcell	Lower Colorado River
San Juan Pueblo	Charles Lujan	Rio Grande
Santa Ana Pueblo	Les Ramirez	Rio Grande
Santa Ana Pueblo	Todd Caplan	Rio Grande

Organization / Affiliation	**Contact**	**Primary Recovery Unit Affiliation(s)**
Southern Nevada Water Auth.	Janet Monaco	Lower Colorado River
Southern Nevada Water Auth.	Zane Marshall	Lower Colorado River
Southern Sierra Research Center	Mary Whitfield	*All*
Southern Ute Tribe	Adam Red	Upper Colorado River
Southern Ute Tribe	Terry Stroh	Upper Colorado River
Southwest Center	Noah Greenwald	Gila
Southwest Rivers	Rick Johnson	Lower Colorado River
SWCA	Bryan Brown	Gila
SWCA	C. Michelle Brown	Rio Grande
SWCA	G. Scott Mills	Gila
Sweetwater Authority	Peter Famolaro	Coastal California
University of Arizona	Larry Sullivan	Gila
Univ. California Santa Barbara	Chris Farmer	Coastal California
Univ. California Santa Barbara	Mark Holmgren	Coastal California
Univ. California Santa Barbara	Stephen Rothstein	*All*
University of New Mexico	Adrian Oglesby	Rio Grande
University of New Mexico	Kris Johnson	Rio Grande
U.S. Army Corps of Engineers	William R. DeRagon	Rio Grande
U.S. Army Corps of Engineers	Roy Proffitt	Basin and Mojave
U.S. Bureau of Indian Affairs	Amy Heuslein	Gila, Lower Colorado
U.S. Bureau of Indian Affairs	Joseph Jojola	Rio Grande, Upper Colorado
U.S. Bureau Land Management	Barney Wegener	Rio Grande
U.S. Bureau Land Management	Bill Grossi	Lower Colorado River
U.S. Bureau Land Management	Bob Welch	Rio Grande
U.S. Bureau Land Management	Dave Smith	Lower Colorado River

Organization / Affiliation	Contact	Primary Recovery Unit Affiliation(s)
U.S. Bureau Land Management	Elroy Masters	Lower Colorado River
U.S. Bureau Land Management	Hilary Donoghue Countess	Rio Grande
U.S. Bureau Land Management	James Jeffery Chynoweth	Upper Colorado River
U.S. Bureau Land Management	Jim Silva	Rio Grande
U.S. Bureau Land Management	John Andes	Lower Colorado River
U.S. Bureau Land Management	Michael Herder	Gila
U.S. Bureau Land Management	Pamela Herrera	Rio Grande
U.S. Bureau Land Management	Paul Sawyer	Rio Grande
U.S. Bureau Land Management	Rebecca Peck	Rio Grande
U.S. Bureau Land Management	Robert Douglas	Upper Colorado River
U.S. Bureau Land Management	Roger Taylor	Gila
U.S. Bureau Land Management	Sam DesGeorges	Rio Grande
U.S. Bureau Land Management	Sid Slone	Lower Colorado River
U.S. Bureau Land Management	Ted Cordery	Gila
U.S. Bureau Land Management	Wesley K. Anderson	Rio Grande
U.S. Bureau Land Management	William Merhege	Rio Grande
U.S. Bureau of Reclamation	Art Coykendall	Rio Grande
U.S. Bureau of Reclamation	Barbara Raulston	Lower Colorado River
U.S. Bureau of Reclamation	Christine D. Karas	Upper Colorado River
U.S. Bureau of Reclamation	Darrell Ahlers	Upper Colorado River, Rio Grande
U.S. Bureau of Reclamation	Diane Laush	Gila
U.S. Bureau of Reclamation	Hector Garcia	Rio Grande
U.S. Bureau of Reclamation	Anne Janik	Rio Grande
U.S. Bureau of Reclamation	Jane Harkins	Lower Colorado River
U.S. Bureau of Reclamation	John Swett	Lower Colorado River

Organization / Affiliation	Contact	Primary Recovery Unit Affiliation(s)
U.S. Bureau of Reclamation	Karen A. Blakney	Upper Colorado River
U.S. Bureau of Reclamation	Karen E. Barnett	Upper Colorado River
U.S. Bureau of Reclamation	Larry White	Upper Colorado River, Rio Grande
U.S. Bureau of Reclamation	Laura Herbranson	Lower Colorado River
U.S. Bureau of Reclamation	Mike Walker	Lower Colorado River
U.S. Bureau of Reclamation	Sarah L. Wynn	Upper Colorado River
U.S. Bureau of Reclamation	Susan Sferra	*All*
U.S. Bureau of Reclamation	Tom Shrader	Lower Colorado River
USDA - APHIS	Julie Gould	Gila
USDA - ARS	Jack DeLoach	Gila, Rio Grande
USDA - ARS	James Tracy	Rio Grande
U.S. Department of Energy	Tom Smigel	Lower Colorado River
USDA Forest Service	Ben Kuykendall	Rio Grande
USDA Forest Service	Bill Brown	Coastal California
USDA Forest Service	Chris Schultz	Rio Grande
USDA Forest Service	Bobbi Barrera	Rio Grande
USDA Forest Service	Craig woods	Gila
USDA Forest Service	Eddie Alford	Gila
USDA Forest Service	Jerry Monzingo	Gila, Rio Grande
USDA Forest Service	Kirsten Winter	Coastal California
USDA Forest Service	Corey Ferguson	Coastal California
USDA Forest Service	Larry Allen	Gila
USDA Forest Service	Maeton C. Freel	Basin and Mojave
USDA Forest Service	Mike Ross	Gila
USDA Forest Service	Paul Boucher	Gila

Organization / Affiliation	Contact	Primary Recovery Unit Affiliation(s)
USDA Forest Service	Ralph Pope	Gila
USDA Forest Service	Ronald L. Rodriguez	Upper Colorado River
USDA Forest Service	Rosemary A. Stefani	Coastal California
USDA Forest Service	Steve Loe	Coastal California
USDA Forest Service	Steven Anderson	Basin and Mojave
USDA Forest Service	Teresa Ritter	Basin and Mojave
USDA Forest Service	Tom Bonomo	Gila
USDA Forest Service	Wally Murphy	Gila, Rio Grande
USDA Forest Service - RMRS	Brian Kent	Upper Colorado River, Rio Grande
USDA Forest Service - RMRS	Deborah M. Finch	*All*
USDA Forest Service - RMRS	Scott Stoleson	Gila
U.S. Fish and Wildlife Service	Al Pfister	Upper & Lower Colorado River
U.S. Fish and Wildlife Service	April Fletcher	Rio Grande
U.S. Fish and Wildlife Service	Bruce Palmer	Gila
U.S. Fish and Wildlife Service	Bryan Arroyo	Rio Grande
U.S. Fish and Wildlife Service	Carol Torrez	Gila, Rio Grande
U.S. Fish and Wildlife Service	Cindy Schulz	Rio Grande, Lower Colorado River
U.S. Fish and Wildlife Service	Dave Krueper	Gila
U.S. Fish and Wildlife Service	David Pereksta	Coastal California, Basin and Mojave
U.S. Fish and Wildlife Service	Diana Whittington	Upper Colorado River
U.S. Fish and Wildlife Service	Doug Duncan	Gila
U.S. Fish and Wildlife Service	Elizabeth Lucas	Coastal California
U.S. Fish and Wildlife Service	John Martin	Coastal California
U.S. Fish and Wildlife Service	Greg Beatty	Gila, Lower Colorado River

Organization / Affiliation	Contact	Primary Recovery Unit Affiliation(s)
U.S. Fish and Wildlife Service	Ina Pisani	Coastal California, Basin and Mojave
U.S. Fish and Wildlife Service	Ivana Noell	Coastal California, Basin and Mojave
U.S. Fish and Wildlife Service	Jackie Ferrier	Lower Colorado River
U.S. Fish and Wildlife Service	Janet Bair	Lower Colorado River
U.S. Fish and Wildlife Service	Jeff Whitney	Rio Grande
U.S. Fish and Wildlife Service	Jeri Kay Krueger	Lower Colorado River
U.S. Fish and Wildlife Service	John Martin	Coastal California
U.S. Fish and Wildlife Service	John P. Taylor	Rio Grande
U.S. Fish and Wildlife Service	John Stephenson	Coastal California
U.S. Fish and Wildlife Service	Kelly J. Goocher	Coastal California
U.S. Fish and Wildlife Service	Kenneth Sanchez	Basin and Mojave
U.S. Fish and Wildlife Service	Kevin Sloan	Lower Colorado River
U.S. Fish and Wildlife Service	Laura Romin	Upper Colorado River
U.S. Fish and Wildlife Service	Loren Hays	Coastal California, Basin and Mojave
U.S. Fish and Wildlife Service	Mary Jo Stegman	Gila
U.S. Fish and Wildlife Service	Patricia Zenone	Gila, Rio Grande
U.S. Fish and Wildlife Service	Paul Tashjian	Rio Grande
U.S. Fish and Wildlife Service	Ron Garcia	Rio Grande
U.S. Fish and Wildlife Service	Sam Spiller	Lower Colorado River
U.S. Fish and Wildlife Service	Sarah Rinkevich	Rio Grande
U.S. Fish and Wildlife Service	Steve Silcox	Gila, Rio Grande
U.S. Fish and Wildlife Service	Terry Ireland	Upper Colorado River, Rio Grande
U.S. Fish and Wildlife Service	Theresa Davidson	Gila, Rio Grande
U.S. Fish and Wildlife Service	Kelly Stone	Rio Grande

Organization / Affiliation	Contact	Primary Recovery Unit Affiliation(s)
U.S. Geological Survey	Barabara Kus	*All*
U.S. Geological Survey	Jim Sedgewick	Upper Colorado River
U.S. Geological Survey	Mark Sogge	*All*
U.S. Geological Survey	Thomas J. Koronkiewicz	*Winter Range Studies*
USMC Camp Pendleton	William Berry	Coastal California
USMC Camp Pendleton	Deborah Bieber	Coastal California
Utah Division of Wildlife Cons.	Frank P. Howe	Upper Colorado River
Virgin River Land Preservation	Lori Rose	Lower Colorado River
Virginia Tech University	Sylvia L. Schmidt	Basin and Mohave
WAPA	John Holt	Lower Colorado River
Washington County Commission	Alan D. Gardner	Upper and Lower Colorado River
Washington County Water Conservation District	Morgan Jensen	Upper and Lower Colorado River
Water Consult	Tom Pitts	Rio Grande
Western New Mexico University	Rolland Shook	Gila
Yavapai County	Chip Davis	Gila
Yavapai County	Dean Lewis	Gila

Appendix B.
List of Acronyms and Abbreviations Used In This Recovery Plan

ABQ	City of Albuquerque
ac	Acre(s)
ADWR	Arizona Department of Water Resources
AFA	all Federal agencies
AGFD	Arizona Game and Fish Department
aka	Also known as
AOU	American Ornithologists' Union
BLM	Bureau of Land Management
BIA	Bureau of Indian Affairs
CDFG	California Department of Fish and Game
CDW	Colorado Division of Wildlife
COE	U.S. Army Corps of Engineers
CPFS	Colorado Plateau Field Station
CSU	Colorado State University
CWA	Clean Water Act
DOD	U.S. Department of Defense
DOI	Department of the Interior
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FS	U.S. Forest Service
FWS	U.S. Fish and Wildlife Service
ft	Foot/feet
g	Gram(s)
GCAMWG	Glen Canyon Adaptive Management Workgroup
ha	Hectare(s)
IRR	irrigation districts
ISGs	Implementation Subgroups
km	Kilometer(s)
LSV	City of Las Vegas
m	Meter(s)
maf	Million acre-feet
mi	Mile(s)
MRGCD	Middle Rio Grande Conservancy District
MSCP	Multi-Species Conservation Program (Lower Colorado River)
mm	Millimeter(s)
MWD	Metropolitan Water District
NCEAS	National Center for Ecological Analysis and Synthesis
NDW	Nevada Division of Wildlife
NMDGF	New Mexico Dept. of Game and Fish
NMOS	New Mexico Ornithological Society
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge (USFWS)
oz	Ounce(s)
PHX	City of Phoenix
RTTS	Recovery Team Technical Subgroup
SAG	State Agriculture
SDNHM	San Diego Natural History Museum
SGF	State Game and Fish Agencies
SND	City of San Diego
SPK	State Parks
SWCA	Steven W. Carothers & Associates
SWCBD	Southwest Center for Biological Diversity
TBD	To Be Determined
TNC	The Nature Conservancy
TPWD	Texas Parks and Wildlife Department
TUC	City of Tucson
UDWR	Utah Division of Wildlife Resources
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service, or "Service"
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USMC	U.S. Marine Corps
WAPA	Western Area Power Administration

Appendix C.
Glossary

Alluvial: Composed of soil and sand deposited by flowing water.

Biocontrol agents: Organisms that are released into an ecosystem for the purpose of reducing the abundance of, or eliminating, a pest species. They often are imported from the pest organism's geographic region of origin. Often, biocontrol agents are insects.

Bioproductivity: In ecosystems, the rate of production of new biomass.

Biotic: Living; usually applied to the biological aspects of an organism's environment.

Browse: **n.** Leaves, twigs, and young shoots of trees or shrubs that animals feed on; **v.** feeding on the leaves, twigs, and young shoots of trees or shrubs. That is, woody plants as forage. This use is as opposed to graze, used in this report to refer to leaves and stems of non-woody plants (grasses & forbs) that animals feed on, or feeding on non-woody plants.

Carrying capacity: The maximum number of a given species of animal that a habitat can support without damage to soil and vegetation resources.

Colonization potential: Likelihood that birds will emigrate to other sites.

Controlled burns or prescribed burns: Fires set by humans within a delimited area under a discrete set of environmental and staffing conditions to achieve certain management goals such as ecosystem restoration, forage production, or wildfire prevention.

Demographic analysis: Identifies the life history aspect or parameter (fecundity, juvenile survival, adult survival) that has the greatest effect on population growth.

Demography: The science of the interrelated life history factors that determine how populations grow, shrink, or change in other ways.

Deterministic model: Model in which the life history aspects or parameters (fecundity, juvenile survival, adult survival) remain constant over time.

Dewater: Reduce the rate or volume of stream flow, and/or lower the water table in the flood plain aquifer.

Disturbance: Any discrete event, usually of short duration and great intensity, that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment

Diversity or biodiversity: The total variety of life and its processes. Includes the variety represented by all species, the different genes within each species, and the variety of different habitats and ecosystems in which these species exist.

Ecosystem functions: Processes that control the products and rates of change of the ecosystem (e.g. soil erosion, water discharge, succession) or that are intrinsic to the perpetuation of the ecosystem (such as cycling of nutrients or balanced rates of soil production and erosion).

Exotic species: A non-native species introduced into a new ecosystem as a result of human intervention. If that species establishes self-sustaining populations, it is then considered a naturalized exotic.

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Extirpated: Locally extinct.

Fecundity: Number of young fledged per female.

Fire regime: The spatial and temporal patterns of a fire within a given biotic community type, including intensity (temperature or amount of combustible fuels consumed), duration (burn time), size (amount of land area burned) and distribution (patchiness), timing (season of occurrence), and frequency (number of years elapsed between fires).

Flood regime: The magnitude, timing, duration, and frequency of flooding that are characteristic of streams in a particular ecoregion.

Flow regime: The magnitude, timing, duration, and frequency of surface flows (including low flows and flood flows) that are characteristic of a particular stream type in a particular ecoregion.

Fluvial: Pertaining to or formed by a river.

Fluvial geomorphology: River processes and forms related to earth materials and surfaces, particularly the sediment that is eroded, transported, and deposited by channel flow in streams and rivers.

Fuel load: Amount of flammable plant biomass in an area

Geomorphology: The study of the physical features of the Earth's surface and their relationship to its geological structures.

Habitat: A place where a species normally lives, often described in terms of physical features (such as topography) and in biological features (such as plant species composition).

Habitat complexity: The extent to which an area provides habitat for multiple species, by providing a variety of physical features and biological associations.

Herbaceous: A seed plant whose stem withers away to the ground after each season's growth, as distinguished from woody plants - i.e., grasses and forbs.

Herbivores: Animals that feed on plants .

Hydrograph: The stage, flow, velocity, and other properties of water with respect to time.

Hydrography: The science of measuring, describing, mapping, and explaining the distribution of surface water.

Hydrologic: Pertaining to the distribution, circulation, and properties of the Earth's waters.

Hydrology: The study of physical and chemical processes related to water in the environment, including precipitation, surface runoff, channel flow, and groundwater.

Hydrophytic vegetation: Plants living in water or wet ground.

Incidence function: Estimates metapopulation persistence within an existing network of occupied habitat patches.

Invasive species: A species that has become particularly abundant in an ecosystem as a result of human activities in the ecosystem. Invasive species can be native or exotic to the area.

Keystone species: A species that through its activities or interactions with other species plays a critical role in determining community structure.

Late Quaternary: Generally, the more recent times of the geologic period following the Tertiary in the Cenozoic Era and comprising all of the Holocene and some of the Pleistocene epochs. Generally, the last 1,000,000 years.

Lentic: Quiet, slow-moving, swampy, or still water.

Meanderbelt: That portion of the active flood plain which is subject to occupation occasionally by the migrating, meandering channel of the main stream.

Mesic: Moderately moist.

Metapopulation: Group of spatially disjunct local willow flycatcher populations connected to each other by immigration and emigration.

Mitigation: Measures to prevent, reduce, or correct the net adverse consequences of particular activities.

Monitoring: (Grazing Activities) The practice of tracking the utilization rates and overall effects of grazing over time, through repeated collection of data. Food plants are examined and measured to determine what percentage has been eaten, trampled, or lost to other causes. Other plants in the area (e.g., willows and other woody species) are examined, and observations are recorded regarding trampling or other damage. Records are maintained of livestock stocking rates (number of cattle per unit of area per unit of time), and all changes are recorded. Significant climatological events are noted (e.g., hard freezes, heavy rains, floods, droughts, high temperatures).

Monotypic: In reference to flycatcher habitat, a condition in which the woody vegetation is strongly dominated by one species, or several very similar species, mostly in similar growth forms and size/ages.

Mycorrhizae: A mutualistic and close association between fungi and plant roots which facilitates the uptake of minerals by plants.

Natal areas: Birth areas.

Parameter: Population statistics such as fecundity, juvenile survival rate, or adult survival rate.

Passerines: Technically, members of the Order Passerines. Commonly referred to as “perching birds”, and accounting for approximately 60% of all bird species.

Phreatophyte: A deep-rooted perennial plant that derives its water from a more or less permanent subsurface water supply, and is thus not dependent on annual rainfall for survival.

Pleistocene: The first epoch of the Quaternary Period in the Cenozoic Era, ranging from 1,800,000 to 10,000 years before present.

Population sink: A population in which the birth rate is below that required to maintain a stable population size.

Population viability analysis: A process of estimating the probability that a population of a specified size will persist over time.

Productivity or bioproductivity: In ecosystems, the rate of production of new biomass.

Rhizomes: Underground, lateral stems that allow a plant species to spread vegetatively.

River regulation: Modification of the flow regime of a river by humans, through the use of engineered structures including dams, diversion structures, and levees.

Salinity: The amount of salts dissolved in a given volume or weight of water.

Selective pressure: A force acting on populations that results in differential reproduction and contribution of genes to future generations.

Site: A variably delimited geographic location, the limits of which may include elements of habitat, land ownership, and practicality. A site may be delimited by habitat, that is, an entire patch of riparian vegetation, or it may be a subdivision of a riparian patch delimited by land ownership and/or the ability to survey effectively. A "site" may encompass a discrete breeding location, or several.

Stochastic events: Random events such as fire, disease, flood, and drought.

Stressor: From an ecosystem perspective, any factor that causes an ecosystem to decline in biodiversity, bioproductivity, or resilience.

Stubble height: Residual vegetation, or the amount of vegetation that remains after grazing animals have used an area. A 3-inch stubble height is a direct measurement indicating that a forage plant is clipped off or broken at 3 inches above the ground.

Suitable habitat: Riparian stands that appear to have all the components necessary for flycatchers to establish territories and/or nest. Occupied habitat is, by definition, suitable. Some suitable habitat may be unoccupied for any of a multitude of reasons.

Transpiration: The movement of water through plants from the roots to the atmosphere via the vascular system.

Utilization: The proportion of current year's forage that is consumed or destroyed by grazing animals. Overall utilization is comprised of both the portion eaten by livestock (harvest efficiency) and the portion lost to trampling, insects, or other causes. In general, these two categories are of equivalent value. Therefore, a 40% utilization rate means that of the current year's growth, 20% was eaten by livestock, 20% was lost to trampling or other causes, and 60% remains.

Vegetation composition: The make-up of a plant community, in terms of the different types of plant species present.

Watershed: A region drained by a river or river system.

Xeric: Dry or desert-like.

Appendix D.
Southwestern Willow Flycatcher Habitat[1]

A. Introduction

The distribution and abundance of a species across a landscape depends in part on the distribution and abundance of suitable habitat. If basic resource needs such as food, water, and other biological and physical features are not present, then that species is excluded from the area. Scarcity of suitable habitat is often the primary reason for the status of most rare and endangered species. An understanding of an endangered species' habitat is crucial to effective management, conservation and recovery.

The southwestern willow flycatcher (*Empidonax traillii extimus*) breeds in relatively dense riparian habitats in all or parts of seven southwestern states, from near sea level to over 2000 m (6100 ft). Although other willow flycatcher subspecies that occur in cooler, less arid regions may breed in shrubby habitats away from water (McCabe 1991), *E.t. extimus* breeds only in dense riparian vegetation near surface water or saturated soil. Other habitat characteristics such as dominant plant species, size and shape of habitat patch, canopy structure, vegetation height, and vegetation density vary widely among sites. This document presents an overview of southwestern willow flycatcher breeding habitat, with an emphasis on gross vegetation characteristics. There have been few quantitative studies of flycatcher habitat (but see Whitfield and Strong 1995, Whitfield and Enos 1996, Spencer et al. 1996, McKernan and Braden 1999, Stoleson and Finch 1999, Uyehara and Whitfield 2000, McKernan and Braden 2001). Therefore, this document focuses on qualitative information on plant species composition and structure. Although many of the details of vegetation characteristics differ among breeding sites, this document describes those elements or attributes that are shared by most.

