U.S. Fish & Wildlife Service

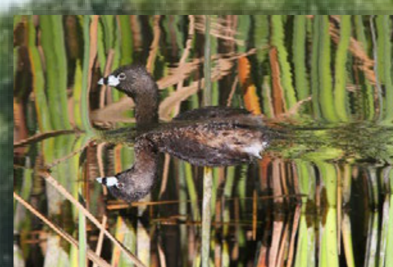
San Luis National Wildlife Refuge Complex

Draft Comprehensive Conservation Plan and Environmental Assessment

Merced National Wildlife Refuge
San Luis National Wildlife Refuge
Grasslands Wildlife Management Area

September, 2023






Disclaimer

Comprehensive Conservation Plans provide long-term guidance for management decisions and set forth goals, objectives and strategies needed to accomplish refuge purposes and identify the U.S. Fish and Wildlife Service's best estimate of future needs. These plans detail program planning levels that are sometimes substantially above current budget allocations and, as such, are primarily for the U.S. Fish and Wildlife Service's strategic planning and program prioritization purposes. The plans do not constitute a commitment for staffing increases, operational and maintenance increases or funding for future land acquisitions.

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Grasslands Wildlife Management Area

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Implementation of the Comprehensive Conservation Plan and alternative management actions/programs have been assessed consistent with the requirements of the *National Environmental Policy Act* (42 USC 4321 et seq.)

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Abbreviations and Acronyms

Refuge Improvement Act	National Wildlife Refuge Improvement Act of 1997
NWRS/Refuge System	National Wildlife Refuge System
USFWS/the Service	U.S. Fish and Wildlife Service
the Complex	San Luis National Wildlife Refuge Complex
AAR	After Action Review
ADA	Americans with Disabilities Act
AF	acre-feet
ATV	all-terrain vehicle
BMP	best management practices
Cal Trans	California Department of Transportation
CA	California
CAA	Cooperative Agricultural Agreements
CAL FIRE	California Department of Forestry and Fire Protection
CARB	California Air Resources Board
CCP	Comprehensive Conservation Plan
CDFA	California Department of Food and Agriculture
CDFW	California Department of Fish and Wildlife (previously CDFG)
CFR	Code of Federal Regulations
Cfs	Cubic foot per second
CLMA	Cooperative Land Management Agreements
CMP	Cooperative Management Plan
CO2	carbon dioxide
CPR	cardiopulmonary resuscitation
CSU	California State University
CVJV	Central Valley Joint Venture
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CWD	Chronic Wasting Disease
CY	calendar year
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethan
DMBM	Division of Migratory Bird Management
DNA	deoxyribonucleic acid

DOI	U.S. Department of the Interior
DWR	Department of Water Resources
EA	Environmental Assessment
EIS	Environmental Impact Statement
EQUIP	Environmental Quality Incentives Program
FERC	Federal Energy Regulatory Commission
FMO	Fire Management Officer
FMP	Fire Management Plan
FWSM	U.S. Fish and Wildlife Service Manual
GEA	Grasslands Ecological Area or Grasslands
GIS	geographic information system
gpm	gallons per minute
GPS	global positioning system
HDPE	high density polyethylene
HSI	habitat suitability
LIP	Landowner Incentive Program
MAPS	Monitoring Avian Productivity and Survival
MBCF	Migratory Bird Conservation Fund
MID	Merced Irrigation District
MIG	metal inert gas
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NAWCA	North American Wetlands Conservation Act
NEPA	National Environmental Policy Act
NGO	non-governmental organization
NOI	Notice of Intent
NRCS	Natural Resources Conservation Service
NRDC	Natural Resources Defense Council
NWR	National Wildlife Refuge
OSHA	Occupational Safety and Health Administration
PFW	Partners for Fish and Wildlife
PM	particulate matter
PRBO	Point Reyes Bird Observatory
PT	part time
PUP	Pesticide Use Proposal