B. What Is "Habitat"?

Birds and bird communities have played a major role in the development of the concept of habitat, yet specific definitions of the term habitat are often vague and/or differ from one another (Block and Brennan 1993). However, a common theme among different definitions and terms is that "habitat" includes the physical and biological environmental attributes that influence the presence or absence of a bird species (Morrison et al. 1992). Habitat involves many components in addition to composition and structure of vegetation. The distribution and abundance of species are influenced by environmental features (climate, food, extent of habitat), predation, competition, parasitism, disease, disturbance, past history and even random chance (Wiens 1989b). Research is usually focused on those habitat components

[1] This document is adapted from Sogge and Marshall 2000. (See Literature Cited)

that are most easily or reliably quantified and/or considered most likely to influence the bird community. No single study can address all of the factors that may influence bird species presence in an ecosystem.

Many factors affect how a species selects habitat, and these factors do not act equally for all species or even for all populations of a single species (Wiens 1989a, 1989b). A species' morphological and physiological traits allow it to exploit certain resources and therefore, certain habitats (Morrison et al. 1992). Life-history or behavioral traits such as foraging and mating strategies are also factors that influence a species' habitat selection (Hansen and Urban 1992). Proximate factors such as song perches, nest sites, and the structure and composition of the vegetation determine whether a bird settles in a habitat. These are part of a habitat selection "template" (Wiens 1989a) that results from both an individual's genetic makeup and information learned. Ultimately, the suitability of a particular habitat is reflected by reproductive success and survivorship. Mere occupancy of a habitat does not confirm the habitat is optimal, only that it meets the (perhaps minimal) selection template for those individuals breeding there. There has yet to be developed a comprehensive habitat model for the southwestern willow flycatcher that enables one to determine which breeding habitats, or parts of a single breeding patch, are better than others based on vegetation characteristics alone.

C. Breeding Habitat

Breeding habitats of the southwestern willow flycatcher vary across its range, in structure and species makeup of vegetation, characteristics of water associated with the site, elevation, and other factors. However, the accumulating knowledge of flycatcher breeding sites reveals important areas of similarity. These constitute the basic concept of what is suitable breeding habitat. These areas of similarity, or habitat features, are each discussed below, with examples from the field. First, it is helpful to state them in general terms to create a basic understanding of what is habitat.

The southwestern willow flycatcher breeds in riparian habitats along rivers, streams, or other wetlands, where relatively dense growths of trees and shrubs are established, near or adjacent to surface water or underlain by saturated soil. Throughout the range of the flycatcher, these riparian habitats tend to be rare, widely separated, small and/or linear locales, separated by vast expanses of arid lands. Common tree and shrub species comprising nesting habitat include willows (*Salix* sp.), boxelder (*Acer negundo*), tamarisk (aka saltcedar, *Tamarix ramosissima*), and Russian olive (*Eleagnus angustifolia*) (Grinnell and Miller 1944, Phillips 1948, Phillips et al. 1964, Whitmore 1977, Hubbard 1987, Unitt 1987, Whitfield 1990, Brown and Trosset 1989, Brown 1991, Sogge et al. 1993, Muiznieks et al. 1994, Maynard 1995, Stoleson and Finch 1999, Paradzick et al. 1999, Uyehara and Whitfield 2000, McKernan and Braden 2001).

Habitat characteristics such as plant species composition, size and shape of habitat patch, canopy structure, vegetation height, and vegetation density vary across the subspecies' range. However, regardless of the plant species composition or height, occupied sites usually consist of dense vegetation in the patch interior, or an aggregate of dense patches interspersed with openings. In most cases this dense vegetation occurs within the first 3 - 4 m (10-13 ft) above ground. These dense patches are often interspersed with small openings, open water or marsh, or shorter/sparser vegetation, creating a mosaic that is not uniformly dense.

Southwestern willow flycatchers nest in thickets of trees and shrubs ranging in height from 2 m to 30 m (6 to 98 ft). Lower-stature thickets (2-4 m or 6-13 ft tall) tend to be found at higher elevation sites, with tall stature habitats at middle and lower elevation riparian forests. Nest sites typically have dense foliage at least from the ground level up to approximately 4 m (13 ft) above ground, although dense foliage may exist only at the shrub level, or as a low dense canopy. Nest sites typically have a dense canopy. Canopy density at nest sites include the following values: 74% on the Kern River, CA (Uyehara and Whitfield 2000 and pers. comm.), less than 50% to 100% (but generally 75%-90%) on the lower Colorado River (McKernan and Braden 1999), 89% to 93% in AZ (Spencer et al. 1996), and 84% on the Gila River, NM (Stoleson and Finch 1999). The diversity of nest site plant species may be low (e.g., monocultures of willow or tamarisk) or comparatively high. Nest site vegetation may be even) or uneven) aged, but is usually dense (Brown 1988, Whitfield 1990, Muiznieks et al. 1994, McCarthey et al. 1998, Sogge et al. 1997a, Stoleson and Finch 1999, McKernan and Braden 2001). On the Gila River, NM, Stoleson et al. (1998) found differences between occupied and unoccupied habitats that were near one another and were generally similar. Occupied sites had greater foliage density, greater canopy cover, and greater numbers of trees than unoccupied sites. Unoccupied sites had fewer shrubs and saplings, more open canopies, and greater variability in these characteristics. Historically, the southwestern willow flycatcher probably nested primarily in willows, buttonbush (*Cephalanthus occidentalis*), and seepwillow *(Baccharis* sp.*)*, sometimes with a scattered overstory of cottonwood (*Populus* sp.) (Grinnell and Miller 1944, Phillips 1948, Whitmore 1977, Unitt 1987). Following modern changes in riparian plant communities, the flycatcher still nests in native vegetation where available, but also nests in thickets dominated by tamarisk and Russian olive (Hubbard 1987, Brown 1988, Sogge et al. 1993, Muiznieks et al. 1994, Maynard 1995, Sferra et al. 1997, Sogge et al. 1997a, McKernan and Braden 1999).

Nesting willow flycatchers of all subspecies generally prefer areas with surface water nearby (Bent 1960, Stafford and Valentine 1985, Harris et al. 1987), but *E. t. extimus* almost always nests near surface water or saturated soil (Phillips et al. 1964, Muiznieks et al. 1994). At some nest sites surface water may be present early in the breeding season but only damp soil is present by late June or early July (Muiznieks et al. 1994, M. Whitfield, Kern River Research Center, in litt.)1993, J. and J. Griffith, Griffith Wildlife Biology, in litt.)1993). At some breeding sites, water may be present in most years but absent in others, especially during drought periods or if reservoir levels recede (see Section 7 below). Ultimately, a water table close enough to the surface to support riparian vegetation is necessary. In some cases a site may dry out, but riparian vegetation and nesting flycatchers may persist for a short time (one or two breeding seasons) before they are eventually lost.

1. General Vegetation Composition And Structure

Southwestern willow flycatcher breeding habitat can be broadly described based on plant species composition and habitat structure. These two habitat characteristics are the common denominators most conspicuous to human perception, but are not the only important components. However, they have proven useful in describing known breeding sites, evaluating suitable survey habitat, and in predicting where breeding flycatchers may be found.

The following habitat descriptions are organized into three broad habitat types - those dominated by native vegetation, by exotic vegetation, and those with mixed native and exotic plants. These broad habitat descriptors reflect the fact that southwestern willow flycatchers now inhabit riparian habitats dominated by both native and non-native plant species. Tamarisk and Russian olive are used as nesting substrates. In some cases, flycatchers are breeding in locations where these species form the dominant canopy species or occur in nearly monotypic stands. Table 1 presents data on flycatcher habitat use from throughout this subspecies' range. Data on the most conspicuous plant species were collected in conjunction with population data at 221 sites across the bird's range (Table 1), and demonstrate the widespread use of riparian habitats comprised of both native and exotic trees and shrubs. A breeding site was considered "dominated" by either native or exotic plants if they comprised an estimated ≥60% of vegetation volume of shrubs and small trees. Table 1 does not reflect an analysis of flycatcher selection of either native- or exotic-dominated communities in relation to the availability of these habitats across the landscape.

Table1. The number of known southwestern willow flycatcher territories located within major vegetation/habitat types, by state. Data are from Sogge et al. 2002, based on last reported habitat and survey data for all sites where flycatchers were known to breed, 1993-2001.

	State						
Vegetation Type	AZ	CA	CO	NM	NV	UT	Total
Native (>90%)	33	172	37	194	32	0	468
Mixed native/exotic (>50 native)	102	52	0	50	27	0	231
Mixed exotic/native (>50% exotic)	140	1	0	3	14	3	161
Exotic (>90%)	79	0	0	11	0	0	90
Unreported	5	31	0	0	0	0	36
Total	359	256	48	258	73	3	986

[1]see Appendix Q for full list of data sources.

Narrative descriptions of the general vegetation types used throughout the southwestern willow flycatcher's range are provided below. These vegetation descriptions focus on the dominant tree and shrub components. The habitat types described below include a continuum of plant species composition (from nearly monotypic to mixed species) and vegetation structure (from simple, single stratum patches to complex, multiple strata patches). Because pictures are often much more effective than verbal descriptions at conveying the general nature of a riparian patch, we include one or more photographs of each type of occupied breeding habitat (See Appendix). The intent of the descriptions and photographs is to provide a basic understanding of the types of habitat occupied by the flycatcher, not to create a standardized definition or classification. All known breeding sites are not described or illustrated, so every potential variant is not shown. However, the sites presented capture most of the known range of patch floristics, structure and size.

2. Native Vegetation Dominated

Approximately half of southwestern willow flycatcher territories are in patches dominated by native trees and shrubs, especially willows (*Salix* spp.). The floristic and gross structural variation of occupied native-dominated habitats is quite broad. Occupied sites vary from monotypic, single strata patches to multi-species, multi-layered strata with complex canopy and subcanopy structure. Overall, sites differ substantially with elevation, and are treated separately below.

Low to Mid-Elevation Native Sites

General characteristics: These sites range from single plant species to mixtures of native broadleaf trees and shrubs including (but not limited to) Goodding's *(Salix gooddingii*) or other willow species, cottonwood, boxelder, ash (*Fraxinus* spp.), alder (*Alnus* spp.), and buttonbush. Average canopy height can be as short as 4 m (13 ft) or as high as 30 m (98 ft). Gross patch structure is generally characterized by individual trees of different size classes, often forming a distinct overstory of cottonwood, willow or other broadleaf tree with recognizable subcanopy layers and a dense understory of mixed species. However, although some descriptions of flycatcher breeding habitat emphasize these multi-species, canopied associations, flycatchers also breed at sites with tall (>5 m/16 ft) monotypic willow. Exotic or introduced trees and shrubs may be a rare component at these sites, particularly in the understory. In an unusual site along the upper San Luis Rey River in San Diego County, CA, willow flycatchers breed in a streamside area dominated by live oak (*Quercus agrifolia*), where willows once predominated but were reduced by a phreatophyte control program several decades ago and are now regenerating (W. Haas, pers. comm.).

Examples

South Fork of the Kern River at Lake Isabella, Kern County, CA., elevation 780 m (2558 ft) (see Whitfield and Enos 1996, Whitfield 2002). This is one of the largest tracts of native-dominated flycatcher habitat in the Southwest (Figure 1). The site includes roughly 500 ha (1235 ac) of riparian woodland dominated by a dense overstory of red willow (*Salix laevigata*) and Gooding's willow, interspersed with open areas often dominated by nettle (*Urtica dioica*) and mule fat (*Baccharis salicifolia*), cattails (*Typha* spp.) and tules (*Scirpus* spp.). Canopy height is typically from 8 to 12 m (26-39 ft). This site has numerous river channels, sloughs, and marshes that provide surface water and saturated soils across a relatively broad floodplain throughout most of the breeding season (Figure 2).

Santa Ynez River, Santa Barbara County, CA., (see Holmgren and Collins 1995). Willow flycatchers breed at several areas along the perennial Santa Ynez River between Buellton (elevation approximately 150 m or 490 ft) and the ocean. These species-rich riparian sites (Figure 3) are comprised of red willow, black cottonwood (*Populus trichocarpa*) and box elder with dense, shrubby thickets of willows (*Salix lasiolepis* and *S. exigua*), mulefat, poison oak (*Toxicodendron diversilobum*) and blackberry (*Rubus spp.*).

San Pedro River, Pinal County, AZ., elevation 600 m (see Spencer et al. 1996, McCarthey et al. 1998, Smith et al. 2002). Several flycatcher breeding sites along this riparian system are dominated primarily by Fremont cottonwood *(P. fremontii*) and Goodding's willow (Figure 4). Understory is comprised of younger trees of these same species, with tamarisk (*Tamarix ramosissima*) as a minor component in some areas. Overstory canopy height averages 15 to 20 m (49-65 ft). Open water, marshes and seeps (including cattail and bulrush), and saturated soil are present in the immediate vicinity.

Gila River, Grant County, NM., elevation 1,480 m (4854 ft) (see Skaggs 1996, Cooper 1997, Stoleson and Finch 1999). One of the largest known population of breeding southwestern willow flycatchers is found in a series of narrow riparian patches distributed over a 13 km (8 mi) stretch of the Gila River. Flycatchers breed in two distinct structural types; riparian scrub and riparian forest. Riparian scrub (Figure 5) is dominated by 4 to 10 m (13-33 ft) tall shrubby willows and seepwillow (*Baccharis glutinosa*) that grow along the river bank or in old flood channels. These shrub strips are sometimes less than 10 m (33 ft) wide and rarely more than 20 m (66 ft). Riparian forest patches (Figure 6) were 100 to 200 m wide (328-650 ft), and dominated by trees such as Fremont cottonwood, Goodding's willow, Arizona sycamore (*Plantanus wrightii*) and boxelder. Understory includes young trees of the same species. Canopy height generally ranges between 20 and 30 m (33-98 ft). Much of this forest vegetation is sustained by water from the river and small, unlined water diversions that function much like a dendritic stream system. To the extent that more specifically quantified data on vegetation structure have been developed, that information comes from this population. Skaggs (1996) found that 90% of territories occurred in Mixed Broadleaf Riparian Forest (Brown et al. 1979), which locally were expressed as "...dense, multi-layered canopies." Greatest foliage density was at heights of 3-13m (10-42 ft), and canopy cover (>2 m height) averaged 95%. In both Mixed Broadleaf Riparian Forest and Mixed Narrowleaf Riparian Scrub, Skaggs found approximately 600 stems/ha of dominant trees. Herbaceous groundcover and understory were not quantified. In comparing nest sites and unused sites in the Cliff-Gila Valley, Stoleson and Finch (1999) found that nest sites were significantly higher in average canopy cover, foliage density at 3-10 m, patchiness, and number of tree stems per unit area. Nest sites were significantly lower in average ground cover, average canopy height, and total basal area of woody stems. Ground cover is probably lower at nest sites because of the high degree of canopy closure or, as at the Kern River, due to standing water.

__High-Elevation Native Sites__

General characteristics: As a group, these sites are more similar than low elevation native sites. Most high elevation (≥1900 m or 6232 ft) breeding sites are comprised completely of native trees and shrubs, and are dominated by a single species of willow, such as coyote willow (*Salix exigua*) or Geyer's willow (*S. geyeriana*). However, Russian olive is a major habitat component at some high elevation breeding sites in New Mexico. Average canopy height is generally only 3 to 7 m (10-23 ft). Gross patch structure is characterized by a single vegetative layer with no distinct overstory or understory. There is usually very dense branch and twig structure in lower 2 m (6.5 ft), with high live foliage density from the ground to the canopy. Tree and shrub vegetation is often associated with sedges, rushes, nettles and other herbaceous wetland plants. These willow patches are usually found in mountain meadows, and are often associated with stretches of stream or river that include many beaver dams and pooled water.

Examples

Little Colorado River near Greer, Apache County, AZ., elevation 2530 m (8298 ft) (see Spencer et al. 1996, Langridge and Sogge 1997, McCarthey et al. 1998). This 14 ha (34.5 ac) site is a mosaic of dense, shrubby Geyer's willow (Figure 7), dense herbaceous ground cover, and open water. The river and associated beaver ponds create marshes, wet meadows and saturated soil conditions. Average willow canopy height is 4 to 6 m (13-20 ft). The willow matrix is a combination of clumps and thin strips 3 to 5 m (10-16 ft) wide. The shrubby vegetation is structurally composed of a single layer of live vegetation, with dense branch and twig structure and high live foliage density from ground level to canopy. Habitat surrounding the broad valley is primarily ponderosa pine (*Pinus ponderosa*) and scattered houses and cabins.

Alamosa National Wildlife Refuge, Alamosa County, CO., elevation 2,290 m (8000 ft) (see Owen and Sogge 1997). This site includes a series of mostly small habitat patches distributed along several kilometers of the upper Rio Grande. The river is narrow, and winds through the generally flat landscape. The shrubby vegetation (Figure 8) is dense, almost monotypic willow, with small amounts of cottonwood present in a few patches. Shrub height is typically 3-4 m high, with some larger emergent cottonwoods at some, but not all, patches.

3. *Exotic Vegetation Dominated*

Exotic plant species such as tamarisk and Russian olive were not introduced or widespread in southwestern riparian systems until approximately 100 years ago. Thus, southwestern willow flycatchers evolved in and until fairly recently (from an evolutionary perspective) bred exclusively within thickets of native riparian vegetation. However, as the widespread loss and modification of native riparian habitats progresses, the flycatcher is found breeding in some exotic-dominated habitats. From the standpoint of flycatcher productivity and survivorship, the suitability of exotic-dominated sites is not known. Flycatcher productivity in at least some exotic-dominated sites is lower than in some native-dominated habitats (Sferra et al. 1997, Sogge et al. 1997a), but higher at other locations (McKernan and Braden 1999). However, other factors such as small riparian patch size may have greater effects on productivity at those sites.

Southwestern willow flycatchers do not nest in all exotic species that have invaded and sometimes dominate riparian systems. For example, flycatchers do not use tree of heaven (*Ailanthus altissima*). Even in the widespread tamarisk, flycatchers tend to use only two discreet forms - low stature tamarisk found in the understory of a native cottonwood-willow gallery forest or the tall (6 - 10 m or 19-33 ft) mature stands of tamarisk that have a high percentage of canopy closure.

Most exotic habitats range below 1,200 m (3,940 ft) elevation. As a group, they show almost as much variability as do low elevation native-dominated sites. Most exotic sites are nearly monotypic, dense stands of exotics such as tamarisk or Russian olive that form a nearly continuous, closed canopy (with no distinct overstory layer). Canopy height generally averages 5 to 10 m (16 - 33 ft), with canopy density uniformly high. The lower 2 m (6.5 ft) of vegetation is often very difficult to penetrate due to dense branches. However, live foliage density may be relatively low from 0 to 2 m (6.5 ft) above ground, but increases higher in the canopy.

Examples

Roosevelt Lake, Gila County, AZ., elevation 640 m (2100 ft) (Sferra et al. 1997, McCarthey et al. 1998, Smith et al. 2002). Two of the largest known southwestern willow flycatcher populations in Arizona breed in large, contiguous stands of dense, mature tamarisk at the Tonto Creek and Salt River inflows to Roosevelt Lake (Figures 9 and 10). Along the Salt River inflow, flycatchers breed in several patches of essentially monotypic saltcedar (as well as in more native-dominated patches nearby). Tamarisk-dominated patches at the Tonto Creek site include a few scattered, large cottonwood trees that emerge above the tamarisk canopy, which averages 8 to 12 m (26 - 40 ft) in height. Within the patches, there are numerous small openings in the canopy and understory. As is often the case in such mature tamarisk stands, there is little live foliage below a height of 3 to 4 m (10-14 ft) within the interior of the patch (although live foliage may be continuous and thick at the outer edges of the patch), and virtually no herbaceous ground cover. However, numerous dead branches and twigs provide for dense structure in the lower 2 to 3 m (6-10 ft) strata (Figure 11). In normal or wet precipitation years, surface water is adjacent to or within the tamarisk patches.

Colorado River in Grand Canyon, Coconino County, AZ., elevation 850 m (2788 ft) (see Sogge et al. 1997). The willow flycatcher breeding sites along the Colorado River in the Grand Canyon (Figure 12) are very small (0.6 to 0.9 ha), dense patches of mature tamarisk, bordered on the upslope side by acacia (*Acacia greggii*) and along the river's edge by a thin band of sandbar willow (*Salix exigua*). Tamarisk canopy height averages 8 to 12 m (26-40 ft). Live foliage is dense and continuous along the edge of the patch, but within the patch interior does not begin until 2 to 4 m (10-14 ft) above ground. A dense layer of dead branches and twigs provides for a thick understory below the live vegetation. These sites have almost no herbaceous understory due to a dense layer of fallen tamarisk branches and leaf litter. All patches are no further than 5 m (16.4 ft) from the river's edge.

4. Mixed Native and Exotic Habitats

General characteristics: Many southwestern willow flycatcher breeding sites are comprised of dense mixtures of native broadleaf trees and shrubs (such as those listed above) mixed with exotic/introduced species such as tamarisk or Russian olive. The exotics are often primarily in the understory, but may be a component of overstory. At several sites, tamarisk provides a dense understory below an upper canopy of gallery cottonwoods, forming a habitat that is structurally similar to the cottonwood-willow habitats in which flycatchers historically nested. A particular site may be dominated primarily by natives or exotics, or be a more-or-less equal mixture. The native and exotic components may be dispersed throughout the habitat or concentrated in distinct, separate clumps within a larger matrix. Sites almost always include or are bordered by open water, cienegas, seeps, marshes, and/or agricultural runoff channels. However, during drought years surface water at some sites may be gone early in the breeding season. Generally, these habitats are found below 1,200 m (3940 ft) elevation.

Examples

Rio Grande at San Juan Pueblo, Rio Arriba County, NM., elevation 1,716 m (5,630 ft)) (see Maynard 1995, Cooper 1997). In this locale, southwestern willow flycatchers breed in a habitat that includes a scattered overstory of cottonwood, with subcanopies and understories comprised of Russian olive and coyote willow. The Russian olive averages 8 to 12 m (26-40 ft) in height, and the willows 3.5 to 6 m (12-20 ft). River channels, diversion ditches, old river oxbows, and associated marshy areas are present within and adjacent to the site (Figure 13).

San Pedro River, Pinal County, AZ., elevation 600 m (1968 ft) (see Spencer et al. 1996, McCarthey et al. 1998). Parts of the extensive riparian tracts of the lower San Pedro River are dominated by cottonwood and willow, but include substantial amounts of dense tamarisk. In some cases, the tamarisk occurs as a dense understory amidst a cottonwood, willow, ash or boxelder overstory (Figure 14), while in others it borders the edge of the native vegetation (Figure 15). Overall canopy height ranges from 10 to 18 m (33-59 ft).