RAMP	Refuges Adaptive Management Project
RAPP	Refuge Annual Performance Plan
RBR	riparian brush rabbit
RHJV	Riparian Habitat Joint Venture
RLE	regional law enforcement
SJR	San Joaquin River
SJRRP	San Joaquin River Restoration Program
SJVAB	San Joaquin Valley Air Basin
SJVAPCD	San Joaquin Valley Air Pollution Control District
SWRCB	State Water Resources Control Board
SYH	Schoolyard Habitat
TA	technical assistance
TBWG	Tricolored Blackbird Working Group
TMDL	total maximum daily load
UC	University of California
U.S. EPA	U.S. Environmental Protection Agency
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USC	United States Code
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WMA	Wildlife Management Area
YCC	Youth Conservation Corps

Chapter 1: Introduction and Background

This Comprehensive Conservation Plan (CCP) will guide the management of the Merced National Wildlife Refuge (NWR), San Luis NWR and Grasslands Wildlife Management Area (WMA) for the next 15 years. Located in Merced County, California (Figure 1-1), these three units are managed and administered by the San Luis National Wildlife Refuge Complex (the Complex). A fourth unit, the San Joaquin River NWR, is also managed and administered by the Complex but already has a CCP for its management, which was completed in 2006 and amended in 2022. For the sake of this document, the term *Complex* refers to the San Luis NWR, Merced NWR and Grasslands WMA only. The Complex comprises just four of the 568 refuges that currently make up the U.S. Fish and Wildlife Service (USFWS or the Service) National Wildlife Refuge System (NWRS or Refuge System). The mission of the NWRS is to conserve a network of lands and water for the conservation and management of fish, wildlife and plant resources of the United States for the benefit of present and future generations. As part of the Refuge System, the three units—Merced NWR, San Luis NWR and Grasslands WMA—addressed in this CCP provide important habitat for a unique assemblage of both wetland- (particularly waterfowl and other waterbirds) and upland-dependent wildlife species of California's Central Valley.

This CCP is divided into five chapters: Chapter 1, Introduction and Background; Chapter 2, Comprehensive Conservation Planning Process; Chapter 3, Refuge Resources; Chapter 4, Refuge Management Direction; and Chapter 5, Implementation.

San Luis NWR Entrance. Photo: USFWS

Location

The San Luis NWR, Merced NWR and the Grasslands WMA are located in the portion of the San Joaquin Valley referred to as the *Grasslands* (also known as the Grasslands Ecological Area or GEA). The Grasslands area contains more than one-third of the wetlands remaining in the Central Valley and is the largest contiguous block of freshwater wetland habitat in California (see Figures 1-1 and 1-2). These wetlands provide habitat for significant concentrations of wildlife, including geese, cranes, ducks, shorebirds and other waterbirds. The need for the protection and management of these significant wildlife resources is what led to the establishment of these three refuge units by the Service.

The GEA has been designated a Wetlands of International Importance through the Ramsar Convention; fewer than 30 sites in the United States have received this importance designation. The importance of this critical area for waterfowl and other waterbirds has been recognized by the Central Valley Joint Venture (CVJV) and the North American Waterfowl Management Plan. It is considered of international importance for migrating shorebirds and has been designated as an International Shorebird Reserve by the Western Hemispheric Shorebird Reserve Network. In addition, the refuges collectively have been selected as a flagship project for California Riparian Habitat Joint Venture (RHJV). The Merced NWR, San Luis NWR and Grasslands WMA are located within the San Joaquin Valley, which is part of the greater Central Valley. The Central Valley averages 40 miles wide by 400 miles long and consists of two lesser valleys (Sacramento in the north and San Joaquin in the south) and a delta where the two drainages meet.

The San Joaquin Valley is bounded by the Sacramento/San Joaquin Delta to the north, the Tehachapi Mountains to the south, the Sierra Nevada Mountains to the east and the Coast Range to the west. The San Joaquin Valley is divided into two distinct drainage basins: the San Joaquin Basin in the northern two-thirds, where these refuge units are located, and the Tulare Basin in the southern one-third. The San Joaquin River and its tributaries drain the San Joaquin Basin.

California supports more than 60 percent of all waterfowl (excluding sea ducks) wintering in the Pacific Flyway and about 20 percent in the entire United States. California's Central Valley specifically is one of the most significant areas for wintering waterfowl in North America (Fleskes et al. 2018). In fact, 10–12 million waterfowl winter in or pass through the region each year (Gilmer et al. 1982; Fleskes, Skalos, and Farinha 2012).