Verde River at Camp Verde, Yavapai County, AZ., elevation 940 m (3,083 ft) (see SWCA 2001). Southwestern willow flycatchers breed here in a mixture of willow, cottonwood, and tamarisk habitat (Figure 16). Most of the territories are found in a cluster of dense mature tamarisk 6 to 8 m (19.5-26 ft) tall that is bordered by narrow bands of young willow, which in turn is surrounded on one side by a large (>50 ha) stand of mature cottonwoods and willows (15-20 m tall) with little understory. Although the patch itself is located on a sandy terrace approximately 4 m (13 ft) above typical summer river level, the Verde River flows along the eastern edge of the patch and a small intermittently flowing irrigation ditch provides water to a small pond adjacent to the tamarisk and willows. Patches of herbaceous ground cover are scattered throughout the site, but are absent under the tamarisk canopy.

Virgin River, Washington County, UT., elevation 1,100 m (3,608 ft) (USFWS unpubl. data). Along one portion of Virgin River riparian corridor near St. George, flycatchers breed in a mixture of dense willow, Russian olive and tamarisk near an emergent marsh (Figure 17). The native trees form a tall overstory 10-12 m (33-40 ft) high, which is bordered by a shorter (10-12 m or 33-40 ft) band of tamarisk, and a strip of 4 to 8 m (13-26 ft) tall willow. The stretch of occupied habitat is approximately 60 m (197 ft) wide and 100 m (328 ft) long, and is located in an old meander channel through which the river no longer flows. In normal and wet years return channels and river flows seasonally inundate the base of the vegetation.

5. Standard BioticVegetation Classifications And Descriptions

In addition to the above habitat descriptions, existing systematic classification systems for biotic and vegetative communities are also helpful to generally categorize southwestern willow flycatcher habitats. The system developed by Brown et al. (1979) as supplemented by Brown (1982) is widely used and provides valuable habitat descriptions. Flycatcher habitats can be placed into the broad biomes and series noted below. Because of local variations in relative abundance of plant species, individual sites will vary in community/ series, association and subassociation (see Brown 1982 for discussion). Below is a listing of several major biotic communities, with subordinate classifications, and examples of known flycatcher habitat areas (Numerical identifiers follow Brown et al. 1979; all in Nearctic Realm).

Lower Elevation Habitats

224 Tropical-Subtropical Swamp, Riparian, and Oasis Forests

224.5 Sonoran Riparian and Oasis Forests

224.53 Cottonwood-Willow Series (historical lower Colorado River, San Pedro River AZ)

234 Tropical-Subtropical Swamp and Riparian Scrub

234.7 Sonoran Deciduous Swamp and Riparian Scrub

234.72 Saltcedar Disclimax Series (current lower Colorado River)

223 Warm Temperate Swamp and Riparian Forests

232.2 Interior Southwestern Riparian Deciduous Forest and Woodland series

223.21 Cottonwood-Willow series

223.22 Mixed Broadleaf series (Gila River, Gila-Cliff Valley, NM)

223.3 Californian Riparian Deciduous Forest and Woodland

223.31 Cottonwood-Willow Series (Kern, Santa Margarita and Santa Ynez Rivers, CA)

223.32 Mixed Broadleaf Series (San Luis Rey River CA)

233 Warm Temperate Swamp and Riparian Scrub

233.2 Interior Southwestern Swamp and Riparian Scrub

233.21 Mixed Narrowleaf Series (Gila-Cliff Valley, NM)

233.22 Saltcedar Disclimax Series (Roosevelt Lake AZ, Grand Canyon AZ)

233.221 *Tamarix chinensis* -Mixed Deciduous association (Verde and San Pedro Rivers AZ)

Upper Elevation Habitats

231 Arctic-Boreal Swampscrubs

231.6 Rocky Mountain Alpine and Subalpine Swamp and Riparian Scrub series (Greer, Alpine, AZ)

232 or the Cold Temperate Swamp and Riparian Scrubs biome

or 232.2 Plains and Great Basin Swamp and Riparian Scrub series

232.3 Rocky Mountain Riparian Scrub (Beaver Creek, CO)

222 Cold Temperate Swamp and Riparian Forests

222.3 Rocky Mountain Riparian Forest (Beaver Creek, CO)

Several sites described in the preceding discussion lie at middle elevations, and have Russian olive as a major habitat component, with varying amounts of tamarisk and/or native trees and shrubs also present. Examples include: the Rio Grande River at San Juan Pueblo, (elevation 1,716 m / 5,630 ft); the Virgin River, UT (elevation 1,100 m /3608 ft). While these sites do not neatly fit into the current categories of Brown et al. (1979), they could most appropriately be characterized as being related to the 233.22 Saltcedar Disclimax Series, *Tamarix chinensis* -Mixed Deciduous association.

6. Patch Size and Shape

The riparian patches used by breeding flycatchers vary in size and shape. They may be relatively dense, linear, contiguous stands or irregularly-shaped mosaics of dense vegetation with open areas. Southwestern willow flycatchers nest in patches as small as 0.1 ha (0.25 ac) along the Rio Grande (Cooper 1997), and as large as 70 ha (175 ac) in the upper Gila River in New Mexico (Cooper 1997).

To summarize characteristics of breeding patch size, we extracted information on patch size values from the following sources: Maynard 1994, Sogge 1995, Cooper 1996, Cooper 1997, Sogge et al. 1997a, Ahlers and White 1998, Paradzick et al. 1999, Johnson and Smith 2000, Paradzick et al. 2000, Ahlers and White 2001, Gallagher et al. 2001, SWCA 2001, Arizona Game and Fish Department unpublished data, and USGS unpublished data. Mean reported size of flycatcher breeding patches was 8.6 ha (21.2 ac) (SE = 2.0 ha; range = 0.1 - 72 ha; 95% confidence interval for mean = 4.6 - 12.6; n = 63 patches). The majority of sites were toward the smaller end, as evidenced by a median patch size of 1.8 ha. Mean patch size of breeding sites supporting 10 or more flycatcher territories was 24.9 ha (62.2 ac) (SE = 5.7 ha; range = 1.4 - 72 ha; 95% confidence interval for mean = 12.9 - 37.1; n = 17 patches). Aggregations of occupied patches within a breeding site may create a riparian mosaic as large as 200 ha (494 ac) or more, such as at the Kern River (Whitfield 2002), Roosevelt Lake (Paradzick et al. 1999) and Lake Mead (McKernan 1997). Based on the number of flycatcher territories reported in each patch, it required an average of 1.1 ha (2.7 ac) (SE = 0.1 ha; range = 0.01 - 4.75; 95% confidence interval for mean = 0.8 - 1.3; n = 63 patches) of dense riparian habitat for each territory in the patch. Because breeding patches include areas that are not actively defended as territories, this does NOT equate to an average territory size.

In some cases where a series of flycatcher breeding sites occur as closely distributed but non-contiguous patches of riparian vegetation, individuals show strong fidelity to that stretch of river but move readily among patches - between and within years. This movement and mixing of individuals occurs to such a degree that the entire reach of river appears to function as a single patch. An example of this is found along the lower San Pedro River and nearby Gila River confluence (English et al. 1999, Luff et al. 2000); here, the occupied habitat patches have an average nearest-neighbor distance of approximately 1.5 km (1 mile) (SD = 1.1 km, Range = 0.03 - 3.9; USGS unpublished data).

Flycatchers often cluster their territories into small portions of riparian sites (Whitfield and Enos 1996, Paxton et al. 1997, Sferra et al. 1997, Sogge et al. 1997b), and major portions of the site may be occupied irregularly or not at all. Recent habitat modeling based on remote sensing and GIS data has found that breeding site occupancy at reservoir sites in Arizona is influenced by vegetation characteristics of habitat adjacent to the actual occupied portion of a breeding site (Arizona Game and Fish Dept, unpublished data), therefore, unoccupied areas can be an important component of a breeding site. It is currently unknown how size and shape of riparian patches relate to factors such as flycatcher site selection and fidelity, reproductive success, predation, and brood parasitism.

Flycatchers are generally not found nesting in confined floodplains where only a single narrow strip of riparian vegetation less than approximately 10 m (33 ft) wide develops, although they may use such vegetation if it extends out from larger patches, and during migration (Sogge and Tibbitts 1994, Sogge and Marshall 2000, Stoleson and Finch 2000z).

7. Presence of Water and Hydrological Conditions

In addition to dense riparian thickets, another characteristic common to the vast majority of flycatcher nesting sites is that they are associated with lentic water (quiet, slow-moving, swampy, or still) or saturated soil. Occupied sites are often located in situations such as along slow-moving stream reaches, at stream backwaters, in swampy abandoned oxbows/ marshes/cienegas, and at the margins of impounded water, including the inflows of streams into reservoirs. Where flycatchers occur along moving streams, those streams tend to be of relatively low slope (or gradient), i.e., slow-moving with few (or widely spaced) riffles or other cataracts. The apparent association between southwestern willow flycatcher habitat and quiet water likely represents the relationship between the requirements of the bird for certain vegetation characteristics and patch size/shape, and the hydrological conditions that allow those conditions to develop. Lentic water conditions may also be important in influencing the insect prey base of the flycatcher.

Flycatcher habitat becomes established because of water flow conditions that result from the following factors (not in order of importance): seasonality/duration, gradient, width of flow, depth of flow, hydraulic roughness, sediment particle sizes for bed and banks, suspended sediment load, channel cross sectional morphology, longitudinal morphology (pool and riffle, rapids, step pools), vegetation in the channel, channel sinuosity, and channel pattern (single thread, braided, compound). It is not possible to define “suitable” or “potential” flycatcher habitat with specific values or configurations for just one or several of these factors (e.g., gradient or channel pattern), because all these factors are related to one other. The range and variety of flow conditions that will establish and maintain flycatcher habitat can arise in free flowing streams differing substantially in these factors. Also, flow conditions that will establish and maintain flycatcher habitat can be achieved in regulated streams, depending on scale of operation and the interaction of the primary physical controls. Still, very generally flycatcher habitat tends to occur along streams of relatively low gradient. However, the low gradient may exist only at the habitat patch itself, on streams that are generally steeper when viewed on the large scale (e.g., percent gradient over miles or kilometers). For example, obstructions such as logjams, beaver dams, or debris deposits from tributaries may partially dam streams, creating relatively quiet, lentic pools upstream.

By definition, the riparian vegetation that constitutes southwestern willow flycatcher breeding habitat requires substantial water. Further, hydrological events such as scouring floods, sediment deposition, periodic inundation, and groundwater recharge are important for the flycatcher’s riparian habitats to become established, develop, and be recycled through disturbance. It is critical to keep in mind that in the southwest, hydrological conditions at a site can vary remarkably within a season and between years. At some locations, particularly during drier years, water or saturated soil is only present early in the breeding season (i.e., May and part of June). At other sites, vegetation may be immersed in standing water during a wet year, but be hundreds of meters from surface water in dry years. This is particularly true of reservoir sites such as the Kern River at Lake Isabella, Tonto Creek and Salt River at Roosevelt Lake, and the Rio Grande near Elephant Butte Reservoir. Human-related factors such as river channel modifications (e.g., by creation of pilot channels) or altered subsurface flows (e.g., from agricultural runoff) can temporarily or permanently dry a site. Similarly, where a river channel has changed naturally (Sferra et al. 1997), there may be a total absence of water or visibly saturated soil for several years. In such cases, the riparian vegetation and any flycatchers breeding within it may persist for several years. However, we do not know how long such sites will continue to support riparian vegetation and/or remain occupied by breeding flycatchers.

In the geographical setting of the southwest, most streams descend from the higher elevations of their upper watersheds at relatively high slope or gradient. Drainages descend toward the lowlands through valleys and canyons where streamflow is in a single-thread channel, confined by steep banks, steep upland slopes, and/or canyon walls. Under these conditions even floodwaters do not spread far laterally from the banks, but rise vertically between the confining slopes or canyon walls. Flood-scour zones often are present at the stream margins, where riparian vegetation is absent or frequently removed. The zone of frequently-wetted land adjacent to the stream is relatively narrow, because the land rises steeply from the level of typical base streamflow (Figure 18). Also, high-gradient streams possess high erosive energy. Soil and sediment comprising streambanks is often coarse, cobbly, bouldery, or even bedrock. Such soil/sediment types are rarely associated with the wet, dense vegetation of willow flycatcher habitat. Under all the above conditions, riparian vegetation is seldom dense enough to provide flycatcher breeding habitat. Riparian vegetation is often present in much narrower configurations, usually a relatively narrow, linear growth with inadequate width to constitute willow flycatcher habitat.

In contrast, streams of lower gradient and/or more open valleys have a greater tendency to support potential willow flycatcher habitat patches. As streams reach the lowlands, their gradients typically flatten out. Simultaneously, the surrounding terrain often opens up into broader floodplains. Under such conditions streams meander back and forth, higher flow events spread shallowly across the floodplain, backwaters develop, and abandoned channels from previous stream alignments persist, often with moist conditions and riparian vegetation. The permanently-wetted perimeter of the stream (by either surface or subsurface water) is much more extensive and wider. The sediments of a lower floodplain are capable of retaining much more subsurface water, being deeper, finer, and extending farther laterally from the active stream channel. Riparian plant communities that are wider, more extensive, and more dense are able to develop. Conditions like these lower floodplains also develop where streams enter impoundments, either natural (e.g., beaver ponds) or human-made (reservoirs). Low-gradient stream conditions may also occur high in watersheds, as in the marshy mountain meadows supporting flycatchers in the headwaters of the Little Colorado River near Greer, Arizona.

In summary, suitable southwestern willow flycatcher habitat is less likely to occur in steep, confined streams as are found in narrow canyons. Flycatcher habitat is more likely to develop, and in more extensive patches, along lower gradient streams with wider floodplains. However, exceptions to this generality indicate that relatively steep, confined streams can also support significant flycatcher habitats. The San Luis Rey River in California supports a substantial flycatcher population, and stands out among flycatcher habitats as having a relatively high gradient and being confined in a fairly narrow, steep-sided valley. The San Luis Rey may not be an eccentric exception to typical flycatcher habitat settings, but instead an indication of the true range of potential habitat. Although stream gradient (and even vegetation) seem unusual there, the many other factors of hydrology and vegetation characteristics allow flycatchers to thrive. Finally, it is important to note that even a steep, confined canyon or mountain stream may present local conditions where just a portion of an acre or hectare of flycatcher habitat may develop. Such sites are important individually, and in aggregate. Flycatchers are known to occupy very small, isolated habitat patches, and may occur in fairly high densities within those patches.

Recovering and conserving such sites may be an important contribution to recovering the flycatcher.

8. Other Habitat Components

Other potentially important aspects of southwestern willow flycatcher habitat include distribution and isolation of vegetation patches, prey types and abundance, parasites, predators, environmental factors (e.g., temperature, humidity), and interspecific competition (see Breeding Season Biology chapter of the Recovery Plan for additional information regarding some of these factors). Population dynamics factors such as demography (i.e. birth and death rates, age-specific fecundity), distribution of breeding groups across the landscape, flycatcher dispersal patterns, migration routes, site fidelity, philopatry, and conspecific sociality also influence where flycatchers are found and what habitats they use. Most of these factors are poorly understood at this time, but may be critical to understanding current population dynamics and habitat use. Refer to Wiens (1985, 1989a, 1989b) for additional discussion of habitat selection and influences on bird species and communities.

9. What Is Not Willow Flycatcher Breeding Habitat

Cottonwood-willow gallery forests that are devoid of an understory and that appear park-like do not provide breeding habitat for southwestern willow flycatchers. Similarly, isolated, linear riparian patches less than approximately 10 m (33 ft) wide do not provide breeding habitat. However, mosaics made up of aggregations of these small, linear riparian “stringers”may be used by breeding flycatchers, particularly at high elevations. Short stature (< 4 m or <13 ft) tamarisk stands as well as sparse stands of tamarisk characterized by a scattering of trees of any height also do not provide breeding habitat for flycatchers. Finally, riparian mesquite woodlands (“bosques’) do not provide willow flycatcher breeding habitat, although they may be adjacent to (typically upland) nesting habitat (See Figures 18 - 20). At Ash Meadows National Wildlife Refuge, a unique exception is found where flycatchers nest in a tamarisk-mesquite association.

10. Potential Habitat

Loss of habitat is one of the primary causes for the endangered status of the southwestern willow flycatcher. As a result, a fundamental question to be addressed in recovering the bird is “where can suitable breeding habitat be re-established?” Suitable habitats arise from areas of potentially suitable habitat.

Potentially suitable habitat (hereafter “potential habitat”) is defined as a riparian system that does not currently have all the components needed to provide conditions suitable for nesting flycatchers (as described above), but which could - if managed effectively - develop these components over time. **Regenerating potential habitats** are those areas that are degraded or in early successional stages, but have the correct hydrological and ecological setting to be become, under appropriate management, suitable flycatcher habitat. **Restorable potential habitats** are those areas that could have the appropriate hydrological and ecological characteristics to develop into suitable habitat if not for one or more key stressors, and which may require active abatement of stressors in order to become suitable. Potential habitat occurs where the flood plain conditions, sediment characteristics, and hydrological setting provide potential for development of dense riparian vegetation. Stressors that may be preventing regenerating and restorable habitats from becoming suitable include, but are not limited to, de-watering from surface diversion or groundwater extraction, channelization, mowing, recreational activities, over-grazing by domestic livestock or native ungulates, exotic vegetation, and fire.

11. Unsuitable Habitat

Unsuitable habitats are those riparian and upland areas which do not have the potential for developing into suitable habitat, even with extensive management. Examples of unsuitable habitat are found far outside of flood plain areas, along steep walled and heavily bouldered canyons, at the bottom of very narrow canyons, and other areas where physical and hydrological conditions could not support the dense riparian shrub and tree vegetation used by breeding flycatchers even with all potential stressors removed.

12. The Importance of Unoccupied Suitable Habitat and Potentially Suitable Habitat.

Because riparian vegetation typically occurs in flood plain areas that are prone to periodic disturbance, suitable habitats will be ephemeral and their distribution dynamic in nature. Suitable habitat patches may become unsuitable through maturation or disturbance (though this may be only temporary, and patches may cycle back into suitability). Therefore, it is not realistic to assume that any given suitable habitat patch (occupied or unoccupied) will remain continually occupied and/or suitable over the long term. Unoccupied suitable habitat will therefore play a vital role in the recovery of the flycatcher, because they will provide suitable areas for breeding flycatchers to: (a) colonize as the population expands (numerically and geographically), and (b) move to following loss or degradation of existing breeding sites. Indeed, many sites will likely pass through a stage of being suitable but unoccupied before they become occupied. Potential habitats that are not currently suitable will also be essential for flycatcher recovery, because they are the areas from which new suitable habitat develops as existing suitable sites are lost or degraded; in a dynamic riparian system, all suitable habitat starts as potential habitat. Furthermore, potential habitats are the areas where changes in management practices are most likely to suitable habitat. Therefore, habitat management for recovery of the flycatcher must include developing and/or maintaining a matrix of riparian patches - some suitable and some potential - within a watershed so that sufficient suitable habitat will available at any given time.

13. Sources of Water Sustaining Breeding Sites

Although some flycatcher breeding sites are along lakes, streams, or rivers that are relatively unimpacted by human activities, most of the riparian vegetation patches in which the flycatcher breeds are supported by various types of supplemental water including agricultural and urban runoff, treated water outflow, irrigation or diversion ditches, reservoirs, and dam outflows (Table 2). Although the waters provided to these habitats might be considered “artificial”, they are often essential for maintaining the habitat in a suitable condition for breeding flycatchers. However, reliance on such water sources for riparian vegetation persistence may be problematic because the availability of the water (in quantity, timing, and quality) is often subject to dramatic change based on human use patterns; there is little guarantee that the water will be available over the long-term.

Table 2. Southwestern willow flycatcher sites dependent on supplemental water to sustain the habitat. Supplemental water type is indicated by an "X" if known and a "?" if uncertain. Sites listed would likely deteriorate in quality if supplemental water supply was terminated. Natural riparian systems where these sites occur may have supported southwestern willow flycatchers prior to disturbance, although they may have been distributed differently. In some cases, even though sites are supported by supplemental water, greater damage may be simultaneously occurring by other activities in the area (e.g., overdrafting).

Management Unit	Site Code	Agricultural / urban runoff	Sewage treatment facility or effluent outflow[1]	Irrigation or diversion canal[2]	Reservoir / dam[3]	Regulated flows[4]
Kern	KEKERN			X	X	
Mojave	MOUPNA		?			
Santa Ynez	SYVAND		X		X	
	SYBUEL	X				
	SYGIBR				X	
Santa Clara	STSATI	X			X	
Santa Ana	SAPRAD	X	X		X	
	SASNTI		X			
San Diego	SOSMCR	X	X			
	SMFALL				X	
	SMCAPE		X			
	LFAFL		X			
	SLPILG		X			
	SLGUAJ	X				
	SLSUP					X
	SLCOUS	X				
	SDSADI	?				?
	SDBATT	?				?
	SDTICA	?				?
	AHMACA	X				
	SOLALA	X				
	SUCAGO					X
Upper San Juan	SJWICR		X			
Little Colorado	LCNUTR			X		
Middle Colorado	COGC50L					X
	COG65L					X
	COG71L					X
	CO246L					X
	CO259R					X
	CO265L					X
	CO266L					X
	CO268R					X
	CO268L					X
	CO270L					X

Table 2, Continued. Southwestern willow flycatcher sites dependent on supplemental water to sustain the habitat. Supplemental water type is indicated by an "X" if known and a "?" if uncertain. Sites listed would likely deteriorate in quality if supplemental water supply was terminated. Natural riparian systems where these sites occur may have supported southwestern willow flycatchers prior to disturbance, although they may have been distributed differently. In some cases, even though sites are supported by supplemental water, greater damage may be simultaneously occurring by other activities in the area (e.g., overdrafting).

Management Unit	Site Code	Agricultural / urban runoff	Sewage treatment facility or effluent outflow[1]	Irrigation or diversion canal[2]	Reservoir / dam[3]	Regulated flows[4]
	CO272R					X
	CO273L					X
	COMEAD				X	X
Virgin	VIMESQ	X				
	VILAME				X	
	VIGEOR		X			
	VILITT	X				
Pahranagat	NLKEYP			X		
	PANRRA	X				
	PAPAHR				X	
Hoover-Parker	COBLAN					X
	COBRLA					?
	COHAVA				X	X
	COTOPO					X
	COTRAM					X
	COWACO				X	X
Bill Williams	BSLOBS				X	
	BWALMO				X	
	BWBUCK					X
	BWDEMA				X	X
	BWGEMI					X
	BWMONK					X
	SNSMLO				X	
Parker-Mexico	COADOB					X
	COCIBO					X
	COCLLA					X
	CODRAP					X
	COEHRE					X
	COFERG				X	X
	COGILA					X
	COMITT					X
	COPICA					X

Table 2, Continued. Southwestern willow flycatcher sites dependent on supplemental water to sustain the habitat. Supplemental water type is indicated by an "X" if known and a "?" if uncertain. Sites listed would likely deteriorate in quality if supplemental water supply was terminated. Natural riparian systems where these sites occur may have supported southwestern willow flycatchers prior to disturbance, although they may have been distributed differently. In some cases, even though sites are supported by supplemental water, greater damage may be simultaneously occurring by other activities in the area (e.g., overdrafting).