California wetlands and California waterfowl occur primarily in the Central Valley. Although the Central Valley has been highly altered since settlement (See Chapter 4 for the history of the Complex environment), it still supports nationally important and critical natural resources. During the 1970s, an estimated 10 to 12 million ducks, geese and swans wintered in or migrated through California (Heitmeyer, Connelly, and Pedersen 1989). The Merced NWR, San Luis NWR and Grasslands WMA support significant waterfowl and waterbird resources. These refuge units have the potential to protect and restore many of the unique native upland and wetland habitats of the Central Valley and the wildlife they support.

The refuges are not considered Federal wilderness study areas because they do not meet wilderness designation criteria (see Appendix F).

Figure 1-1. Map of the San Luis NWR, Merced NWR and Grasslands WMA

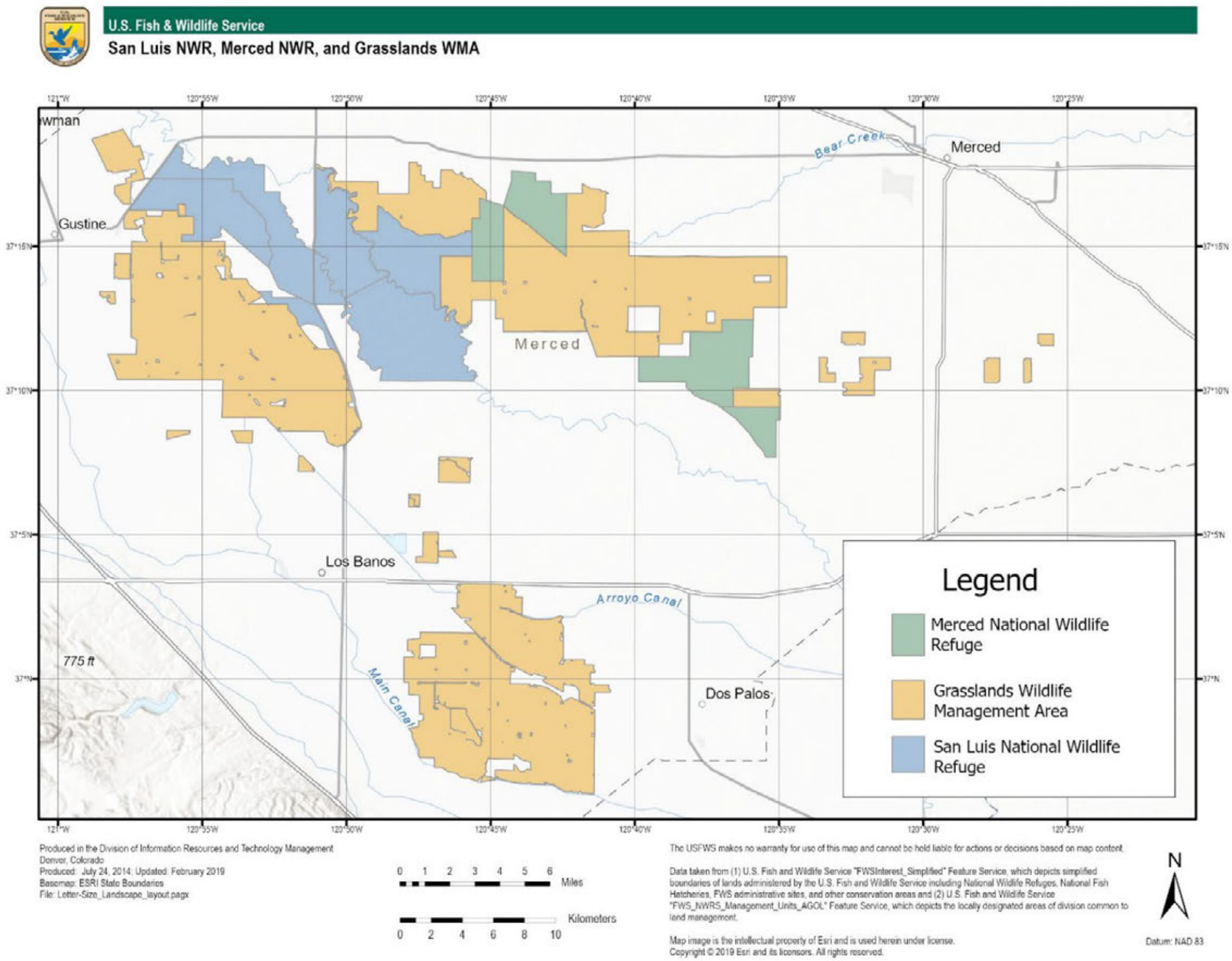
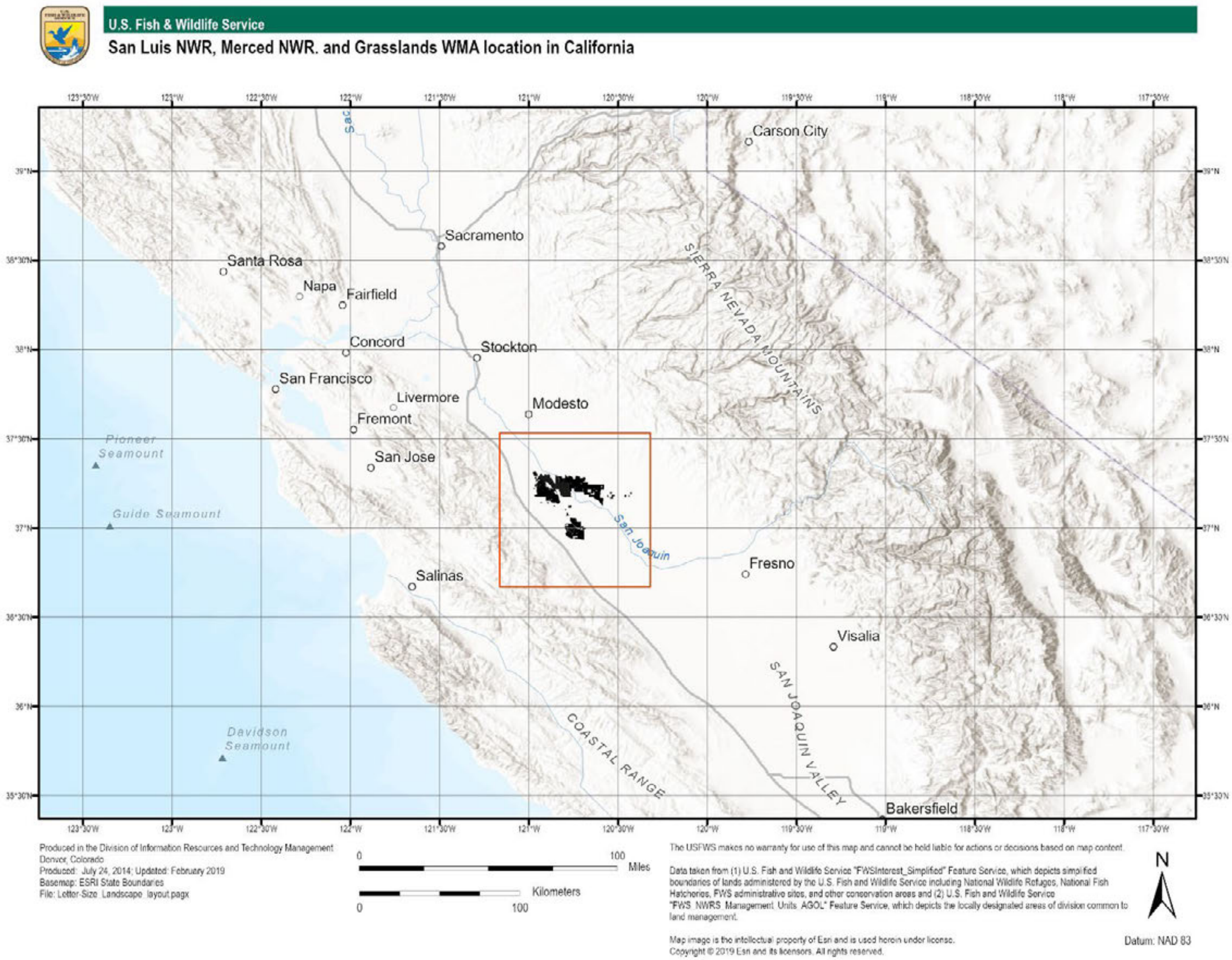


Figure 1-2. Location of the San Luis NWR Complex within California's Central Valley



Purpose and Need for a Plan

The Service develops CCPs to guide the management and resource use for each refuge of the Refuge System. The Refuge System currently includes 568 individual refuges, forming the largest network of public lands in the world managed principally for fish and wildlife.

A CCP provides a description of the desired future conditions and long-range guidance necessary for meeting refuge purposes. The CCP and associated environmental assessment (EA) meet the mandates of the National Wildlife Refuge Improvement Act of 1997 (Refuge Improvement Act) and address Service mandates, policies, goals and appropriate National Environmental Policy Act (NEPA) compliance. The Service's future management plan for the Merced NWR, San Luis NWR and Grasslands WMA are provided in this document. The final plan will be developed based on comments received during public review.

The Complex staff will use this CCP as a management tool for the Merced NWR, San Luis NWR and Grasslands WMA. The CCP will guide management decisions for the next 15 years using the vision, goals and objectives developed during the planning process.

These three units of the Complex currently do not have a comprehensive management plan that provides guidance for managing habitat, wildlife and public use. However, a CCP was developed for the San Joaquin River NWR (which is formally a part of the San Luis NWR Complex) in 2006 and was revised in 2022. The plan sets goals and objectives and provides strategies for achieving them based on specific refuge unit purposes, Federal laws, Refuge System goals and Service policies. Management activities are selected based on their efficacy in fulfilling refuge goals and objectives.

The CCP is comprehensive, as it seeks to address all activities that occur on the refuge; however, the noted management activities or strategies are broadly stated. The refuge staff will prepare detailed step-down plans that tier from the CCP and provide specific and actionable management strategies. San Luis NWR and Merced NWR have developed one step-down plan as a part of the Refuges Adaptive Management Project (RAMP), which includes SMART[1] Objectives for the riparian ecosystem (see Section 3.4).

Step-down plans are adjusted based on monitoring results, available funds, staff and current Service policy. The effects of management actions are monitored to provide information for needed modifications of management practices or activities. Step-down plans will be reviewed periodically to ensure that any goals, objectives, strategies and/or time frames reflect the most up-to-date management actions.

The Service is preparing this plan to:

- Provide a clear vision statement of the desired future conditions when refuge unit purposes and goals have been accomplished.

[1] Specific, Measurable, Achievable, Results-oriented and Time-bound

- Provide a basis for management that is consistent with the Refuge System mission and refuge unit purposes and ensure that the needs of wildlife come first, before other uses.
- Provide a scientific foundation for refuge unit management.
- Provide long-term continuity in refuge unit management.
- Ensure the compatibility of current and future uses of the refuge units.
- Ensure that the management of refuge units is consistent with Federal, state and local plans.
- Provide an opportunity for the public to help shape the future management of the refuge units.
- Provide visitors, partners, neighbors and the general public with a clear understanding of the reasons for management priorities and actions on the refuge units.
- Provide a basis for operation, maintenance and development budget requests.

The U.S. Fish and Wildlife Service

All three refuge units—San Luis NWR, Merced NWR and Grasslands WMA—are managed by the Service as part of the NWRS. The Service is the primary Federal agency responsible for conserving, protecting and enhancing fish and wildlife and their habitats for the continuing benefit of the American people. Although the Service shares this responsibility with other Federal, state, Tribal, local and private entities, the Service has specific responsibilities for migratory birds, threatened and endangered species, anadromous and interjurisdictional fish and certain marine mammals—referred to as Federal Trust Species. The Service also manages the Refuge System and National Fish Hatcheries; enforces Federal wildlife laws and international treaties on importing and exporting wildlife; assists state fish and wildlife programs; and helps other countries develop wildlife conservation programs.

Preschool Class Field Trip. Photo: USFWS

The Service holds its official mission as:

"*Working with others, to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.*"

The National Wildlife Refuge System

In 1903, President Theodore Roosevelt named Florida's Pelican Island the nation's first bird sanctuary, which, along with other sanctuaries and preserves, evolved into the Refuge System. Since that time, the Refuge System has grown to more than 150 million acres. It currently includes 568 refuges, with at least one in every state and in many U.S. territories. The Refuge System is the world's largest collection of lands and waters set aside specifically for wildlife conservation and ecosystem protection. The Refuge System provides important habitat for native plants and many species of mammals, birds, fish and threatened and endangered species.