Management Unit	Site Code	Agricultural / urban runoff	Sewage treatment facility or effluent outflow[1]	Irrigation or diversion canal[2]	Reservoir / dam[3]	Regulated flows[4]
	COTAYL					X
	COWALK					X
Upper Gila	GIFORT			X		
	GIUBAR			X		
Mid Gila / San Pedro	GIKRNY		X			
	GIPIEA	X				
	SPINHI	X				
	SRCOTT				X	
	SRSALT				X	
	SRSCHN				X	
	SRSCHS				X	
	TOTONT					
Verde	VECAVE			X		
	VEISTE				X	
	VETAVA		X	X		
San Luis Valley	RIALAM			X		
	RIMSCP			X		
Upper Rio Grande	CHPARK			X		
	CNGUNO			X		
	RILACA				X	
	RILARI	X				
	RIGARC			X		
	RISAJU	X		X		
Middle Rio Grande	RIBOSQ			X		
	RISAMA			X	X	

[1]Pond, treated or untreated effluent. [2]Channel edge, overflow, outflow, and/or seepage.

[3]Backed up water, reservoir edge. [4]Including pumped or piped in water.

D. Migration and Wintering Habitat

The migration routes used by southwestern willow flycatcher are not well documented. *Empidonax* flycatchers rarely sing during fall migration, so that means of distinguishing species is not available. However, willow flycatchers (all subspecies) sing during spring migration. As a result, willow flycatcher use of riparian habitats along major drainages in the southwest has been documented (Sogge et al. 1997b, Johnson and O'Brien 1998, McKernan and Braden 2001). Migrant willow flycatchers may occur in non-riparian habitats and/or be found in riparian habitats that are unsuitable for breeding. Such migration stopover areas, even though not used for breeding, may be critically important resources affecting local and regional flycatcher productivity and survival.

Although little is known specifically about southwestern willow flycatcher wintering habitats, recent wintering ground surveys allow a general description of the habitats used by *Empidonax traillii* in general. Willow flycatchers can be distinguished from other *Empidona*x flycatchers on wintering grounds by the subtle distinguishing field marks, and because on wintering grounds they do emit characteristic calls, occasionally including the territorial "fitz-bew" song (Gorski 1969, Koronkiewicz et al. 1998). Unitt (1997) found no evidence that the various willow flycatcher subspecies are separated geographically on the wintering grounds. And although distinguishing the flycatcher subspecies in the field is not possible (except by in-hand examination by experts), wintering habitats occupied by any willow flycatchers are therefore likely to be representative of the southwestern subspecies. The flycatcher winters in Mexico and Central America, where they are known to sing and defend winter territories, and northern South America (Phillips 1948, Gorski 1969, McCabe 1991, Koronkiewicz et al. 1998, Unitt 1999). Popular literature on the birds of Mexico, Central, and South America describes willow flycatcher wintering habitat as humid to semi-arid, partially open areas such as woodland borders (Stiles and Skutch 1989, Howell and Webb 1995, Ridgely and Gwynne 1989). Second growth forest, brushy savanna edges, and scrubby fields with hedges as at plantations are also used. Looking specifically for wintering willow flycatchers in Panamá, Gorski (1969) found them in transitional and edge areas, often with a wetland (river, wet field) nearby. Similarly, in Costa Rica and Panamá, Koronkiewicz et al. (1998) and Koronkiewicz and Whitfield (1999) found willow flycatchers in lagunas and intermittent freshwater wetlands, muddy seeps, seasonally inundated savanna/pasture and sluggish rivers, meandering waterways and oxbows. They only found willow flycatchers in areas that consisted of these four main elements: 1) Standing or slow-moving water and wetland flora; 2) Patches of dense woody shrubs; 3) Patches and/or stringers of trees; 4) Open to semi-open areas. The most commonly used vegetation used was patches of dense woody shrubs (*Mimosa* sp. and *Cassia* sp.) approximately 1-2 m (3-7 ft) tall, bordering and extending into wet areas. In early 1999, a southwestern willow flycatcher banded on breeding grounds in southern Nevada was recaptured on wintering grounds in the Guanacaste region of northwestern Costa Rica (Koronkiewicz pers. comm). Wintering range and habitat requirements are areas of much-needed research for the southwestern willow flycatcher. See Appendix E for more detailed information.

14. Summary and Conclusion

Southwestern willow flycatchers breed in substantially different types of riparian habitat across a large elevational and geographical area. Breeding patch size, configuration, and plant species composition can vary dramatically across the subspecies' range. However, certain patterns emerge and are present at most sites. Regardless of the plant species composition or height, occupied sites always have dense vegetation in the patch interior. In most cases this dense vegetation occurs within the first 3 - 4 m (10-13 ft) above ground. Canopy cover is usually very high - typically 80% or greater. These dense patches are often interspersed with small openings, open water, or shorter/sparser vegetation, creating a mosaic that is not uniformly dense. Nesting habitat patches will tend not to be very narrow, as single rows of trees bordering a small stream. In almost all cases, slow-moving or still surface water and/or saturated soil will be present at or near breeding sites during wet or normal precipitation years. The ultimate measure of habitat suitability is not simply whether or not a site is occupied. Suitable habitats are those in which, with other significant stresses absent (e.g., cowbird parasitism), flycatcher reproductive success and survivorship results in a stable or growing population. Without long term data showing which sites have stable or growing populations, we cannot determine which habitats are suitable or optimal for breeding southwestern willow flycatchers. Some occupied habitats may be acting as population sources, while others may be functioning as population sinks (Pulliam 1988).

Unfortunately, a habitat model or template that specifically describes flycatcher breeding habitat is not available at this time. Our understanding of what is "suitable" is confounded by several observations. Even very experienced flycatcher researchers have seen what they consider to be suitable habitat go unoccupied. Specifically, at the Kern River, Whitfield (pers. comm.) notes that many individuals are not resighted as yearlings, but are resighted in later years as older breeders. This suggests that some yearling birds, although they are reproductively mature, exist as non-breeding "floaters." This would seem to be due to a shortage of breeding habitat; however, the experienced impression of researchers is that substantial amounts of "suitable" but unoccupied habitat are available. These observations likely suggest that there are subtleties of habitat suitability that researchers have not yet discerned. Even that likelihood is confused by the effects of the species' rarity, and slight tendency to be a semi-colonial nester.

E. Literature Cited

Please see Recovery Plan Section VI.

Figure 1. Breeding site at South Fork of Kern River, CA. Note canopy height and breadth of floodplain at this cottonwood-willow dominated site.

Figure 2. Breeding site at South Fork of Kern River, CA. Note the dense tangle of willow understory and small openings directly above surface water.

Figure 3. Breeding site at Santa Ynez River, CA. Note proximity to surface water, and the structural complexity and density of native broadleaf species.

Figure 4. Breeding site on the San Pedro River, AZ. Note the emergent plants bordering dense willows and buttonbrush. Water is present throughout site.

Figure 5. Breeding site on Gila River, NM. Note mosaic of riparian stringers, proximity to surface water. Exposed banks remnant of past grazing.

Figure 6. Breeding site on Gila River, NM. Note openings within dense cottonwood and boxelder vegetation, and presence of water in channel.

Figure 7. Breeding site on the Little Colorado River, AZ. Note dense shrubby high-elevation willows and surface water.

Figure 8. Breeding site at Alamosa, CO. Note dense structure and short stature. This patch is adjacent to the upper Rio Grande.

Figure 9. Breeding site on Tonto Creek at Roosevelt Lake, AZ. Note dense, tall, monotypic tamarisk with openings in patch interior. No water present when photo taken.

Figure 10. Breeding site on the Salt River at Roosevelt Lake, AZ. Note dense, tall, monotypic tamarisk with mosaic of openings in patch interior.

Figure 11. Breeding site at Topock Marsh, AZ. Note dense, structure in lower 3-4 m within this tamarisk stand.

Figure 12. Breeding site on the Colorado River in the Grand Canyon, AZ. Note dense, tall, monotypic tamarisk adjacent to backwater.

Figure 13. Breeding site on the Rio Grande, NM. This dense, Russia olive dominated patch is bordered by marsh and a slough channel along the Rio Grande.

Figure 14. Breeding site on the Verde River, AZ. Note dense, tall tamarisk interspersed with and surrounded by willows and cottonwoods.

Figure 15. Breeding site on San Pedro River, AZ. Note the height, density and openings in this mixed native-exotic site. Surface water is present but not visible in foreground.

Figure 16. Breeding site at Tonto Creek, Roosevelt Lake, AZ. Note tall cottonwoods and willows interspersed with tamarisk, and the patch interior openings.

Figure 17. Breeding site on Virgin River, UT. The dense native-exotic vegetation is bordered by slough channel. Foreground is 2-3 m above terrain in which trees are rooted.

Figure 18. Example of native riparian habitat (in Grand Canyon, AZ) not suitable for Willow Flycatcher breeding. Habitat too narrow and short stature.

Figure 19. Example of native riparian habitat (in CO) that is not suitable for Willow Flycatcher breeding. Park-like gallery forest is devoid of dense understory.

Figure 20. Example of tamarisk-dominated riparian habitat (at Roosevelt Lake, AZ) that is not suitable for Willow Flycatcher breeding. Habitat too sparse and short stature.

Figure 21. High-elevation willow habitat (on San Francisco River, AZ) that is not suitable for Willow Flycatcher breeding. Habitat too narrow, short, and low-density.

Appendix E.
Willow Flycatcher Migration and Winter Ecology

A. Introduction

As with all other Neotropical migrants, willow flycatchers (all subspecies) breed in North America, but winter in portions of Central and South America. This migration requires a round trip migration of about 3,000 - 8,000 km (roughly 2,000 to 5,000 miles) each year, depending upon exact breeding and wintering locations of a particular individual. The migration and wintering periods account for over half of the annual cycle of the flycatcher, and therefore are important to the species' ecology and conservation. Unfortunately, it is very difficult to distinguish willow flycatcher subspecies during migration and on the wintering grounds (Hubbard 1999, Yong and Finch 1999). Thus, little of what is known about willow flycatcher migration and wintering ecology is specific to the southwestern willow flycatcher (*Empidonax traillii extimus*). The information below generally pertains to the entire species and not just the endangered subspecies.

A recurring question in the overall study of Neotropical migrants, and one about which there has been much dispute, is whether these species are limited by recruitment (reproductive success on the breeding grounds in North America) or by survivorship during the winter (Rappole 1995, Bohning-Gaese et al. 1993, Sherry and Holmes 1995). As applied to declining or endangered species, such as the southwestern willow flycatcher, this question becomes one of whether the major problems facing the species are in North America or in the Neotropics. Applying this issue further to management actions, the question arises as to whether management should be focused on North America or the Neotropics. There may be a temptation to use the existence of known or potential migration and wintering ground threats as an excuse for avoiding conservation and management actions on the breeding grounds. This course of action (or inaction) is unsupportable. Neotropical migrant birds such as the willow flycatcher have a complex annual cycle that requires favorable conditions during all stages. Limiting or inadequate conditions during any of three periods (migration, winter or breeding) can cause the population to decline and/or prevent recovery. Managing for the flycatcher by addressing only threats on the migration and wintering grounds will fail to address a number of known problems on the breeding grounds (USFWS 1993, USFWS 1995; refer to Appendices F, G, H, I, and J), and recovery of the flycatcher will not be achieved.

A related but also unsupportable contention is sometimes made that it does no good to document and understand the threats on the wintering grounds because U.S. agencies have no regulatory authority to mandate or enforce conservation actions. While it is true that foreign countries through which flycatchers migrate and in which they spend the winter are not obligated to undertake conservation actions, the USFWS and many non-government organizations and conservation groups have active international programs that have successfully promoted foreign conservation issues in the past. Partners-in-Flight is one example of how governments and non-governmental organizations can interact across international boundaries to accomplish important conservation and research activities. Further, many of the conservation actions for wintering flycatchers may involve relatively small, local actions that can be executed with the assistance of foreign biologists and private citizens, without the need for "official" funds or actions. Thus, it is clearly worthwhile to identify conservation threats and pursue remedial actions outside of the United States.

Although it is important to focus management concerns and actions on both the wintering and breeding grounds of the flycatcher (USFWS 1993, USFWS 1995), one set of data suggests that the primary problems responsible for this bird's endangerment may occur on the breeding grounds. Available data (Unitt 1997) suggest that willow flycatcher subspecies all winter in the same general region (though we do not know if the proportion of each subspecies is similar throughout the winter range). If the southwestern willow flycatcher's decline were due solely or mostly to events on the wintering grounds, then all subspecies of the willow flycatcher should show declines because they all winter over the same region. However, while confirming an overall decline in the western populations (including *E.t. extimus*), Breeding Bird Survey data (from the U.S. Geological Survey) indicate that willow flycatchers are increasing in the central and eastern portions of their range. Willow flycatchers in the eastern and central parts of North America increased at average annual rates of 0.9 and 1.4%, respectively, between 1966 and 1996 (n=628 eastern and 114 western BBS routes; eastern trend significant at $P = 0.05$). By contrast, willow flycatchers in the western regions show an annual decline of 2.3% ($P < 0.01$) for the same period. These differences in population trends are not unexpected, given the fact that mesic riparian habitats that willow flycatchers require in the West are rare and have been severely impacted over the last century (USFWS 1993). In contrast, mesic habitats in which flycatchers breed are widespread in eastern and central North America and are not restricted to riparian corridors. Avian population trends are often difficult to assess, and determining underlying causes can be even more problematic. Factors causing declines in southwestern willow flycatcher populations may occur during the breeding, wintering, and/or migration periods. Prudence dictates that conservation challenges and management actions should be addressed in all three stages of the flycatcher's annual cycle. Certainly there is no justification for suggesting that management actions be restricted only to the breeding grounds or only to the wintering grounds.

B. Migration

Southwestern willow flycatchers are among the latest arriving spring migrants, and typically settle on breeding grounds between early May and early June (Muiznieks et al. 1994, Maynard 1995, Sferra et al. 1997). In south-central Arizona, a few *E.t. extimus* arrive on territories as early as the third week in April (Paradzick et al. 1999). Data on southward departure are few, but it appears that most Southwestern Willow Flycatchers leave their breeding areas in mid- to late August (Arizona Game and Fish Dept unpubl. data, B. Haas unpubl. data).

Because arrival dates of individuals vary annually and geographically, northbound migrant willow flycatchers (of all subspecies) pass through areas of the Southwest in which *E.t. extimus* are actively nesting. Similarly, southbound migrants in late July and August may occur where southwestern willow flycatchers are still breeding (Unitt 1987). This spatial and temporal overlap between migrating and breeding willow flycatchers can cause some confusion as to the actual residency and breeding status of birds detected at a site during May or early June, and detections in the "non-migration" period are often critical in verifying that flycatchers are actually attempting to breed at a site (Unitt 1987, Sogge et al. 1997a).

The migration routes used by southwestern willow flycatcher are not well documented, though more is known of spring migration than of fall migration because it is only during the former that willow flycatchers sing and can therefore be distinguished from other *Empidonax* flycatchers. In spring, mist-netting studies and general flycatcher surveys show that many willow flycatchers (all subspecies) use riparian habitats along major drainages in the Southwest such as the Rio Grande (Finch and Kelley 1999), Colorado River (McKernan and Braden 1999, Sogge et al. 1997b), San Juan River (Johnson and Sogge 1997, Johnson and O'Brien 1998), and Green River (M. Johnson unpubl. data). On these drainages, migrating flycatchers utilize a variety of riparian habitats, including ones dominated by natives or exotic plant species, or mixtures of both. Where native and non-native habitats co-occur, preliminary evidence suggests that migrating flycatchers favor native habitats, especially willow (Yong and Finch 1997), possibly because of higher insect availability (Moore et al. 1993, DeLay et al. 1999). Migrant southwestern willow flycatchers are also found, though less commonly, in non-riparian habitats.

Many of the willow flycatchers found migrating through riparian areas are detected in riparian habitats or patches that would be unsuitable for breeding (e.g., the vegetation structure is too short or sparse, or the patch is too small). Such migration stopover areas, even though not used for breeding, are critically important resources affecting productivity and survival. Willow flycatchers, like most small passerine birds, require food-rich stopover areas in order to replenish energy reserves and continue their northward or southward migration. First-year migrants travel southward through unfamiliar habitats, and may have difficulty locating stopover sites if the sites are small or highly fragmented. If stopover sites are lacking, migrating birds could fail to find sufficient food and perish. Less dramatic, but perhaps as important ecologically, flycatchers forced to spend more time in poor quality stopover habitats could arrive on the breeding grounds late and/or in poor physical condition, both of which could reduce reproductive fitness (Moore et al. 1993).

C. Wintering Locations and Biology

The willow flycatcher winters in Mexico, Central America, and northern South America (Phillips 1948, Gorski 1969, McCabe 1991, Koronkiewicz et al. 1998, Ridgely and Tudor 1994, Unitt 1999). Recent examination of flycatcher museum skins collected on the wintering grounds (Unitt 1997) suggests that the different subspecies do not winter in separate regions, rather, the subspecies co-occur on the wintering grounds. However, we do not know if the relative proportions of each subspecies are similar throughout the winter range. Two wintering southwestern willow flycatchers were recaptured 4230 and 3668 km (2820 and 2445 miles) from the U.S. breeding sites at which they were banded (Koronkiewicz and Sogge 2001). In Costa Rica, male and female flycatchers wintered at the same sites and showed no evidence of sex-based habitat segregation (Koronkiewicz and Sogge 2000, Koronkiewicz 2002).

Popular literature on the birds of Mexico, Central, and South America describes willow flycatcher wintering habitat as humid to semi-arid, partially open areas such as woodland edges (Stiles and Skutch 1989, Howell and Webb 1995, Ridgely and Gwynne 1989). Second growth forest, brushy savanna edges, and scrubby fields with hedges such as at plantations are also used. In Panamá, Gorski (1969) found them in transitional and edge areas, often near a wetland. Similarly, in Costa Rica, Panamá, and El Salvador, Koronkiewicz et al. (1998), Koronkiewicz and Whitfield (1999), and Lynn and Whitfield (2002) detected willow flycatchers in lagunas and intermittent fresh water wetlands, muddy seeps, seasonally inundated savanna/pasture and sluggish rivers, meandering waterways and oxbows (Figure 1). They found willow flycatchers only in areas that consisted of the these four main elements: 1) standing or slow moving water with associated wetland flora; 2) patches of dense woody shrubs; 3) patches and/or stringers of trees; and 4) open to semi-open areas. The most commonly used vegetation was patches of woody shrubs (*Mimosa sp*. and *Cassia sp*.) approximately 1-2 m (3-7 ft) tall, bordering and extending into wet areas.

Willow flycatchers defend winter territories at their wintering sites, and these territories remain relatively consistent over the winter (Koronkiewicz and Sogge 2000). Territorial behavior suggests that wintering flycatchers are defending one or more resources, and that high-quality winter habitat may be limited or limiting (Sherry and Holmes 1996). Individual flycatchers also return to the same wintering sites and territories each year (Koronkiewicz and Sogge 2000, Koronkiewicz 2002).

Figure 1. Willow flycatcher habitat adjacent to a sugar cane field, Pese, Panama. Photo taken by M. Whitfield, 2000.

D. Possible Threats to Migrating and Wintering Willow Flycatchers

As noted above, the migration and wintering periods are critical phases in the life of the willow flycatcher. Conservation of *E.t. extimus* must take into account the challenges and threats that the flycatcher faces during its migration and on its wintering grounds. At this time, it is not possible to identify threats specific to the endangered subspecies. However, because the timing and areas of migration and wintering overlap for all subspecies, threats that affect any one subspecies (or the species as a whole) probably affect *E.t. extimus*.

Following are some of the major and/or most obvious known and suspected threats to the flycatcher and its migration/wintering habitat.

1. Habitat Loss and Degradation

The southwestern riparian habitats through which many (likely most) southwestern willow flycatchers migrate make up only a small fraction of the landscape, are highly fragmented, and often highly impacted by human-related activities. Continued loss and degradation of migration stop-over habitats could lead to direct mortality of migrating flycatchers and/or longer migration periods with subsequent late arrival on the breeding grounds. Any of these outcomes could reduce the chances for recovery of the flycatcher. Researchers have estimated that migrating willow flycatchers can fly from about 150 km (Otahal 1998) to 225 km (Yong and Finch 1997) between stopovers (though greater distances may be possible if weather conditions [e.g., wind] are favorable). Thus, spacing of usable stopover habitats should be as continuous as possible, and should not exceed these distances.

The wintering habitats in which flycatchers have recently been found in Costa Rica, Panama, El Salvador, and Mexico (Koronkiewicz et al. 1998, Koronkiewicz and Whitfield 1999, Lynn and Whitfield 2000, Lynn and Whitfield 2002) are similarly rare at the landscape level, and subject to many human-related threats. If wintering willow flycatchers are restricted to these wet lowlands, any changes or impacts to these relatively scarce wetlands could have profound effects on a large proportion of flycatchers. These areas of the Pacific lowlands are essentially remnant woodland-wetlands in a landscape dominated by man-made savannas, pasture lands, and agricultural areas (especially sugar and rice plantations; Figure 2). Koronkiewicz and Whitfield (1999) reported that the principal threat to flycatcher wintering habitat is agriculture-related destruction, and described the loss of two occupied willow flycatcher wintering sites over the course of their short (two month) survey.

Recent increases in human populations in Central and South America have resulted in widespread loss and degradation of native habitats, including conversion of riparian and lowland wet woodlands (e.g., willow flycatcher migration and wintering habitats) to agricultural landscapes. Even if these habitats are not currently limited with respect to the flycatcher, current trends in human population growth will likely continue and further reduce available natural habitats to the point where winter and/or migration habitat becomes limiting.

2. Agrochemicals

Flycatcher wintering sites in Costa Rica, Panama, and El Salvador are embedded within a matrix of intensive agricultural land uses, many of which involve widespread and intensive use of a variety of agrochemicals (Koronkiewicz et al. 1998, Lynn and Whitfield 2000). Because wintering willow flycatchers forage extensively in wetlands that are adjacent to, or downstream of, agricultural areas, they are potentially exposed (through their prey base) to these chemicals. Recent research on the breeding grounds has identified flycatcher deformities (Sogge and Paxton 2000) and low egg hatchability (Valentine et al. 1988, Whitfield 1999, AGFD unpubl. data) that may be related to environmental toxins on the winter and/or breeding grounds.