The mission of the Refuge System, as stated in the Refuge Improvement Act, is:

"*To administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within United States for the benefit of present and future generations of Americans*"
(16 USC 668dd et seq.).

The goals of the Refuge System, as defined in the Refuge System Mission and Goals and Refuge Purposes Policy (601 FW 1 of the Service Manual) are to:

- Conserve a diversity of fish, wildlife and plants and their habitats, including species that are endangered or threatened with becoming endangered.
- Develop and maintain a network of habitats for migratory birds, anadromous and interjurisdictional fish and marine mammal populations that is strategically distributed and carefully managed to meet important life history needs of these species across their ranges.
- Conserve those ecosystems, plant communities, wetlands of national or international significance and landscapes and seascapes that are unique, rare, declining or underrepresented in existing protection efforts.
- Provide and enhance opportunities to participate in compatible wildlife-dependent recreation (hunting, fishing, wildlife observation, photography, environmental education and interpretation).
- Foster understanding and instill appreciation of the diversity and interconnectedness of fish, wildlife, plants and their habitats.

Collectively, these goals articulate the foundation for our stewardship of the Refuge System and define the unique and important niche it occupies among the various Federal land systems. These goals will help guide development of specific management priorities during development of CCPs.

In addition, the guiding principles of the Refuge System are:

- We are land stewards, guided by Aldo Leopold's teaching that land is a community of life and that love and respect for the land are extensions of ethics. We seek to reflect that land ethic in our stewardship and to instill it in others.

- Wild lands and the perpetuation of diverse and abundant wildlife are essential to the quality of the American life.
- We are public servants. We owe our employers, the American people, hard work, integrity, fairness and a voice in the protection of their trust resources.
- Management, ranging from preservation to active manipulation of habitats and populations, is necessary to achieve Refuge System and Service missions.
- Wildlife-dependent uses involving hunting, fishing, wildlife observation, photography, interpretation and education, when compatible, are legitimate and appropriate uses of the Refuge System.
- Partnerships with those who want to help us meet our mission are welcome and indeed essential.
- Employees are our most valuable resource. They are respected and deserve an empowering, mentoring and caring work environment.
- We respect the rights, beliefs and opinions of our neighbors.
- We are a science-based organization. We subscribe to the highest standards of scientific integrity and reflect this commitment in the design, delivery and evaluation of all our work.

Refuge Purposes

Refuge System lands have been acquired under a variety of legislative acts and administrative orders. The legislative acts authorizing the Service to acquire land usually have one or more purposes for which land can be acquired. Each refuge in the Refuge System is managed to fulfill the mission of the NWRS and the specific purposes for which the refuge was established. The acquisition authorities and corresponding purposes for the Merced NWR, San Luis NWR and Grasslands WMA are listed below.

Merced NWR

The purposes for acquiring lands for this refuge include:

"… for the management and control of migratory waterfowl and other wildlife …" 16 USC Sec 695 (Lea Act)

"… for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 USC Sec 715d (Migratory Bird Conservation Act)

"… to conserve (A) fish or wildlife which are listed as endangered species or threatened species … or (B) plants …" 16 USC Sec 1534 (Endangered Species Act of 1973)

San Luis NWR

The purposes for acquiring lands for this refuge include:

"… for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 USC Sec 715d (Migratory Bird Conservation Act)

"…shall be administered by [the Secretary of the Interior] directly or in accordance with cooperative agreements … and in accordance with such rules and regulations for the conservation, maintenance, and management of wildlife, resources thereof, and its habitat thereon, …" 16 USC Sec 664 (Fish and Wildlife Coordination Act)

Grasslands WMA

The purposes for acquiring lands for this management area include:

"… for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 USC Sec 715d (Migratory Bird Conservation Act)

"… the conservation of the wetlands of the Nation in order to maintain the public benefits they provide and to help fulfill international obligations contained in various migratory bird treaties and conventions …" 16 USC Sec 3901(b), 100 Stat. 3583 (Emergency Wetlands Resources Act of 1986)

"… to conserve (A) fish or wildlife which are listed as endangered species or threatened species … or (B) plants …" 16 USC Sec 1534 (Endangered Species Act of 1973)

Merced NWR wetland. Photo: Rick Lewis

Legal and Policy Guidance

National Wildlife Refuges are guided by the purposes of acquiring lands for each individual refuge, mission and goal of the Refuge System and Service policy, laws and international treaties. Relevant guidance includes the National Wildlife Refuge Administration Act of 1966, as amended by the Refuge Improvement Act, Refuge Recreation Act of 1962, selected portions of the Code of Federal Regulations and the Service Manual.

Refuges are also governed by a variety of other laws, treaties and executive orders pertaining to the conservation and protection of natural and cultural resources.

National Wildlife Refuge System Improvement Act

The Refuge Improvement Act, which amends the National Wildlife Refuge System Administration Act of 1966, provides comprehensive legislation on how the Refuge System should be managed and used by the public. The Refuge Improvement Act:

- Identified a new mission statement for the Refuge System.
- Established six priority public uses (hunting, fishing, wildlife observation and photography, environmental education and interpretation).
- Emphasized conservation and enhancement of the quality and diversity of fish and wildlife habitats.
- Stressed the importance of partnerships with Federal and state agencies, Tribes, non-governmental organizations, industry and the general public.
- Mandated public involvement in decisions on the acquisition and management of refuges.
- Required, prior to acquisition of new refuge lands, identification of existing compatible wildlife-dependent uses that would be permitted to continue on an interim basis pending completion of comprehensive conservation planning.

The Refuge Improvement Act established the responsibilities of the Secretary of the Interior for managing and protecting the Refuge System; requires a CCP for each refuge by the year 2012; and provides guidelines and directives for the administration and management of all areas in the Refuge System, including wildlife refuges, areas for the protection and conservation of fish and wildlife threatened with extinction, wildlife ranges, game ranges, wildlife management areas and waterfowl production areas.

Appropriate Use Policy

This policy describes the initial decision process the refuge manager follows when first considering whether to allow a proposed use on a refuge. The refuge manager must find a use appropriate before undertaking a compatibility review of the use. An appropriate use, as defined by the Appropriate Use Policy (603 FW 1 of the Service Manual), is a proposed or existing use on a refuge that meets at least one of the following four conditions:

The use is a wildlife-dependent recreational use as identified in the Refuge Improvement Act. The use contributes to the fulfilling of the refuge purpose, the Refuge System mission, or goals or objectives described in a refuge management plan approved after October 9, 1997, the date the Refuge Improvement Act was signed into law. The use involves the take of fish and wildlife under state regulations. The use has been found to be appropriate as specified in section 1.11 (603 FW 1 of the Service Manual).

If an existing use is not appropriate, the refuge manager will eliminate or modify the use as expeditiously as practicable. If a new use is not appropriate, the refuge manager will deny the use without determining compatibility. If a use is determined to be an appropriate refuge use, the refuge manager will then determine if the use is compatible (see the following Compatibility Policy section). Although a use may be both appropriate and compatible, the refuge manager retains the authority to modify or not allow the use. Uses that have been administratively determined to be appropriate are the six wildlife-dependent recreational uses—hunting, fishing, wildlife observation and photography, environmental education and interpretation—and take of fish and wildlife under state regulations (See Appendix C).

Compatibility Policy

Lands within the Refuge System are different from other multiple use public lands in that they are closed to all public uses unless specifically and legally opened. The Refuge Improvement Act states:

"*… the Secretary shall not initiate or permit a new use of a Refuge or expand, renew, or extend an existing use of a Refuge, unless the Secretary has determined that the use is a compatible use and that the use is not inconsistent with public safety.*"

In accordance with the Refuge Improvement Act, the Service has adopted a Compatibility Policy (603 FW 2 of the Service Manual) that includes guidelines for determining if a use proposed on an NWR is compatible with the purposes for which the refuge was established. A compatible use is defined in the policy as a proposed or existing wildlife-dependent recreational use or any other use of an NWR that, based on sound professional judgment, will not materially interfere with or detract from the fulfillment of the Refuge System mission or the purposes of the refuge. Sound professional judgment is defined as a finding, determination or decision that is consistent with the principles of sound fish and wildlife management and administration, available science and resources (funding, personnel, facilities and other infrastructure) and applicable laws. The Service strives to provide priority public uses when they are compatible. If financial resources are not available to design, operate and maintain priority use, the refuge manager will take reasonable steps to obtain outside assistance from the state and other conservation interests.