Figure 2. Willow flycatcher habitat in La Barra de Santiago, El Salvador. The sugar cane field in the left foreground has been harvested and burned. Willow flycatchers were detected on the other side of the canal. Photo courtesy of M. Whitfield.

E. Potential Actions to Eliminate or Reduce Threats to Migrating and Wintering Flycatchers

At this time, it is not possible to target management actions specifically for the endangered subspecies. However, because the timing and areas of migration and wintering overlap for all subspecies, actions that benefit any one subspecies (or the species as a whole) will probably benefit *E.t. extimus*.

Following are research and management actions that could be used to reduce known and suspected threats to the flycatcher and its migration/wintering habitat.

1. Protect Existing Riparian Habitats

Prevent or minimize loss and degradation of riparian habitats that currently exist. Protection should be afforded to a wide variety of habitats, not simply those that have the characteristics of flycatcher breeding sites. For a migrating flycatcher, almost any riparian vegetation (with the possible exception of *Arundo*) is preferable to rip-rap banks, agricultural fields, or urban development. The presence of water can influence local insect abundance, and thus potential prey base and energy resources. Therefore, keeping water present in or adjacent to riparian habitats is desirable.

2. Restore and Expand Riparian Habitats

Expansion of riparian habitats, and restoration of those that are heavily damaged, will increase the distribution and amount of food (energy) resources available to migrating flycatchers. Thus, opportunities for creation or restoration of riparian vegetation should be pursued wherever possible, especially along portions of major river systems where riparian vegetation is rare or lacking. Again, the presence of water can influence local insect abundance, and thus potential prey base and energy resources. Therefore, riparian restoration or creation projects should include the goal of maintaining water in or adjacent to these riparian habitats.

3. Expand Research on Post-Breeding Movements and Migration Ecology

We know nothing about the immediate movements of flycatchers upon completing their nesting activities. Although recent work has shed some light on migration timing and habitat use within some major southwestern rivers, we know almost nothing about migration. Studies of migration within the U.S. should be expanded. Given that most of the distance that southwestern willow flycatchers travel during migration is outside of the U.S., research should also include the types, locations, and extent of habitats used in these areas. This could identify geographic areas of habitats of particular concern, and allow development of specific management actions. Furthermore, additional research is needed to document important migratory behaviors and pathways in the U.S., including the relative value of different riparian habitats and extent of use of non-riparian habitats. Data on age-specific survivorship during migration could yield valuable insights.

4. Expand Research on Wintering Distribution, Status, and Ecology

Recent work (Koronkiewicz et al. 1998, Koronkiewicz and Whitfield 1999, Lynn and Whitfield 2000, Lynn and Whitfield 2002) has provided valuable information on flycatcher wintering distribution, status, and ecology. However, these data are limited to only Costa Rica, Panama, El Salvador, and Mexico, which represent only a fraction of the willow flycatcher's winter range. Knowledge of winter distribution, habitat use, and threats is needed for other areas. Furthermore, research is needed on how patch characteristics such as size, vegetative composition, and landscape setting affect habitat quality and, therefore, winter survival and site fidelity. It would also be valuable to determine whether remote sensing and Geographic Information System technology could be used to characterize the distribution and availability of wintering habitat. Further information is also needed on the influence of environmental toxins and other human activities.

5. Conduct Education and Outreach

Develop and institute a program to inform the foreign governments and public about the endangered *E.t. extimus*, the importance of migration stopover and winter habitats, and the threats the flycatcher faces during these periods. Work with local biologists, government officials, and private landowners to identify specific actions that can be undertaken, at particular sites, that will benefit wintering and migrating flycatchers.

F. Literature Cited

Please see Recovery Plan Section VI.

Appendix F.

COWBIRD PARASITISM AND THE SOUTHWESTERN WILLOW FLYCATCHER: IMPACTS AND RECOMMENDATIONS FOR MANAGEMENT

1. Introduction

High rates of successful reproduction are essential for the survival and growth of populations of the southwestern willow flycatcher (*Empidonax traillii extimus*), as is the case for all small to moderate sized passerines. Large numbers of young must be produced to make up for the high mortality rates that are normal for adult passerines in temperate regions, about 44.7-64.5% for female willow flycatchers (Sedgwick and Iko 1999, Whitfield et al. 1999). Because of this high annual mortality, most willow flycatchers do not live long enough to breed in more than one breeding season. Many factors act to lower the reproductive output of passerines (Martin 1992), including predation of eggs and nestlings, poor feeding conditions due to marginal habitat or inclement weather, anthropogenic toxins and cowbird parasitism. This paper addresses the ways in which cowbird parasitism affects willow flycatcher reproduction, whether such effects are important to population growth or regulation on local and regional bases, whether population level effects are sufficient to warrant management action and the most appropriate actions that land managers can take if cowbird management is warranted. These are complicated issues because cowbirds are native, widespread songbirds that are closely associated with human activity and because impacts to individual willow flycatchers that are parasitized, no matter how severe, may have little or no effect on flycatcher populations. On the other hand, even small reductions in willow flycatcher reproductive success could be the difference between a declining population versus a stable or slowly growing one if a population is experiencing other difficulties. This paper's goal is to provide the necessary background information needed for managers to make appropriate decisions regarding cowbirds; a basic message throughout the document is that managers need to be flexible rather than reflexive when it comes to cowbird parasitism. Predation of eggs and nestlings lower flycatcher reproductive output as much as or more than cowbird parasitism. However, management actions at present need to focus on parasitism, when it is sufficiently intense according to the guidelines laid out herein, because there are no feasible means of lowering nest predation without severely impacting entire ecosystems, unlike the case for deterrence of cowbird parasitism. Predation and the need for research on acceptable means to deter it are discussed in an appendix to this paper.

To guide the reader through this document an outline of the remaining major sections appears below. Readers familiar with cowbird and host biology can skip to section 7; those wanting a quick guide to management recommendations can skip to section 11.

2. Background on brood parasitism.
3. Cowbird impacts on host populations.

4. Host defenses against cowbird parasitism.
5. Key indicators of impacts at the population level.
6. Recent changes that may be responsible for possible increases in cowbird impacts.
7. Can southwestern willow flycatcher populations survive in the presence of cowbird parasitism?
8. Does cowbird parasitism necessitate management actions? .
9. Potential management approaches.
10. Is cowbird control a longtime or even permanent need?
11. Conclusions regarding cowbird management methods.
12. Potential positive and negative aspects of cowbird control.
13. Recommendations for cowbird management.

Appendix. The importance of nest predation and potential management actions.

2. Background on Brood Parasitism

Brood parasitism is an alternate form of breeding biology in which animals lay eggs in the nests of other individuals, their hosts, which then provide all needed parental care. This form of breeding biology has been widely studied in birds and insects (Davies et al. 1989). Among birds, parasitism can be intraspecific or interspecific. In intraspecific parasitism, which occurs in numerous bird species, individuals lay eggs in nests tended by other members of their own species. Interspecific parasitism involves laying eggs in the nests of other species. Worldwide, about 1% or roughly 100 species of birds are obligate interspecific parasites, meaning that no members of their species care for their own young (Rothstein and Robinson 1998). One or more species of obligate interspecific parasites occur over most of the land masses of all continents except Antarctica and this form of breeding biology has evolved independently six to eight times among extant bird species. Recent books providing general treatments of avian brood parasitism are Johnsgard (1997), Ortega (1998) and Rothstein and Robinson (1998).

Three obligately parasitic birds occur in North America, the brown-headed, bronzed and shiny cowbirds (*Molothrus ater, M. aeneus* and *M. bonariensis*, respectively). Lowther (1993, 1995) provides reviews of the overall biology of the first two species and Ahlers and Tisdale (1998a) have compiled a useful annotated bibliography for the genus *Molothrus*. Only the brown-headed cowbird is widespread in the United States, with breeding occurring in all states except Hawaii and only it has been implicated frequently in declines of other bird species in North America. The bronzed cowbird occurs sporadically from southeastern California to southern Louisiana and may be a factor, along with habitat loss, in declines of several oriole species (*Icterus* spp.) in the Lower Rio Grande Valley (Brush 1993, Brush pers. comm.). Bronzed cowbirds generally parasitize moderate to large passerines (Friedmann and Kiff 1985) and there are no published reports of parasitism on willow flycatchers in the scientific literature.

There was only one case of bronzed cowbird parasitism among the hundreds of southwestern willow flycatcher nests monitored in the 1990s in Arizona and New Mexico, a New Mexico nest cited Skaggs (1996). Therefore, this cowbird is not a management concern at present given the rarity with which it parasitizes willow flycatchers. The shiny cowbird has recently begun to occur in southern Florida and may be breeding there (Cruz et al. 1998). Because of the restricted ranges of the bronzed and shiny cowbirds, this paper focuses only on brown-headed cowbirds. However, if the two former cowbird species were to increase substantially in distribution and abundance, they too might require attention as regards management issues (Cruz et al. 1998). All further mention of cowbirds refers to the brown-headed cowbird.

Most parasitic bird species specialize on one or a few host species, or a complex of similar species, but brown-headed cowbirds are generalists and parasitize most co-occurring passerine species, although at greatly varying intensities. They are known to have parasitized at least 220 bird species and to have been raised by 144 of these (Lowther 1993). Even individual female cowbirds do not specialize on a single host species (Friedmann 1963, Fleischer 1985, Hahn et al. 1999). Therefore, parasitism can drive a rare host species to extinction because there is no feedback process that lowers cowbird numbers and thus parasitism rates when a rare and heavily impacted host species declines (Rothstein 1975a, Mayfield 1977, Grzybowski and Pease 1999). In other words, common host species could maintain high cowbird populations even as a rare host is pushed to extinction by cowbird parasitism. Another aspect of cowbird biology that raises the potential of major effects on host populations is the large number of eggs individual females lay. Studies from diverse regions and habitats across North America used postovulatory follicles or oviducal eggs to assess cowbird laying rates and reported that females lay eggs on about 70% of the days during their breeding season (Rothstein et al. 1986, Fleischer et al. 1987). This laying rate translates to 42 eggs for a two month breeding season and 40 or more eggs per season is commonly cited as the likely number of eggs females lay. However, many, perhaps most, of these eggs have no effect on host productivity because they are laid in nests that are lost to predation or in nests of host species that eject them (Rothstein 1977, Robinson et al. 1995a). Furthermore, a recent study (Hahn et al. 1999) that used molecular markers to determine the identity of laying females responsible for cowbird eggs and nestlings found in host nests estimated that a female's "effective fecundity" is only 2 to 8 eggs. Effective fecundity refers to cowbird eggs that are laid in nests of hosts that accept cowbird eggs. These new data suggest that cowbirds have much less potential to impact host populations than is currently believed to be the case (Hahn et al. 1999). More research is needed on this important issue because it is possible that Hahn et al. (1999) did not find all of the nests in which cowbirds might have laid eggs, whereas previous studies using the postovulatory follicle or oviducal egg methodologies are reliable in revealing numbers of eggs laid.

Unlike some brood parasites, whose young directly kill off all host young, nestling cowbirds take no direct action against host young (see Hoffman [1929] in Ahlers and Tinsdale [1998] and Dearborn [1996] for possible rare exceptions). However, host species divert parental care from their own offspring to cowbird offspring. As a result, hosts nearly always experience some reduction in their own reproductive output. More explicitly, host losses are due to female cowbirds removing one or more host eggs from most nests they parasitize (Sealy 1992), to host egg damage by adult cowbirds (Peer and Sealy 1999) and to cowbird nestlings hatching before those of most hosts (Briskie and Sealy 1990, McMaster and Sealy 1998) and usually being larger (Friedmann 1963, Lowther 1993). The larger, more advanced cowbird nestlings often outcompete host nestlings for food brought to the nest by adult hosts although large host species usually raise some of their own young when parasitized. Small hosts with long incubation periods experience the greatest losses and willow flycatchers, in particular, usually lose all of their own young if a cowbird egg is laid during their laying period and hatches successfully (Sedgewick and Iko 1999, Whitfield 2000). For southwestern willow flycatchers, only 14% of 133 and 13% of 31 parasitized nests in California and Arizona, respectively, produced any host young, compared to 54% of 190 and 60% of 133 unparasitized nests in these two states (Whitfield and Sogge 1999). Lorenzana and Sealy (1999) have provided a recent review of the costs a range of cowbird host species incur when parasitized.

Robinson et al. (1993, 1995) provide comprehensive reviews of cowbird biology and impacts on hosts. Two extensive recent works on cowbird-host interactions and cowbird management are Morrison et al. (1999) and Smith et al. (2000). The latter volumes contain papers presented at two national workshops on cowbirds and their hosts in 1993 and 1997, each attended by at least 200 people (Holmes 1993, Rothstein and Robinson 1994). These two workshops have greatly expanded our knowledge of cowbird-host interactions and related management issues and the resulting volumes are essential reading for anyone contemplating cowbird management. Another recent useful reference is Ahlers and Tinsdale (1998), which provides an annotated bibliography of technical literature on cowbirds. Schweitzer et al. (1998) and Boren (1997) provide reviews of cowbird-host interactions and focus on southwestern willow flycatchers.

3. Cowbird Impacts on Host Populations

It is essential to keep in mind that although the individual hosts that are parasitized incur costs, such reductions in reproductive output do not necessarily have impacts upon host populations or entire species because density dependent processes, such as habitat availability, may limit passerine birds (Sherry and Holmes 1995). The decrease in recruitment to a host population due to cowbird parasitism may simply mean that fewer excess individuals die without producing young because they can not secure a breeding territory or because they can not find enough food to feed themselves. Determining whether cowbird parasitism has an impact at the level of a host population or species is the most significant challenge facing conservation biologists concerned with cowbirds and their hosts. Even if parasitism is shown to limit a host species, one must decide whether that limitation is a cause for concern because every population must ultimately be limited by some factor. Unless population limitation due to parasitism is a recent situation brought about by anthropogenic factors, there is no reason to believe that this limitation is any less natural than limitation by competition, habitat, nest predation or disease.

On the other hand, any factor that limits a species or subspecies that is rare is of course a source of concern, even if the factor is wholly natural. Thus even a moderate loss in recruitment due to parasitism may require management action for a rare species and especially for an endangered one. If parasitism is the only reason for a taxon's rarity, then long-term reduction of cowbird impacts is likely to be needed. However, all endangered passerines that appear to be affected adversely at the population level by parasitism also suffer from a severe scarcity or degradation of habitat due to anthropogenic factors (Rothstein and Cook 2000). It is likely in all cases that these endangered birds would be able to coexist with cowbirds if their habitat problems were remedied.

Besides a reduction in the total number of young produced, parasitism can also affect small host populations negatively by causing some host individuals to suffer complete failure. These failures reduce the number of adults that contribute offspring to succeeding generations. The latter number is known as the effective population size and population viability theory holds that as populations decline, there is an increasing risk that stochastic events and genetic factors will lead to extinction. Another potential cost of parasitism is the possibility that the extra parental effort needed to rear cowbirds and to renest after deserting parasitized nests reduces the subsequent survival of adult hosts. But a long-term study of the willow flycatcher found no evidence for such reductions (Sedgwick and Iko 1999).

Another potential impact of cowbirds is that they may depredate unparasitized nests to cause renesting by hosts with nests too advanced to be parasitized (Arcese et al. 1996). This cowbird predation hypothesis is based on a correlation between nest failure rates and cowbird presence in an island population of song sparrows (*Melospiza melodia*) in British Columbia and could mean that host populations suffer greater losses due to cowbirds than has previously been realized. If cowbirds manage host populations as predicted by the cowbird predation hypothesis, unparasitized nests should have higher predation rates than parasitized ones but no such overall trend has been found among nesting studies of cowbirds and their hosts (Rothstein 1975b, Kus 1999, Whitfield 1999). The hypothesis also predicts that nest predation should decline when host populations are protected by cowbird removal programs. But no such decline is evident for southwestern willow flycatchers, either among years with versus without cowbird removal (Whitfield et al. 1999) or within the same year between areas with and without cowbird removal (Whitfield 2000). There was also no marked change in predation of nests of another endangered species, Kirtland's warbler (*Dendroica kirtlandii*), after a cowbird removal program began (Walkinshaw 1983). Similarly, Stutchbury (1997) reported that removal of cowbirds had a large effect on parasitism rates of hooded warblers (*Wilsonia citrina*) but no effect on reproductive success because nest predation was high in areas with reduced cowbird numbers.

There are direct observations of cowbirds removing nestlings and eggs and therefore acting as predators (Tate 1967, Scott and McKinney 1994) but this is also true for other passerines not regularly thought to be predators such as red-winged blackbirds (*Agelaius phoeniceus*), yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) and gray catbirds (*Dumetella carolinensis*) (Belles-Isles and Picman 1986, Sealy 1994, Cimprich and Moore 1995). Video documentation of predators at nests of two frequently parasitized host species showed that a cowbird was responsible for only one of 25 predation events at a Missouri study site where cowbirds were abundant (Thompson et al. 1999). Observations of removal of eggs or nestlings in Manitoba showed that cowbirds were responsible for five of 26 events. But none of the events involving cowbirds were clear cases of nest predation because only single eggs were removed in each case (Sealy 1994).

Recent studies by the same research group in British Columbia that proposed the cowbird predation hypothesis have produced results generally supporting the hypothesis for song sparrows (DeGroot et al. 1999, Arcese and Smith 1999). However, these recent studies have not determined whether heightened rates of nest failure associated with cowbirds are due to desertion of parasitized nests (a well known phenomenon) or to predation of unparasitized nests. With the present data available, we do not believe that cowbirds depredate unparasitized nests regularly enough to make this a management concern but additional research is needed.

4. Host Defenses Against Cowbird Parasitism

Besides its relevance to conservation biology, brood parasitism has long attracted the attention of biologists due to the opportunities it provides for studies of the evolution of adaptations that facilitate and deter parasitism by parasites and hosts (Rothstein 1990). These studies of parasite-host coevolution have shown that many species have evolved egg recognition in response to brood parasitism and selectively remove foreign eggs from their nests. In North America, such birds are known as rejecter species and nearly 100% of the individuals in their populations reject eggs unlike their own (Rothstein 1975a). Species that possess effective host defenses are unlikely to be impacted at the population level by cowbird parasitism. Most passerine birds in the Old World show some level of egg recognition (Davies and Brooke 1989, Moksnes et al. 1991, Nakamura et al. 1998) probably reflecting their long histories of contact with parasitic cuckoos of the subfamily Cuculinae (Rothstein 1994a). However, cowbird parasitism evolved much more recently than cuckoo parasitism (Rothstein et al. 2002)and only about 25 North American species are rejecters (Rothstein 1975a, Ortega 1998).

Most North American passerines are accepters in that they do not remove cowbird eggs placed in their nests and continue to incubate parasitized clutches. These species even incubate clutches consisting totally of cowbird eggs (Rothstein 1982, 1986). Recent work indicates that a small number of species that have cowbird-like eggs and that were previously classed as accepters actually manifest some degree of egg recognition when experimentally parasitized with eggs divergent from their own and from cowbird eggs (Burhans and Freeman 1997). It has long been known that although accepter species do not remove cowbird eggs from their nests, they often desert naturally parasitized nests and renest (Friedmann 1963, Rothstein 1975a, Graham 1988). This desertion/renesting response is not in response to cowbird eggs, because it is very rare after nests are experimentally parasitized by people (Rothstein 1975a,b) and is apparently in response to detection of adult cowbirds near or at nests (Burhans 2000). A recent synthesis of data from 60 studies on 35 host species showed that heightened desertion tendencies are likely to have evolved in response to cowbird parasitism. Desertion of parasitized nests is most likely in species that have broad habitat overlap with cowbirds and that experience high losses when they accept parasitism (Hosoi and Rothstein 2000).

However, even species with relatively high desertion rates often accept cowbird parasitism (Hosoi and Rothstein 2000) and parasitized individuals that fail to desert commonly suffer extreme reductions in reproductive output. Thus nest desertion, unlike egg ejection, is only partially effective as a host defense. As a number of recent studies on avian breeding biology have shown (Sedgewick and Knopf 1988, Pease and Gryzbowski 1995, Gryzbowski and Pease 1998, 2000; Schmidt and Whelan 1999, Woodworth 1999), the key metric of productivity for birds should be a female's seasonal output of young, not the more easily determined metric of productivity per nest. Because of renesting, the latter metric inflates the impacts of parasitism and nest predation. Southwestern willow flycatcher's desert about 35-57% of parasitized nests (Table 1). Thus the decline in willow flycatcher recruitment due to cowbird parasitism is something on the order of 43-65% of the parasitism rate, i.e., individuals that desert and then are not parasitized during a renesting attempt may experience little or no decline in reproductive output due to cowbirds. Similarly, many parasitized nests will be depredated and this too will often lead to renesting and an unparasitized nest. A small number of flycatchers build over parasitized nests and lay a new clutch in the same structure (Whitfield 1990), which is functionally similar to renesting.

Table 1. Desertion rates of parasitized willow flycatchers in different regions.

Subspecies	Region	New contact[1]	Parasitism rate (N[2])	Desertion rate (N[3])	Reference
extimus	California	Yes	68% (19)	57% (14)	Harris 1991
extimus	California	Yes	63% (60)	45% (38)	Whitfield 1990
extimus	New Mexico	No	22% (129)	35% (26)	Stoleson & Finch 1999
extimus	Arizona	No	7% (203[4])	36% (14)	Paradzick et al. 1999
trailii	Colorado	?[5]	45% (27)	82% (11)	Sedgwick & Knopf 1988
trailii	Michigan	Yes	10% (325)	27% (33)	Berger 1967
trailii	Ohio	Yes	9% (88)	63% (8)	Holcomb 1972

[1] Populations noted as yes under New Contact were allopatric with respect to cowbirds in pre-Columbian times.
[2] N reflects number of nests for which parasitism status (parasitized or unparasitized) could be determined.
[3] N reflects number of parasitized nests for which desertion status (deserted or not deserted) could be determined.
[4] Most of these nests were protected by cowbird trapping. Parasitism at two sites with no trapping was 0 of 8 nests (Alamo Lake) and 6 of 16 nests (Camp Verde).
[5] Sedgwick and Knopf (1988) thought this high elevation population was only recently exposed to parasitism but it is close to the

cowbird's center of abundance in the Great Plains, and Chace and Cruz (1999) suggest that cowbirds occurred in the region in the 1800s before bison were nearly extirpated.

Desertion of a parasitized nest results in total failure for the nest and renesting incurs a risk that a willow flycatcher's new nest will also be parasitized. Nevertheless, desertion and renesting is nearly always the best tactic for parasitized willow flycatchers because it allows them to trade a 100% certainty of parasitism and little chance of producing any young of their own for a lesser chance of parasitism. However, while renesting may allow parasitized flycatchers that desert to raise as many young as unparasitized individuals, it could incur costs such as increased reproductive effort and late fledging of young, which could result in reduced survivorship of adults and young. But extensive analyses have found no clear evidence for such costs (Sedgewick and Iko 1999). For example, 48.9% of 92 parasitized female *E. t. adastus* returned in a subsequent breeding season compared to 55.2% of 255 unparasitized females, a difference that is not significant statistically. Among birds that were successful in fledging one or more flycatcher young, 72.0% of 50 parasitized females and 56.5% of 184 unparasitized females returned in a subsequent breeding season, a significant ($P < 0.048$) difference (Sedgewick and Iko 1999). The lack of detectable deleterious effects of breeding effort on adult willow flycatcher survival is a common result for passerines and only manipulative studies can address this issue adequately (Nur 1988). Sedgewick and Iko (1999) reported that the earliest fledged flycatchers (*E. t. adastus*) were significantly more likely to return to their study sites than were young that fledged in mid-season or later. Whitfield et al. (1999a) found that southwestern willow flycatcher young that fledged early in the breeding season were more likely to return to the South Fork Kern River than those that fledged later but the difference was not significant statistically. Another potential cost of desertion and renesting is that it may not allow birds enough time to engage in double brooding, which is the raising of a second brood after young from the first nest fledge. Paradzick et al. (1999) reported that 15 of 123 southwestern willow flycatchers in Arizona raised two broods in 1998. The extent to which renesting after parasitism deters attempts to raise second broods is unknown, but could have a small to moderate depressing effect on recruitment. Lastly, desertion of a series of nests, each of which is parasitized could leave a flycatcher with insufficient time to raise any young. However, the latter may be a rare occurrence because willow flycatchers continue to breed well after all or most cowbirds have stopped laying (below).

In addition to nest desertion as a host defense, many hosts, including southwestern willow flycatchers (Uyehara and Narins 1995), recognize cowbirds as special threats and attack them or sit tightly on nests in an attempt to keep cowbirds from laying (reviewed in Sealy et al. 1998). However, such tactics are not very effective, especially for small hosts, which are often parasitized at high rates despite their responses to adult cowbirds because they are unable to drive cowbirds away. Heightened aggression towards cowbirds may even be maladaptive as cowbirds may use this host behavior to reveal nest locations (Smith et al. 1984).

5. Key Indicators of Impacts at the Population Level

The degree of lost reproductive output that individual parasitized members of a species incur and the parasitism rate (% of nests parasitized) are the two most vital parameters as regards impacts of parasitism at the population level. The timing and duration of a host species' breeding season are important determinants of parasitism rate. Cowbirds begin to breed later than some of their major hosts. Because early nests tend to have the greatest potential productivity, early breeding hosts may experience little or no impact at the population level even if late nests suffer high rates of parasitism. However, southwestern willow flycatchers are among the last passerines to breed (Whitfield 2000) and may experience high parasitism levels of their earliest and potentially most productive nests. Willow flycatchers may also sometimes be subject to unusually high rates of parasitism due to the scarcity of other hosts species nesting late in the season. Thus cowbird impacts on willow flycatcher populations are potentially greater than on most host species. Late willow flycatcher nests are likely to escape parasitism completely because the cowbird laying season generally ends in early to mid-July (Stafford and Valentine 1985, Fleischer et al. 1987, Lowther 1993), although exceptional eggs have been laid into early August (Friedmann et al. 1977, p. 47).

As with all host species (Robinson et al. 1995a), parasitism rates on willow flycatchers are highly variable in space and time, both within a breeding season and across years. Even populations separated by only a few km may experience markedly different parasitism rates (Sedgewick and Iko 1999). Table 2 lists parasitism rates (for samples of 10 or more nests), in the absence of cowbird control, for populations from throughout the range of the southwestern willow flycatcher. Note that parasitism ranges from 29% to 66% for California sites, and from 3% to 48% for Arizona sites. Parasitism has the greatest impact on willow flycatchers in California because the largest population in that state consistently experienced rates of at least 50% in the absence of cowbird control. By contrast, the largest populations in Arizona (San Pedro River, Roosevelt Lake) and New Mexico (Gila River) have experienced mean yearly rates of 3% to 18% (Table 2).

Because of the large range in parasitism rates of the southwestern willow flycatcher, baseline nesting studies need to be done on each population to determine whether cowbird parasitism is a serious problem (Whitfield and Sogge 1999). Some populations that incur parasitism may be doing well even without management efforts directed at cowbirds. For example, the largest southwestern willow flycatcher population, in the Cliff-Gila Valley of NM, appeared to grow from 1997-1999 (Stoleson and Finch 1999; S. H. Stoleson pers. comm.) despite parasitism rates of 11% in 1997, 27% in 1998 and 16% in 1999. This population declined from 1999 to 2000 and was stable from 2000 to 2001. The parasitism rates in 2000 and 2001 were within the range seen in earlier years.

Table 2. Geographic variation in cowbird parasitism rates (in the absence of cowbird control) of southwestern willow flycatchers from different regions. Data are from Whitfield and Sogge (1999) unless noted otherwise.

Locality	Years covered	No. nests	Mean annual parasitism rate
South Fork Kern R., CA	87, 89-92	163	66%
Santa Ynez R., CA[1]	95-97	17	29%[1]
Virgin R. delta, NV	97	14	21%
Grand Canyon, AZ	82-86, 92-96	25	48%
White Mtns., AZ	93-96	36	19%
San Pedro R., AZ	95-96	61	3%
Roosevelt Lake, AZ	95-96	17	18%
Verde R., AZ	96	13	46%
Verde R., AZ[2]	98	16	38%
Gila R., NM	95,97	49	18%
Gila R., NM[3]	97-99	>129[3]	18%[3]
various sites, NM	95	10	40%

[1] Data from Farmer (1999b). Parasitism rate is an overall one, not a mean for years covered.
[2] Data from Paradzick et al. (1999).
[3] Data from Stoleson and Finch (1999) and Stoleson (pers. comm.). There were 129 nests in 1997-98 and sample size for 1999 nests was not available, hence number of nests is given as > 129.

Given the temporal variability in the frequency of cowbird parasitism (Sedgewick and Iko 1999; Whitfield and Sogge 1999), baseline studies to assess degree of risk due to cowbirds should usually include at least two and preferably more years of data collection before cowbird management is considered. However, a first year of data collection showing a rate of parasitism of >30% may alone warrant cowbird management if based on a reliable sample size free of temporal and spatial biases (see Management Recommendations, below). In addition, field workers can remove cowbird eggs from accessible parasitized nests (or addle them) during baseline studies to lessen the impacts of parasitism if there is concern about the persistence of a parasitized population. This sort of manipulation of parasitized nests has proven effective with another endangered cowbird host (Kus 1999), and is discussed in more detail below.

In reporting data on parasitism rates, workers should always include sample sizes if the intent is to represent region-wide impacts, i.e., the number of nests sampled and not just parasitism rates. Because of sampling error, parasitism rates based on small numbers of nests may have little statistical validity when it comes to assessing overall cowbird impacts, i.e., statements that parasitism can reach 100% may mean little if the 100% rate is based on a small sample. Baseline data on parasitism rates need to control for spatial and temporal variation in parasitism rates. For example, a sample composed of only early or late nests or of only nests from the periphery of a large habitat patch may not reflect overall parasitism rates. In addition, small populations may experience especially high parasitism rates that are not representative of larger ones (see below). However, if a small population is consistently parasitized heavily and if it has enough suitable habitat to allow significant growth, it may still be a good candidate for cowbird management, as discussed below under Management Recommendations.

6. Recent Changes That May Be Responsible For Possible Increases In Cowbird Impacts

The cowbird is a native North American bird with widespread fossils from California, Florida, Virginia, New Mexico and Texas dating from 10,000 to 500,000 years before the present (Lowther 1993). Data on DNA sequence divergence indicate that cowbirds have been in North America for at least 800,000 years (Rothstein et al. 2000). Because cowbirds represent an ancient component of the North American fauna, at least as regards ecological time scales, their impacts are unlikely to endanger host species in the absence of major ecological changes. One such change is a loss or deterioration of breeding habitat, something that is well recognized as the major cause of the southwestern willow flycatcher's decline (Unitt 1987, U. S. Fish and Wildlife Service 1995) and of the declines of other endangered host species that are impacted by cowbirds (Rothstein and Cook 2000). Another possible ecological change that could perturb stable cowbird-host interactions is an increase in the abundance and distribution of cowbirds, which could cause a previously parasitized and stable host population to decline. Host populations that have only begun to experience parasitism due to documented cowbird range extensions in the last century might be especially likely to decline because they could lack evolved host defenses present in conspecific populations with long histories of parasitism. Given these considerations, trends in cowbird numbers and range extensions are important issues.

The first available historical records show the presence of cowbirds throughout the Southwest as far west as the Colorado River in the mid 1800s (Rothstein 1994b). These were members of the dwarf race of the cowbird, *M. a. obscurus.* The much larger Nevada race, *M. a. artemisiae,* occurred to the north of the southwestern willow flycatcher's range in California, Oregon and Washington on the eastern slopes of the Sierra Nevada and Cascades mountain ranges and east to the northern Great Plains (Friedmann 1929, Rothstein 1994b). Dwarf cowbirds colonized southern California and all of the area west of the Sierra and Cascades since 1900. Thus parasitism is a new pressure only for southwestern willow flycatchers breeding in southern California.

However, cowbirds might be more common and more widespread today than under original conditions, even within their historical range. An analysis of parasitism rates of southwestern willow flycatchers showed large increases in data for California and Arizona combined (Whitfield and Sogge 1999). However, more analyses are needed to determine whether cowbird impacts have increased in the original contact zone in Arizona because the increasing trend in the lumped data for both states may have been driven by the cowbird's increase in California. Some early pre-1920s visitors to the cowbird's original range in the Southwest reported that cowbirds were uncommon, while others reported them to be common in habitats used by southwestern willow flycatchers (Whitfield and Sogge 1999).

In contrast to the uncertainty concerning cowbird population trends over the last century, data from the Breeding Bird Survey (BBS) provide more reliable indicators of recent population trends. Averaged across North America, cowbirds have shown a significant decline of 1.1% per year since the inception of the Survey in 1966 (Sauer et al. 1997). Among 21 states and Canadian provinces with statistically significant ($P < 0.05$) increasing or decreasing cowbird numbers, 19 show declines and two increases. Fish and Wildlife Service Regions 2-5 show significant yearly declines of 0.7 to 2.7%. Region 1 shows a yearly decline of 1.6%, which is not quite significant ($P = 0.06$). Only Region 6 shows an increasing trend, 0.2% per year, but this trend is not close to significance ($P = 0.49$). Focusing on the states that contain the largest numbers of southwestern willow flycatchers, cowbirds have shown moderate declines in Arizona and California and a moderate increase in New Mexico (all trends nonsignificant statistically). These data refer to the entire period over which the BBS has been carried out. If data are partitioned by time, and states or provinces with positive or negative trends are tallied (regardless of whether trends for individual states/provinces are significant statistically), 25 of 51 states/provinces had negative trends from 1966-79 versus 37 of 52 from 1980-96. Significantly more states and provinces had decreasing cowbird numbers in the more recent period than in the first period ($X^2 = 5.26$, df = 1, $P = 0.02$). Thus cowbird numbers appear to have gone from no overall trend from 1966-79 to a mostly declining trend from 1980-96. Most recent BBS data for 1997 to 1999 show stable cowbird numbers in Arizona, California and New Mexico for these years. These various data are contrary to the widespread belief (Brittingham and Temple 1983, Terborgh 1989) that cowbirds are increasing over much of their range.

It is worth keeping in mind that even if cowbirds have not increased in recent years or since the 1800s (except in California), willow flycatchers and other riparian species have decreased, so increasing cowbird to host ratios may have resulted in escalated rates of parasitism even in areas of old sympatry between cowbirds and southwestern willow flycatchers. The potential phenomenon of increased cowbird impacts in the absence of increased cowbird numbers may be especially likely in riparian habitats because cowbirds show a distinct preference for riparian habitats in the West (Farmer 1999a, Tewksbury et al. 1999). This preference, along with the massive loss of riparian habitat in the southwestern willow flycatcher's range may mean that the numbers of cowbirds that use riparian habitat may be similar to those that prevailed years ago but that those cowbirds are now highly concentrated into the small remnants of remaining habitat, with consequent large increases in parasitism rates.

7. Can Southwestern Willow Flycatcher Populations Survive In The Presence of Cowbird Parasitism?

It is clear that most southwestern willow flycatcher populations are viable even when exposed to cowbird parasitism, at least under primeval conditions, because cowbirds and southwestern willow flycatchers have long been sympatric over most of the latter's range. Cowbird parasitism is a new pressure only for southwestern willow flycatchers in southern California. These latter populations might not be viable in the presence of cowbirds, regardless of environmental conditions, because they lack evolved defenses against cowbirds, as proposed for the least Bell's vireo, *Vireo bellii pusillus* (U. S. Fish and Wildlife Service 1998). However, the willow flycatcher's only evident defense against parasitism, renesting, is as frequent in southern California populations as in populations further east with longer histories of parasitism (Table 1). Because the latter willow flycatcher populations have coexisted with cowbirds, it is likely that newly exposed populations can also do so, unless they are experiencing a marginal existence even in the absence of parasitism.

Given what is known about rates of subspecific differentiation (Avise and Walker 1998) in birds, southwestern willow flycatchers have probably been undergoing genetic divergence and been at least partially isolated spatially from other willow flycatcher races for more than 200,000 years. Except for the last 10-20,000 years of this period, various species of bison, horses and other ungulates likely to serve as cowbird foraging associates have occurred throughout the range of the willow flycatcher, including southern California (Pielou 1991, Stock 1992). It is unlikely that the southwestern willow flycatcher had precisely the same range in the past as it does today but the ubiquitousness of large ungulates throughout North America (Pielou 1991), leaves little doubt that they and cowbirds occurred everywhere or most places willow flycatchers occurred. Thus it is likely that all southwestern willow flycatcher populations are descended from populations that experienced past episodes of cowbird parasitism and therefore selection for host defenses. The occurrence of high nest desertion tendencies in California willow flycatchers is likely due to retention of host defenses that evolved in ancestral populations that experienced cowbird parasitism, although gene flow from other parts of the flycatcher's range may also be a factor.

The occurrence and long term retention of high nest desertion tendencies in unparasitized populations is characteristic of North American hosts that use habitats similar to those used by cowbirds, namely woodland edges and fields rather than forest interior. Indeed, the degree of habitat overlap with cowbirds is a better predictor of desertion tendency than is current or recent degree of geographic overlap with cowbirds over historical time scales (Hosoi and Rothstein 2000). Another endangered riparian host, and one whose entire range has been occupied by cowbirds in this century is the Least Bell's Vireo. Kus (1999) reported that it deserted 29% of 205 parasitized nests, contrary to the widespread belief (U. S. Fish and Wildlife Service 1998) that it lacks defenses against parasitism. A study of Bell's Vireos in Missouri where the species has experienced cowbird parasitism since pre-Columbian times reported desertion at 59% of 66 parasitized nests (M. Ryan pers. comm.). It is unclear whether these different desertion rates reflect intrinsic differences in the California and Missouri vireo populations or differences in research techniques. Observed incidences of desertion are inversely proportional to the interval between nest checks (Pease and Grzybowski 1995) and nests were checked weekly in the California study but daily in the Missouri one.

Thus given adequate habitat and an absence of unusually severe demographic impacts such as high levels of nest predation and low levels of juvenile and adult survival, it is possible that all populations of these obligate riparian hosts, even ones newly sympatric with cowbirds, can remain viable if exposed to cowbirds. A demographic analysis of the southwestern willow flycatcher population along the Kern River, which is among the largest populations in California, indicates that this population can not grow unless parasitism is about 10% or less (Ueyahara et al. 2000). If a population cannot sustain itself in the presence of a 10% or less loss in recruitment, it must be a marginal one for reasons unrelated to cowbird parasitism. This same population was able to remain stable and possibly even grow from 1982-89 (Whitfield 1999) despite a 68% parasitism rate in 1987 (Harris 1991), the one year this rate was determined. Thus some critical variable, probably a decreaase in egg hatchability (Whitfield 2002), has changed in recent years. In short, data from extant populations and inferences based on the Pleistocene history of North America, indicate that all southwestern willow flycatcher populations can co-exist with cowbirds unless they also experience some new pressure such as severe habitat losses.

8. Does Cowbird Parasitism Necessitate Management Actions?

As described above, cowbird parasitism per se does not necessarily warrant management action. Parasitism is a naturally occurring process and may have no effect on the size of host breeding populations, even if it causes major reductions in host breeding success. But parasitism can push a host population or even an entire host species or subspecies to extinction under certain conditions. Furthermore, even if a local parasitized host breeding population is stable, parasitism may reduce the number of excess host individuals that might become floaters available to replace breeders lost to mortality or that might disperse and sustain other populations or initiate new populations. Nevertheless, there is no need to always attempt to reduce cowbird parasitism whenever it occurs. Cowbirds are native birds and as such are as important to biodiversity as are endangered species. They may even affect overall avifaunas in complex and unexpected ways, by for example limiting the numbers of some common species and thereby allowing the persistence of other species that might be out-competed by these species. Thus cowbirds could serve as keystone species (Simberloff 1998) just as do some predators that enhance biodiversity by reducing the numbers of certain prey species that would otherwise out-compete and cause the extinction of less competitive species.

Nevertheless, there are certainly some circumstances in which it is prudent to employ management actions designed to deter cowbird parasitism. The circumstances that should trigger cowbird management may differ from site to site because a number of potential site-specific factors are involved, including a host population's current size, its recent population trend, its parasitism rate, the amount of suitable habitat and the extent of the losses attributable to cowbird parasitism. These and other factors are discussed in greater detail below but management actions are constrained by what is possible to achieve. So first we review the range of management actions that may be available.

9. Potential Management Approaches

1. Landscape-Level Management

Cowbird distribution and abundance might be reduced to some extent by landscape-wide measures aimed at reducing anthropogenic influences that benefit this species. Cowbirds typically feed in areas with short grass (Friedmann 1929, Morris and Thompson 1998) and in the presence of ungulates such as bison and domesticated livestock. Besides livestock, cowbird feeding is often associated with other anthropogenic influences such as campgrounds, suburban areas with lawns and bird feeders and golf courses. It is unclear whether cowbirds always require anthropogenic food sources or native ungulates (Goguen and Mathews 1999). But the extent to which they associate with anthropogenic food sources depends on local landscapes. In the Eastern Sierra of California where most of the habitat is forests, sagebrush or arid, sparsely vegetated meadows, cowbird foraging is nearly always linked to human influences such as bird feeders, campgrounds, range cattle and pack stations (Rothstein et al. 1980, 1984; Airola 1986). A similar link with anthropogenic influences, has been found in other forested regions in the western (Tewksbury et al. 1999) and eastern U. S. (Coker and Capen 1995, Gates and Evans 1998). Cowbirds probably require anthropogenic food sources in these regions. But human influences and possibly even native ungulates are less essential for cowbirds in areas where mesic grasslands occur naturally, such as the Great Plains.

An essential factor in attempts to limit cowbird numbers on landscape scales is the cowbird’s commuting behavior (Rothstein et al. 1984). In most regions, cowbirds spend the morning in areas such as forest edges or riparian strips that have large numbers of hosts. Their major actives in these habitats are related to breeding (e.g., egg laying, searching for nests, courtship and intrasexual aggression) but not feeding and birds occur singly or in small groups of up to several individuals. If these morning breeding areas are adjacent to or intermixed with good foraging habitat, cowbirds may spend their entire day in the same vicinity (Elliott 1980, Rothstein et al. 1986). But optimal feeding and breeding habitat are usually spatially separated and cowbirds typically leave their morning-breeding ranges by late morning to early afternoon and commute to feeding sites (Rothstein et al. 1984, Thompson 1994, Ahlers. and Tisdale 1999a), where large groups of several dozen birds may feed on concentrated food sources.

Several studies showed that the maximum commuting distance between morning/breeding and afternoon/feeding sites was 7 km (Rothstein et al. 1984, Thompson 1994, Gates and Evans 1998, Ahlers. and Tisdale 1999a), thereby implying that anthropogenic opportunities for cowbird feeding need to be at least 7 km from habitat critical of endangered hosts. However, a recent study in northeast New Mexico (Curson et al. 2000) has shown that a small proportion of female cowbirds have daily commutes of 14 km or more each way. Given the pervasiveness of human influence and these large distances over which cowbirds are known to fly between feeding and breeding areas, there may be few areas of North America where landscape-level management measures can completely eliminate local cowbird populations. Rather than complete elimination, cowbird abundance may at least be reduced by landscape-level actions because abundance has been shown to decline with increasing distance from anthropogenic food sources over distances as short as 2-4 km (Verner and Rothstein 1988, Tewksbury et al. 1999, Curson et al. 2000). Candidates for such areas are large expanses of desert or forested habitat with no human influences. Cowbirds may be adept at exploiting feeding opportunities even in regions where such opportunities are not evident to observers. An attempt to produce a region-wide decline in cowbird abundance in the heavily forested western Sierra Nevada by removing all cowbirds from horse corrals that attracted large numbers of birds had at best limited success because cowbirds also fed in small groups at other sites (Rothstein et al. 1987).

Effective landscape-level measures may be costly and time consuming given the likely economic impacts to agricultural and other interests that will occur if activities and facilities such as grazing and golf courses are curtailed. Furthermore, landscape-level measures may have only limited success in reducing parasitism rates. Therefore, although land managers should have long range goals that address landscape-level actions in regions where parasitism is a threat to host populations, effective results may require many years due to resistance from people whose economic and recreational interests are likely to be impacted. These long periods needed to produce benefits may not be acceptable for severely endangered hosts whose populations are strongly impacted by cowbirds and that need quick amelioration of cowbird impacts.

We know of only one landscape-level management action that seems to have been highly effective. Removing cattle from large areas of Fort Hood, Texas resulted in substantial reductions in cowbird numbers (Cook et al. 1998, Kolosar and Horne 2000). However, this was in a larger landscape setting in which cowbirds on adjacent areas with livestock or other foraging opportunities were controlled by extensive trapping and shooting (Eckrich et al. 1999). So removal of cattle might have been less effective if cowbirds had been present in normal numbers in surrounding areas thereby creating social pressures for individuals to disperse into the less desirable areas with no livestock.

2. Habitat alterations

Recent studies have indicated that the structure of riparian vegetation influences rates of cowbird parasitism or cowbird numbers. Parasitism rates and cowbird densities usually decline with increases in the density of vegetation (Larison et al. 1998, Averill-Murray et al. 1999, Farmer 1999a,b; Spautz 1999, Staab and Morrison 1999, Uyehara and Whitfield 2000), probably because nests are more difficult to find in dense vegetation. This relationship with vegetation density, which is not necessarily a universal result in cowbird studies (see Barber and Martin 1997), raises the possibility that cowbird parasitism might be reduced by measures that result in denser riparian vegetation, such as increased water flows (see Appendix I). However, as with landscape level management measures, attempts to increase the quality of riparian habitat may require periods of several years or longer for successful results. Given that habitat loss or degradation is probably the ultimate cause of the problems all endangered hosts face (Rothstein and Cook 2000), managers should vigorously pursue efforts to augment habitat. But endangered hosts severely impacted by parasitism may require actions that produce benefits more quickly.

3. Inhibition of cowbird breeding

A nonlethal method of limiting or eliminating cowbird impacts on hosts might be to inhibit their breeding. Yoder et al. (1998) reviewed the literature on avian contraceptives. They report that several compounds can be delivered via baited food and therefore might be administered to large numbers of birds. But these all have various problems. Some compounds are environmental hazards. Others keep eggs from hatching but allow breeding and would therefore not avoid host loses due to adult female cowbirds. The most promising compound, DiazaCon prevents egg laying and also inhibits fertility in males but must be administered over a 7-14 day period with available modes of delivery. Currently, there is no feasible method of inhibiting breeding of a large proportion of a local cowbird population but this approach is worthy of additional research.

4. Cowbird control

Although altering local landscapes or habitats to reduce cowbird impacts should be long-term management goals, local cowbird populations can often be quickly and easily reduced by intensive trapping efforts. The species is highly social (Rothstein et al. 1986) and is attracted to decoy traps, which can remove most cowbirds from large areas where willow flycatchers and other endangered hosts breed (Eckrich et al. 1999, DeCapita 2000, Griffith and Griffith 2000). These traps are referred to as decoy traps because the vocalizations and even the sight of live decoy cowbirds in the traps, along with food such as millet, attract wild cowbirds (see Dufty 1982, Rothstein et al. 1988, 2000), which then enter through small openings. Trap openings are generally on the tops of the traps and birds walking on the traps enter easily by folding their wings against their bodies and dropping into traps. Escape is difficult because birds cannot fly through the openings and traps are built so as to ensure that no inside perches are near the openings.

In addition to trapping, shooting cowbirds attracted to playback of female calls (Rothstein et al. 2000) can be a valuable supplemental way to reduce cowbird numbers (Eckrich et al. 1999). Removing or addling cowbird eggs from parasitized nests can further reduce host losses (Hall and Rothstein 1999). However, removing or addling cowbird eggs does not recover host egg losses inflicted by adult cowbirds and can not be done at nests too high to be reached. Addling cowbird eggs by shaking them may be preferable to removing cowbird eggs because birds like the willow flycatcher that do not remove cowbird eggs from their nests come to consider cowbird eggs as part of their clutch. Willow flycatchers will even incubate clutches consisting solely of cowbird eggs (M. Sogge pers. comm.). Accordingly, they will desert if the combined volume of eggs is reduced below a certain value by removal of cowbird eggs (Rothstein 1982; Kus 1999). Indeed a close relative of the willow flycatcher, the eastern phoebe (*Sayornis phoebe*) is more likely to desert a nest after cowbird eggs are removed than after its own eggs are removed because the larger cowbird eggs make up more of the combined clutch volume (Rothstein 1986). On the other hand, there may be situations in which a parasitized flycatcher is better off deserting a nest because renesting will allow it to recoup those of its eggs that were lost to damage and removal by female cowbirds. In such cases, it may be best to remove all eggs to induce renesting and to place any viable willow flycatcher eggs in active unparasitized flycatcher nests at a similar stage of incubation. However, there are many factors to consider in such manipulations and few researchers are likely to have the experience necessary to make appropriate decisions. Anyone contemplating such manipulations will need to consult with the Fish and Wildlife Service and obtain permits in addition to those usually needed for study of southwestern willow flycatchers.

Shooting cowbirds and removal/addling of cowbird eggs may be more cost effective and practical than trapping if cowbird and/or local host numbers are low and if experienced personnel are available. These latter measures may also be better options than trapping if an impacted host population is in a remote or rugged area where the set-up and servicing of traps is difficult (Winter and McKelvey 1999). But cowbird trapping is likely to be the most effective management action in most situations.

Cowbird trapping efforts are typically highly successful in reducing parasitism rates. Parasitism is usually reduced from 50% or higher to below 20% and sometimes much less (Table 3). Increases in host reproductive output are well documented for four endangered species (Table 3), although this is on a per nest basis in some cases rather than a per female/season basis. Cowbird trapping was highly successful in boosting southwestern willow flycatcher reproduction along the South Fork of the Kern River. The mean number of young each female fledged per season went from 1.04 before control to 1.88 afterwards (Table 3).

Table 3. Summary of results of major cowbird control programs. Data shown are values for years before--after control.

Host species	Locality	Years	Parasitism rate	Young per female[1]	Nest success[2]	Host increase?[3]
Sw WIFL[4]	California	89-91--94-97	63%--17%	1.04--1.88	23%--43%	No
BCVI[5]	Texas	87-88--91-97	91%--22%	----	9%--40%	Yes
LeBEVI[6]	California	82--84-91	47%--6%	1.33--2.79	----	Yes
KIWA[7]	Michigan	66-71--72-77	70%--6%	0.80--3.11	----	No[7]

[1] Number of young fledged over entire breeding season.

[2] % of nests fledging one or more host young.

[3] Column refers to whether the host showed an increase in breeding population size within 5 years of the initiation of cowbird control.

[4] Southwestern willow flycatcher. Data reported (Whitfield et al. 1999) are for years with no cowbird control (1989-91) and with intensive control (1994-97). Intervening years (92-93) had intermediate levels of control and intermediate values for most parameters.

[5] Black-capped vireo. Data reported (Eckrich et al. 1999; Hayden et al. 2000) are for years with little or no cowbird control (1987-88) and years with extensive and well developed control (1991-97). Even within the latter period, personnel have improved methodology, e.g., parasitism rate ranged from 26-39% in 1991-93 and from 9-23% in 1994-97. Nest success data cover only up to 1994, when it had risen to 56%.

[6] Least Bell's vireo. Data reported (Griffith and Griffith 2000) are for a year (1982) with no cowbird control and for years (1984-91) with extensive and well developed control. Trapping intensified over the latter years, with the parasitism rate close to zero and the young per female 3 or more since 1989.

[7] Kirtland's warbler. Data are from DeCapita (2000). This species began to increase about 18 years after cowbird control began.

Unfortunately, the efficacy of control efforts is difficult to assess in some cases in California and Arizona because baseline data on parasitism rates and host nesting success were not collected before control began (Winter and McKelvey 1999). The latter action deviates from proposed guidelines for cowbird management (U. S. Fish and Wildlife Service 1991, 1992; Robinson et al. 1995a, Whitfield and Sogge 1999, this paper) but might be justified if a local population or an entire metapopulation appears to be in danger of imminent extinction. That is, in some cases, cowbird control may be the only short-term option for increasing willow flycatcher productivity in populations on the edge of extirpation.

Although the productivity of host nests has increased markedly in all cowbird control efforts, cowbird management has a mixed record (Table 3) when it comes to the ultimate measure of success, namely increases in host breeding populations (Rothstein and Cook 2000). The least Bell's vireo and black-capped vireo have generally increased markedly since cowbird control began (Eckrich et al. 1999, Griffith and Griffith 2000), although little attempt has been made in some or all cases to assess the extent to which other management actions, such as improved and expanded habitat, have contributed to the increases. In addition, a key population of the least Bell's vireo (the northernmost in the taxon) declined after cowbird trapping began (Rothstein and Cook 2000), although this is largely attributed to habitat maturation and an associated reduction in suitability (J. Greaves, J. Uyehara pers. comm.). Kirtland's warbler and willow flycatcher populations did not increase in response to cowbird trapping. Trapping may have forestalled further declines in these latter species (DeCapita 2000, Whitfield et al. 1999, 2000) but Rothstein and Cook (2000) argue that the evidence for such effects is far from conclusive. The Kirtland's warbler began to increase dramatically about 18 years after trapping began but only after large amounts of new breeding (DeCapita 2000) and wintering habitat (Haney et al. 1998) became available, although the importance of wintering habitat is in some dispute (Sykes and Clench 1998).

Focusing on the willow flycatcher, cowbird trapping since 1993 has not resulted in population increases in the Kern River Valley. Instead the population has declined from 34 pairs in 1993 to 23 in 1999 and was down to 12 and 11 pairs, respectively, in 2000 and 2001 (Whitfield 2002). A demographic analysis indicates that control needs to be even more intense and that parasitism needs to be reduced from the present 11-19% to < 10% for this population to increase (Uyehara et al. 2000). If this is indeed the case, then other factors affecting this population need to be identified as the population would barely be replacing itself even in the absence of cowbird parasitism. Nor did this demographic model predict the sharp decline in 2000. It is likely that the Kern population has a low rate of nest success relative to other populations of the southwestern willow flycatcher (Stoleson et al. in press). This low rate may relate to recently elevated levels of hatching failure starting in 1997 due to an increased incidence of inviable eggs, 3.0% before 1997 versus 13.1% for 1997 to 2001 (Whitfield and Lynn 2001, Whitfield 2002). However, the population remained stable from 1993 until 1997 when cowbird trapping occurred while hatching rates were at normal levels. Also, as discussed above, the South Fork Kern River population grew or remained stable in the 1980s even though there was no cowbird control then.

Cowbirds have been controlled at Camp Pendleton since 1983 as part of management actions to recover the least Bell's vireo (Griffith and Griffith 2000). Although there was an early report of a modest increase in willow flycatchers as of 1991 (Griffith and Griffith 1994), the population later declined despite intensified cowbird trapping and overall there has been no marked increase in flycatchers as of 2000 after 18 years of cowbird control. It is possible that there may not be sufficient habitat at Pendleton for willow flycatcher population growth but the increase in the riparian obligate Bell’s vireos from 60 to over 800 pairs suggests that there might be at least some unused flycatcher habitat on the base. Because it is designed to protect least Bell's vireos, cowbird trapping at Pendleton ends well before the willow flycatcher breeding season ends so it is possible that the willow flycatcher population there has not been sufficiently protected from parasitism. However, this is unlikely because trapping data show that nearly all cowbirds are removed in the first half of the trapping period, and no parasitism of willow flycatchers has been detected since nest monitoring began in 1999 (Griffith Wildlife Biology 1999, Kus et al. in prep.). Only minimal numbers of cowbirds remain when willow flycatcher breeding begins in June (Griffith and Griffith 2000). As with Camp Pendleton, long-term cowbird trapping to protect least Bell's vireos at another southern California site, the Prado Basin, has not resulted in an increase in the small number of flycatchers (three to seven territories) that breed there (Pike et al. 1997).

Trapping programs to protect flycatchers began in 1996 and 1997in Arizona (Table 4). No baseline data on parasitism rates were collected and local flycatcher habitat was not completely surveyed at some sites before trapping began. These problems, along with subsequent increases in survey area and effort at most sites and increases in suitable habitat at some sites, make it difficult to assess effects of cowbird control. A critical assessment of the efficacy of cowbird control for these Arizona populations can only be done after compensating for changes in survey effort and in habitat area and quality. Unfortunately, available data do not allow such compensations. The best overall assessment of field workers familiar with these populations is that increases at the Roosevelt Lake, Salt River inflow site reflect the effects of increased survey effort and increased habitat but may also be partially attributable to cowbird control. It is worth noting that there may have been population increases at other sites before control began; although it may have already been at dangerously low levels (Table 4).

Table 4. Numbers of southwestern willow flycatcher pairs counted at Arizona sites before and after cowbird control began. Data underlined and in bold denote years with cowbird control. Inferences concerning numerical trends after cowbird control began are complicated by changes in habitat extent and quality, survey intensity and amount of area surveyed (see text). Data are from Arizona Game and Fish Department and White and Best (1999).

SITE AREA	1993	1994	1995	1996	1997	1998	1999	2000	2001
San Pedro River	3	30	26	27	**40**[1]	**38**	**61**[2]	**59**	**67**
Roosevelt Lake, Salt	1	15	9	**18**	**17**[1]	**20**	**52**[2]	**80**	**106**
River inflow	1	7	8	**11**[1]	**18**	**23**	**22**	**25**	**25**
Roosevelt Lake, Tonto									
Creek inflow									
Alpine/Greer	7	10	10	13	**7**	**7**	**5**	**3**	**2**
Alamo Lake	0	0	2	4	6	9	**21**[1]	**20**	**15**
Gila Sites	0	0	0	3	**30**	**46**	**58**	**48**	**40**[3]

[1] **Higher numbers of birds are likely due to increased survey effort not to an actual increase in the population.**

[2] **Higher numbers of birds in these and subsequent years are likely to reflect actual increases in populations due to increases in amount and/or quality of habitat.**

[3] **Cowbird control has occurred at only one of several sites.**

Data from a New Mexico site, San Marcial, along the Rio Grande River show no clear effect of cowbird trapping on flycatcher population size. In the absence of cowbird trapping, this site had six flycatcher nests in 1995 (all data were reported in terms of numbers of nests not pairs). Cowbird control was carried out in 1996, 1997 and 1998 with the following numbers of nests in each year: one, two and two, respectively (Robertson 1997, Ahlers and Tisdale 1998b, 1999b). The small numbers of flycatchers breeding at this site may mean that stochastic effects are overwhelming any benefits derived from cowbird control.

10. Is Cowbird Control A Longtime Or Even Permanent Need?

Even if it results in the growth of a host's breeding population, cowbird control is a stopgap measure (U. S. Fish and Wildlife Service 1995) that must be done for a number of years if a host population is to continue growing, as all studies show that it has either no effect on cowbird numbers in subsequent years (Eckrich et al. 1999, DeCapita 2000, Ahlers and Tisdale 1999, Griffith and Griffith 2000) or too small an effect to negate the need for yearly trapping (Whitfield et al. 1999). Cowbird control efforts are often done with little care to maintaining constant procedures and possibly even with incomplete record keeping from year to year, so long term effects on cowbird populations are hard to judge in some cases. Indeed, the state of Texas encourages landowners to trap cowbirds and does not require trappers to report information on the numbers of cowbirds killed (Texas Parks and Wildlife pamphlet). This is unfortunate because it will be impossible to assess whether such actions have any long-term effects on cowbird numbers and even whether they benefit the targeted host species in the absence of record keeping and suitably designed control programs.

Even though intensive cowbird trapping efforts do not negate the need for trapping in subsequent years, it is possible that trapping may not be needed as a permanent solution to a rare host whose endangerment is due in part to parasitism. If a small host population grows and becomes large as a result of cowbird trapping and possibly other measures, it may experience parasitism rates that are much lower than when it was small. Small host populations may experience high rates of parasitism because they provide few nests for cowbirds to parasitize. But once small host populations have grown, they may experience much lower rates of parasitism because a similar number of cowbird eggs may be dispersed amongst a larger number of nests. These lowered parasitism rates would be similar to the well-known effect that increased numbers of prey have on predators. Just as increased prey numbers may swamp out the per capita risk of nest predation, so too may increased host numbers lower the per capita risk of parasitism. These lower rates of parasitism may have no impact on host population dynamics. Parasitism will not decline if increased numbers of an endangered host result in commensurate increases in cowbird numbers. But given the extent to which some endangered hosts have increased, such as the more than ten-fold increase in Bell’s vireos on Camp Pendleton, it is unlikely that cowbirds would show commensurate increases.

The hypothesis that parasitism rate is inversely proportional to host population size views small host populations as ecological traps that can result in local extinctions due to parasitism. It further views the need for protection from parasitism as essential only until a population becomes large. The hypothesis is compatible with Spautz's (1999) discovery that parasitism rates of common yellowthroats (*Geothlypis trichas*) at sites in the Kern River Valley were inversely proportional to this host's density although other factors may also be involved. The best test of the hypothesis would be achieved by ending trapping, at least temporarily, for host populations that have grown to be large, such as least Bell's vireos at Camp Pendleton or Kirtland's warblers in Michigan and monitoring parasitism rates for two or more years. A temporary cessation of cowbird control would reveal whether parasitism rates are lower than they were with much smaller host populations and whether cowbirds show increases commensurate with those of the targeted host. Although it may be difficult to change current management policies, a temporary halt to cowbird control would be of considerable interest to researchers concerned with basic ecological mechanisms. It could also have high management value because considerable resources would be saved if results show that parasitism rates are so low that yearly cowbird control is no longer necessary.

11. Conclusions Regarding Cowbird Management Methods

In addition to the discussion presented here, Ortega (1998:279) provides a useful discussion of management actions that might lessen cowbird impacts. Management measures such as landscape level alterations in human land use patterns or increases in vegetation density are appealing because they are likely to have long lasting effects on cowbird parasitism and do not involve massive killing of a native songbird. However, we suggest that cowbird trapping seems to be the only viable management measure for most situations involving hosts that are endangered by parasitism. Trapping reduces parasitism levels and does so immediately. Moreover, trapping may need to be carried out for only a limited number of years if it boosts a host’s population size and if increased host numbers alone reduce parasitism rates, as described above.

By contrast, landscape level measures may take years to institute and may be impossible in many to most areas given the extent to which humans have altered North America in ways that benefit cowbirds. Similarly, increased vegetation density takes time to develop and may be difficult to achieve in arid areas of the Southwest where water is scarce and likely to become more scarce given the high rate of human population growth in this region. It is likely that any increases in vegetation will benefit endangered hosts much more by increasing the amount of breeding habitat than by direct effects on levels of parasitism. For further discussion of riparian restoration techniques, see Appendix K.

Here we focus further discussion of cowbird management on trapping programs, although we stress that there is as yet no evidence that cowbird trapping results in increases in the breeding population sizes of southwestern willow flycatchers (as discussed above). We further stress that increases and improvements in host breeding habitat should always accompany cowbird management efforts because habitat is a limiting factor for all endangered species impacted severely by cowbird parasitism (Rothstein and Cook 2000) and cowbird control alone is a stop gap measure (U.S. Fish and Wildlife Service 1995). Similarly, regulators should never be satisfied with mitigation under the Endangered Species Act or other management approaches that involve only cowbird management and no attention to habitat augmentation. And they should give careful scrutiny to long-term management plans or actions that are focused mostly on cowbird trapping, even if the plan gives some attention to improving or increasing a host’s habitat. Nevertheless, if cowbird parasitism is indeed a limiting factor for an endangered species given the amount of currently available habitat, agencies may have to commit to a number of years of cowbird trapping, with the length of the period determined by criteria in Management Recommendations 3 and 6 (below).

Although trapping is likely to be the most efficacious management tool for reducing unacceptably high cowbird impacts, three caveats are necessary. First, it may not be necessary to carry out trapping indefinitely, much less the trapping in “perpetuity” advocated for the least Bell's vireo in its draft recovery plan (U. S. Fish and Wildlife 1998). The putative need for trapping in perpetuity seems to be based on the mistaken belief (above) that least Bell's vireos cannot withstand any level of cowbird parasitism due to a lack of defenses, even though conspecific populations long exposed to parasitism have been able to coexist with cowbirds. In addition, the need for trapping will be reduced or eliminated if enlarged host populations alone result in lowered parasitism rates, as described above. Secondly, although trapping is likely to be the most effective management tool in most situations in which cowbirds threaten the survival of flycatcher populations that are otherwise viable, managers need to be flexible regarding alternative approaches. Some host populations may be in areas that are so remote and far from roads that it may be difficult to use the large decoy traps that are effective for cowbird trapping. In such cases, it may be more cost effective to shoot cowbirds after they are attracted to female chatter calls (Eckrich et al. 1999, Rothstein et al. 2000) and/or to monitor host nests and remove or addle cowbird eggs in nests that are accessible to field workers (Kus 1999, Winter and McKelvey 1999). Similarly, if a host population is very small, it may be most cost effective to monitor all nests even if trapping is feasible. Although nest monitoring and removal or addling of cowbird eggs avoids the major losses incurred by cowbird nestlings, it cannot recover egg losses due to the actions of adult cowbirds. On the other hand, trapping alone may not remove all adult cowbirds and therefore some nests may still be parasitized. Our last caveat is that, even if trapping is eventually shown to be effective in boosting southwestern willow flycatcher population sizes, managers may find it cost effective and biologically effective to leave some small and or remote host populations unprotected and divert the scarce management funds thereby saved to other actions. With these caveats in mind, this document next addresses the potential benefits and downsides of cowbird control (achieved largely by trapping), at least as it is currently conducted.

12. Potential Pros and Cons Of Cowbird Control

Although the list of potential downsides of cowbird control is longer than the list of potential benefits, choosing whether to control cowbirds should not be a matter of tallying up a score. If the first benefit listed below occurs, an increase in an endangered species' breeding population, it alone is likely to outweigh all negative aspects put together and therefore dictate making control efforts a high priority, at least for a number of years. Although it is currently unclear as to whether cowbird control increases southwestern willow flycatcher breeding populations, more definitive data may be available in several years.

As regards the potential positive and negative aspects of cowbird control, it is also worthwhile to recognize that some managers might not agree that each benefit we have listed is in fact a benefit or that each downside is in fact a potentially negative aspect of cowbird control. But we have chosen to list all of these points so that managers can be as well informed as possible regarding the consequences of cowbird control. We also point out that some of the downsides of control are not inherent in the control methods but may or do occur in some circumstances because of the manner in which control is done.

1. Potential Benefits or Positive Aspects of Cowbird Control

a) Cowbird control appears to have resulted in large increases in the populations of least Bell's vireos and black-capped vireos and this might eventually be shown to be true for the southwestern willow flycatcher as well.

b) Cowbird control clearly increases the reproductive output of willow flycatchers and other hosts. Even if the numbers of breeders in a population protected by control do not increase, perhaps because of limited breeding habitat, control may lessen chances of extinction by increasing the numbers of individuals that colonize other habitat patches or that become floaters, i.e., sexually mature birds capable of breeding but kept from doing so by a shortage of habitat.

c) Cowbird control may have stalled a decline in willow flycatcher numbers along the South Fork of the Kern River in the early 1990s and may have forestalled the extinction of the Kirtland's warbler.

d) Cowbird trapping is easy to do, although ease of application should not itself be used as a reason for choosing to trap cowbirds.

e) Cowbird control may benefit other sensitive species in addition to an endangered species that is targeted for management action.

2. Potential Downsides or Negative Aspects of Cowbird Control

a) Control has to be done every year or at least for sustained periods due to the failure of trapping to sufficiently reduce cowbird numbers in subsequent years.

b) Control has yet to result in an increase in a willow flycatcher population, although sufficient data are not yet available for Arizona willow flycatcher populations where trapping began in the last several years.

c) When cowbird trapping is not needed or has minimal benefits, trapping uses money/resources that could be used for management/research efforts that might result in greater benefits for endangered hosts such as the willow flycatcher.

d) Trapping might result in cowbirds developing either learned or genetic resistance to trapping. An unknown number of cowbirds escape from the decoy traps commonly used to catch cowbirds (S. Rothstein pers. obs.) and some cowbirds appear to be reluctant to enter these traps (M. Whitfield pers. obs.). Cowbirds at long-term Sierran study sites eventually learned to associate Potter traps with danger and flew off at the sight of people carrying these traps (S. Rothstein and others, pers. obs.). Trapping exerts potential selection pressures of enormous strength on cowbird populations and the potential problem here is akin to the well-known tendency of pathogens to evolve resistance to antibiotics. Just as antibiotics should be used only when really necessary, cowbird trapping too should only be employed when it is clearly justified.

e) Because it is easy to do and results in easily cited numerical indicators (e.g., numbers of cowbirds killed, increases in willow flycatcher productivity), cowbird control (usually via trapping) can be used by developers, other private interests or governmental agencies to show that endangered species are being aided or that legally mandated mitigation obligations for adverse impacts are being met, even if cowbird trapping results in little or no actual mitigation or host benefits. It is especially unfortunate if cowbird control is used as mitigation under the Endangered Species Act in the absence of baseline data needed to determine the level of cowbird impacts. Control should never be the sole mitigation measure for habitat destruction of an endangered species. If the availability of ocntrol as a mitigation measure in consultations with governmental agencies allows or legitimizes actions that result in habitat loss, a local flycatcher population may suffer greater detriment than if cowbird control had not been considered as a mitigation option (especially if cowbird parasitism was not a major impact).

f) There are ethical and animal care issues related to cowbird control, especially if the need for control has not been adequately justified. Importantly, excessive trapping efforts that are not justified could create challenges to the use of cowbird trapping and thereby jeopardize the potential to use this approach when it is justified.

g) Personnel involved in cowbird trapping efforts may not be researchers and may provide insufficient documentation, although if the latter occurs, the fault lies ultimately with the supervising agency. Another potential personnel problem relates to the fact that cowbird trapping efforts in the West are often contracted out to private consulting firms. Because of profit incentives, some private parties may lobby unduly for continued or expanded trapping efforts and there may be no motivation for contractees to suggest cost saving changes in trapping methods. Even cowbird control done by governmental agencies may have some momentum towards expansion or continuance because stopping control for a year or more might make it difficult to acquire funds if it appears that control needs to be reinstated.

h) Cowbird control is sometimes initiated without sufficient baseline data to assess cowbird impacts which means that there may be no basis for determining whether the action is having beneficial population level effects on hosts. In the absence of any data on effects, there may be little insight as to decisions about ending control and directing resources towards other goals.

i) Cowbird control without sufficient baseline data could retard some components of the overall effort to recover endangered species such as the southwestern willow flycatcher because vital baseline data on such things as parasitism rates needed for population viability analyses (PVA) may not be available (although the increased numbers of young could result in more data on dispersal, an essential element in most PVA models).

j) Cowbird trapping results in the capture of non-target species. For example, there were 8,453 captures of about 1,500 individuals of non-target species during cowbird trapping efforts at the Camp Pendleton Marine Corp Base in 1994 (Griffith and Griffith 1994). Most species do poorly when left in traps and individuals often die within 24 h or less. Even if non-target birds are released promptly, time spent away from their nests may result in reproductive failure.

k) Because cowbird control constitutes human intervention, it is uncertain whether willow flycatchers can be removed from the endangered species list as long as control continues.

l) Cowbird control constitutes active management intervention and might therefore deter attention from other types of intervention, such as actions that reduce the impacts of nest predators. Because nest predation is usually as harmful to willow flycatcher population growth as is cowbird parasitism or more so, we provide a brief discussion of predation and of possible management actions in an appendix to this paper.

13. Recommendations For Cowbird Management

Managers need to be flexible in their approaches and should not adopt the view that cowbird trapping is one of the very first things that should be done as soon as a willow flycatcher population or a population of any endangered species impacted by cowbirds is identified. Similarly, managers should not adopt cowbird trapping just because funding becomes available for a particular site and regulators should not restrict available management funds to cowbird trapping simply because this is an easily executed action. An endangered host may benefit more in the long run by first using funds to monitor interactions between cowbirds and the endangered host because the data collected may show that the funding will be of more benefit if applied to management actions other than cowbird control. Trapping should be instituted only when baseline data justify its use, as indicated below. Lastly, managers should also address other factors that reduce passerine nesting success, such as nest predation (see Appendix to this paper).

More specifically, our recommendations regarding cowbird management are as follows:

1. Increase the amount and quality of riparian habitat.

Regardless of whether cowbird management actions are undertaken, and what form those actions might take, managers should strive for increased amounts of riparian habitat. Consideration of endangered host species across North America shows that a shortage of breeding habitat (or poor habitat quality) is always a major problem or the major problem if cowbird management is contemplated. Although endangered hosts may have large amounts of habitat in some localities, the amount, and often the quality, of habitat summed over a species' range is considerably less than under original conditions in all cases. Increased amounts of high quality habitat and increased patch sizes of such habitat will allow for larger breeding populations of willow flycatcher and other species. These larger populations are likely to experience reduced levels of cowbird parasitism by dispersing cowbird eggs over a larger number of nests. In addition, larger populations are more resistant to extinction for a range of well-known reasons. Due to their relatively larger amounts of interior habitat, large patches of riparian woodland are likely to further reduce cowbird parasitism and nest predation, both of which tend to be concentrated along habitat edges in some regions (Robinson et al. 1995b, Tewksbury et al. 1998, Farmer 1999b). Measures to increase the quantity and quality of riparian habitat are discussed in Appendices G (grazing management), H (exotic species), I (water management), K (habitat restoration), and L (fire management).

2) Initiate cowbird control to protect a particular flycatcher population only after sufficient baseline data show cowbird parasitism to be a significant threat for that population.

Cowbird control to aid local willow flycatcher populations and other rare/endangered hosts should be instituted only after baseline data show parasitism rates to be above a critical level. The need for baseline data is in accord with recovery plans for other endangered southwestern hosts. Recovery plans for the black-capped vireo and golden-cheeked warbler, *Dendroica chrysoparia* (U. S. Fish and Wildlife Service 1991, 1992) recommend at least two years of baseline data to determine whether cowbird control is warranted. If control is instituted, managers should consider it a stop gap action (U. S. Fish and Wildlife Service 1995) and have a long range goal that includes restoring flycatcher populations to conditions that no longer require cowbird control. Robinson et al. (1993, 1995) discuss conditions that should be addressed in a management decision concerning cowbird trapping and Smith (1999) makes explicit recommendations regarding levels of parasitism that should initiate consideration of cowbird management actions. In general, Smith suggests that management should only be considered if parasitism is > 60% for two or more years but lists a number of considerations that dictate raising or lowering this threshold. In particular, he recommends that the critical parasitism level for management considerations be lowered to >50% if a species is listed as threatened as endangered. Given the southwestern willow flycatcher's low numbers, we suggest that cowbird control should be considered if parasitism exceeds 20-30% after collection of two or more years of baseline data. But even our guidelines must be applied with flexibility that gives weight to available data on local populations, i.e. sites need to be treated individually. An important consideration should be current population trends. For example, there has been a decline in the willow flycatcher population at the South Fork Kern River since cowbird control began, despite a reduction in parasitism rates from 65% to 11-20% from 1994-99 (Whitfield et al. 1999, Whitfield unpubl. data). This decline is in accord with demographic evidence indicating that this population cannot sustain itself if parasitism exceeds 10% (Uyehara et al. 2000), so current data clearly warrant a 10% threshold for this population. However, other populations such as at the Cliff-Gila one in New Mexico increased between 1997-1999, despite parasitism rates ranging from 11-27%, and for them parasitism rates of 30% or even higher may not warrant cowbird control. Monitoring nests to collect baseline data needed to determine whether control is needed can be costly but trapping and other control methods are also costly. Moreover, collection of baseline data could easily save funds in the long run if it shows that control is not necessary. Although available resources may make it unrealistic to monitor nests in all small populations, all populations with more than five nests should be monitored. If available funds allow attention only to some small populations, managers should give higher priority for both control and monitoring nests to populations that are not limited by habitat availability. Cowbird eggs should be removed or addled during years when nests are monitored to determine parasitism rates, unless a population is part of an experiment designed to test whether cowbird trapping alters flycatcher population trends. Although a single parasitism rate that triggers the initiation of cowbird control, rather than a range that spans 20-30% (or even more, see above), would make management decisions easier, it wouldn't necessarily make those decisions better. Rather than adhering to the upper or lower end of the suggested range, managers and regulators should make adaptive management decisions that take into account other important factors in addition to parasitism rates. Such factors are a population's current trend (increasing, stable or decreasing), the potential for growth afforded by a population's current and anticipated habitat availability and whether control is the best use of management funds. There are complex scientific issues to assess, and managers and regulators should consider consulting with members of the USFWS Southwestern Willow Flycatcher Technical Recovery Team or other scientists.

3) When a cowbird control program is initiated, define goals that will lead to a successful completion of the program and plan for periodic, 3-5 year, peer reviews to judge the program's efficacy.

If a cowbird control program is begun, the following actions should be codified as part of the control program: a) a program of periodic reviews, every 3-5 years, by scientists who are not involved in the control program but who will assess the program's efficacy (as regards increases in the sizes of willow flycatcher breeding populations); b) a statement of goals that define conditions that will end the control program; c) provisions for a nest monitoring program for at least 3-5 years after control ceases (and at several year intervals after that) to determine whether parasitism rates exceed acceptable levels as defined in Recommendation 2 (see also Recommendation 6); d) a commitment to seek new funding if cowbird control needs to be reinstated after a period without control. Conditions that would result in cessation of control under item b for a particular flycatcher population include, but should not be limited to, removal of the southwestern willow flycatcher from the endangered species list.

4) Because current cowbird control programs have not yet resulted in increased numbers of southwestern willow flycatchers, design overall control programs as experiments that have the potential for critical assessments of the efficacy of this management approach.

Current control programs may have little or no potential to demonstrate that cowbird control affects willow flycatcher population sizes, regardless of the trends that ensue after control is instituted, because multiple factors are being altered, as is usually the case in the management of endangered species. Available evidence from the Kern River flycatcher populations (Whitfield et al. 1999) indicates that cowbird trapping does not result in increases in the breeding populations of southwestern willow flycatchers. Therefore, trapping efforts should be designed in part as experiments that can determine whether cowbird trapping increases willow flycatcher populations. To accomplish this, populations with cowbird control should be compared with a limited number of similar populations that have no cowbird control. Populations with and without control should be chosen so as to be as similar as possible as regards such parameters as size and recent population trends. Such experiments will mean that cowbird control is not instituted in all willow flycatcher populations that appear to need it under the conditions laid out in Recommendation 2. All willow flycatcher populations with no cowbird control should be monitored for parasitism rates and control should be instituted if there is clear evidence that parasitism threatens survival of the population.

5) Cease cowbird trapping at selected southwestern willow flycatcher populations to allow collection of baseline data and to provide populations without cowbird trapping for the balanced experiment (Recommendation 4) designed to test the efficacy of cowbird control.

Cowbird trapping should be stopped at selected willow flycatcher populations to allow collection of baseline data on flycatcher nesting biology (cowbird parasitism rates and other factors affecting flycatcher productivity, such as egg hatchability, nest predation, etc.) and to provide populations without cowbird trapping for the balanced experiment (Recommendation 4) designed to test the efficacy of cowbird control. After collection of at least two years of baseline data, an adaptive management decision should be made as to whether control needs to be reinstated, as defined under Recommendation 2. However, a limited proportion of populations that meet the conditions for control should become part of the no trapping sample for the balanced experimental studies described in Recommendation 4. Such populations should be selected on the basis of the criteria described under Recommendation 4.

6) Determine the need for continued cowbird control once a southwestern willow flycatcher population has grown to be large.

Cowbird control should be stopped after a local willow flycatcher population reaches a large size because the increased numbers of willow flycatchers may experience a level of parasitism, even in the absence of cowbird control, that is much less than the level that occurred when the population was small, as described above. But qualified researchers should monitor such populations to determine whether parasitism rates are at tolerable levels as defined under Recommendation 2. Because we do not at present know the extent of reduction in parasitism rate as the population of an endangered host increases, we can not precisely determine how much increase a population must show before its enlarged size results in a significant reduction in parasitism rates. Instead, we suggest that a population that is at least two or three times as large as it was when conditions justified initiation of cowbird control should be considered for cessation of cowbird control so long as the increased population has an absolute number of pairs equal to or exceeding 25. A two to three fold increase in flycatcher population size could reduce parasitism rates to one half or one third of their pre-cowbird control levels if cowbirds do not show a commensurate increase in numbers and the target of 25 pairs conforms to the recovery plan's goal of ensuring local population sizes at which the likelihood of persistence and dispersal approach asymptotic levels. Even with these guidelines, managers may need to exercise their own judgement or consult with the Technical Recovery Team or other experts, as there are additional complexities to consider. For example, a flycatcher population inhabiting a habitat patch whose current and potential capacity is fewer than 25 pairs might be considered for cessation of trapping if it has reached its carrying capacity.

7) Consult previous accounts of cowbird control programs and develop guidelines, as regards trap design, placement and seasonality, that maximize the effectiveness of cowbird control under local conditions (including actions alternative to, or in addition to, trapping).

Managers need to keep in mind that the goal of cowbird control is to aid impacted host populations, not to maximize the number of cowbirds killed. In fact, benefits to the host population with the minimum number of cowbirds killed should be the goal. Although the number of cowbirds killed can be increased by trapping at cowbird feeding sites and at times other than a host's breeding season, managers need to determine whether these trapping policies provide increased protection for endangered hosts. There is little justification for trapping outside of an endangered host's breeding season if this trapping results in killing of large numbers of migratory cowbirds. Trapping from 1 May to 31 July should provide maximal protection for southwestern willow flycatchers. These dates would initiate trapping two weeks prior to host arrival times, as with guidelines for black-capped vireos (U. S. Fish and Wildlife Service 1991). Whether trapping is best conducted in the breeding habitat of the host, at cowbird feeding sites or both, probably depends on the local landscape. In many landscapes however, trapping in host breeding habitat is likely to be the best strategy as this removes the cowbirds that are putting hosts at risk. In addition to trapping, managers should determine whether significantly increased benefits could be gained by supplementary activities such as shooting cowbirds and removing or addling their eggs from parasitized nests. Because no single control protocol is best for all situations, managers should consult a range of published, peer-reviewed accounts of cowbird control programs (Eckrich et al. 1999, Whitfield et al. 1999, 2000; Winter and McKelvey 1999, DeCapita 2000, Griffith and Griffith 2000) for information on the design, number, placement, and visit schedule for traps and on euthanasia methods plus activities that may supplement trapping.

8) Minimize impacts on non-target species.

Measures must be taken to minimize impacts on non-target species by following appropriate trapping protocols (see references cited under Recommendation 7), e.g., by adjusting the sizes of trap openings to reduce captures of other species and by daily visits so that all non-target birds that are captured are released daily. However, reasonable levels of unavoidable negative impacts on common, non-target species should not deter cowbird trapping if control is well justified. Just as sacrificing cowbirds is an undesirable but unavoidable consequence of trapping programs that benefit endangered hosts, so too should impacts on non-target species be considered undesirable but acceptable if they are an unavoidable consequence of cowbird trapping. However, if large numbers of non-target birds are captured, research should be undertaken to elucidate the impacts on the survival and reproductive success of these other species.

9) Determine whether cowbird management actions other than control, such as removal of cowbird food sources, can result in drastic reductions in cowbird numbers.

Although cowbird control is likely to be the best management tool in most situations in which there are unacceptably high rates of parasitism (as defined under Recommendation 2), managers should determine whether their situation is best dealt with via other approaches. They should determine whether changing certain landscape conditions might allow for rapid and drastic reductions in cowbird numbers by alterations to one or a few key anthropogenic food sources. This may be especially appropriate in remote regions with little human influence. In addition, if a willow flycatcher population is very small or is in a remote area where trapping would be difficult, managers should consider whether it is preferable to shoot cowbirds and/or remove or addle cowbird eggs in parasitized nests.

10) If cowbird control is undertaken, identify and pursue long-term landscape objectives that can reduce cowbird numbers over large areas.

Even if cowbird control is undertaken, a long-term management objective should be a reduction of anthropogenic influences that provide foraging opportunities for cowbirds so as to reduce cowbird numbers at landscape levels. These influences include bird feeders and other anthropogenic food sources such as livestock. But there should be no standard distance over which livestock must be excluded from flycatcher populations because the effectiveness of livestock exclusion depends on the availability of other food sources for cowbirds in the local landscape, as described above. Indeed, in some landscapes there are so many potential food sources for cowbirds that the only limits on livestock should be exclusion from riparian habitat to protect the habitat itself. For habitat benefits that can be gained by removing livestock from riparian zones see Krueper (1993). Furthermore, livestock grazing, even in uplands, in landscapes containing flycatchers should be at levels that avoid overgrazing, as discussed in Appendix G (grazing management).

11) If cowbird control is undertaken, identify and pursue habitat enhancement actions that reduce levels of cowbird parasitism.

Even if cowbird control is undertaken, a long-term management objective should be reducing parasitism rates by measures that increase vegetation density or alter vegetation in other ways likely to reduce parasitism. Increases in the size and width of riparian habitat patches may also reduce parasitism levels.

12) Initiate programs of public education to inform people about measures that can reduce cowbird numbers and about the justification for controlling cowbirds.

Managers should inform the public that certain activities enhance cowbird abundance. Individuals should be encouraged to suspend bird feeding activities or use bird feeds that are not preferred by cowbirds (such as sunflower seeds as opposed to millet) during the passerine breeding season. Operators of feedlots, pack stations and similar facilities housing livestock should be encouraged to maintain clean conditions that minimize the amount of livestock feed (such as hay and grain) and manure that is available to foraging birds. Certain types of feed may be relatively unattractive to cowbirds. For example, cowbirds appear to show reduced interest in cubed or pelleted hay. If cowbird control is undertaken and people complain that it is wrong to kill one native bird to help another, managers should explain that cowbird control is viewed as a short term management tool necessitated by increased rates of parasitism and/or drastically reduced host populations that are threatened by loss of reproductive potential. Managers should explain that action against one native bird to aid another reflects no value judgement as to the worth of one species over another but instead reflects the need the need to maintain current levels of biodiversity.

N. Literature Cited

Please see Recovery Section VI.

APPENDIX: The Importance of Nest Predation and Potential Management Actions

If cowbird control is indicated by available data, managers should keep in mind that low rates of reproductive success are the basic problem and that factors besides cowbird parasitism, in particular nest predation, may need to be addressed. Predation has a greater effect on nest success than parasitism in many situations, depending on host species and habitat type (Best and Stauffer 1980, Schmidt and Whelan 1999, Woodworth 1999, Grzybowski and Pease 2000). Sedgwick and Iko (1999) determined that nest predation reduced the lifetime reproductive output of willow flycatchers of the race *E. t. adastus*, by 0.70 fledglings per female whereas the overall 23% parasitism rate in their long term study resulted in a reduction of 0.37 fledglings. Some populations of forest nesting host species, especially those in small to moderate sized midwestern forest patches, experience such high rates of nest predation that even complete elimination of parasitism might not be sufficient to make these populations self-sustaining (Rothstein and Robinson 1994, Donovan et al. 1995, 1997; Robinson et al. 1995a,b).

As with all open-cup nesting passerines (Martin 1993, Grzybowski and Pease 2000), nest predation reduces southwestern willow flycatcher breeding success to a significant degree. Paradzick et al. (1999) found that kingsnakes (*Lampropeltis getulus*) victimized two of four flycatcher nests and three of five nests of other riparian passerines that were monitored with video cameras in Arizona. A spotted skunk (*Spilogale gracilis*) depredated one nest of another species. In a long-term study of the South Fork Kern River population of southwestern willow flycatchers in California (Whitfield et al. 1999), predation has been responsible for the loss each year of an average of 40% of all nests, (range 28-57% for five years), even with cowbird trapping. Similarly, predation caused the failure of 37% of 110 nests in 1997-98 in the New Mexico flycatcher population in the Cliff-Gila Valley (Stoleson and Finch 1999). Although these predation rates are not especially high for passerines (Grzybowski and Pease 2000), they are a major burden for an endangered species.

There may be some means of reducing nest predation. For example, chemical repellants might deter nest predators that rely on olfaction, such as snakes and mammals. Cones or collars of smooth plastic or sheet metal or sticky tape (duct tape with the adhesive side facing outwards) placed on the trunks of nest-trees and adjacent tress may sometimes keep snakes and small mammals from reaching nests. Barriers of smooth plastic or sheet metal placed on the ground around trees may keep snakes and small mammals from accessing tree trunks. It may also be possible to make habitat patches less attractive to predators. Although such measures are unlikely to reduce predation by amounts comparable to the reduction in parasitism achieved by cowbird trapping, more research is needed. Furthermore, the uncertain extent to which nest predation can be reduced should not deter managers and researchers from attempts to address losses due to predation. We will never have effective means of dealing with nest predation if managers make no attempts to lessen it, which has been the case so far in all recovery efforts for endangered cowbird hosts. If actions are taken to deter predation, nests will have to be monitored and this means that cowbird eggs can be removed or addled at nests that are accessible, thereby also providing protection against some or most of the costs of parasitism.

Given the lack of highly effective means of predator deterrence and the relative ease with which cowbird parasitism can be reduced, it is unlikely that there will be situations in which this approach should be done instead of cowbird control but managers might give predator deterrence and cowbird control high priority in certain circumstances. Such circumstances might be habitat patches that are just beginning to be colonized or populations that occupy vital spatial positions as defined by population viability analysis. As we have done for southwestern willow flycatchers, recovery efforts for black-capped vireos and golden-cheeked warblers also noted the importance of predation and amelioration of this pressure as a potential management action (U. S. Fish and Wildlife Service 1991, 1992).

If attempts are made to lessen nest predation, managers should focus attention deterring predation of flycatcher nests not on complete predator control or removal, as the latter actions could have ramifications throughout an ecosystem. Any attempts to remove or kill off predators should be done only after in depth consideration of the sorts of issues raised in our list of the downsides of cowbird control, such as ethical considerations and the need for sustained year to year intervention. A similar cautionary note about predator control has been proposed for black-capped vireo recovery efforts (U. S. Fish and Wildlife Service 1991). However, it might be worthwhile to remove individual predators that appear to specialize on flycatcher nests. We note that as with cowbird removal, predator removal consistently boosts avian reproductive output but often does not increase the numbers of breeding birds (Cote and Sutherland 1997).