When a determination is made as to whether a proposed use is compatible or not, this determination is provided in writing and is referred to as a compatibility determination. An opportunity for public review and comment is required for all compatibility determinations. For compatibility determinations prepared concurrently with a CCP or step-down management plan, the opportunity for public review and comment is provided during the public review period for the draft plan (see Appendix C).

Biological Integrity, Diversity and Environmental Health Policy

In addition, the Refuge Improvement Act directs the Service to "*ensure that the biological integrity, diversity, and environmental health of the Refuge System are maintained for the benefit of present and future generations of Americans …*" To implement this directive, the Service has issued the Biological Integrity, Diversity and Environmental Health Policy (601 FW 3 of the Service Manual), which provides policy for maintaining and restoring, where appropriate, the biological integrity, diversity and environmental health of the Refuge System. The policy is an additional directive for refuge managers to follow while achieving refuge purpose(s) and the Refuge System mission. It provides for the consideration and protection of the broad spectrum of fish, wildlife and habitat resources found on refuges and associated ecosystems. Further, it provides refuge managers with an evaluation process to analyze their refuge and recommend the best management direction to prevent further degradation of environmental conditions and restore lost or severely degraded components, where appropriate and in concert with refuge purposes and the Refuge System mission. When evaluating the appropriate management direction for refuges, refuge managers will use sound professional judgment to determine their refuges' contributions to biological integrity, diversity and environmental health at multiple landscape scales.

San Luis NWR, Merced NWR and Grasslands WMA

The three refuge units outlined in this CCP—Merced NWR, San Luis NWR and Grasslands WMA—are all located in the central portion of Merced County, California (Figures 1-1 and 1-2).

The three units are bounded by the major transportation routes of Highway 99 to the east and Interstate 5 to the west. The Refuge Complex is six miles west from the City of Merced and the City of Los Banos separates the West and South units of the Grasslands WMA. The Refuge Complex is located in the northern portion of the San Joaquin Valley, which is enclosed by the foothills of the Sierra Nevada Mountains to the east and the Coast Range to the west. The fourth unit of the Complex, San Joaquin River NWR, is located approximately 35 miles north of the Merced NWR, San Luis NWR and Grasslands WMA. Large metropolitan centers within two hours' driving distance to the San Luis NWR Complex include San Francisco, San Jose, Fresno, Oakland, Modesto and Sacramento. The main office of the San Luis NWR Complex is located at the San Luis NWR in Los Banos, California.

The Merced NWR is 10,262 acres in size and consists of four main units: Merced, Lonetree, Snobird and Arena Plains (Figure 1-3). The San Luis NWR is 26,878 acres in size and consists of six contiguous units: San Luis, West Bear Creek, East Bear Creek, Blue Goose, Freitas and Kesterson. The San Luis NWR is located to the west of the Merced NWR, although its East Bear

Creek unit borders the Snobird unit of Merced NWR. The Grasslands WMA consists of 94,576 acres of perpetual conservation easements on private lands. Of this total acreage, 11,150.6 acres of Service-owned fee-title land are managed as part of the San Luis NWR, and 4,497.7 acres are managed as part of the Merced NWR. The Grasslands WMA is the largest concentrated easement program for wildlife in the State of California. The Grasslands WMA consists of three broad units: West, South and East.

The Grasslands West and East units surround most of the San Luis NWR, while the East unit surrounds the majority of Merced NWR. The South unit of the Grasslands WMA, situated southeast of Los Banos, is isolated from the rest of the Grasslands WMA and San Luis and Merced NWRs.

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Chapter 2: Comprehensive Conservation Planning Process

Introduction

The Refuge Improvement Act requires that every refuge in the NWRS prepare a CCP. Both the Service and the public benefit from this requirement because the CCP process helps ensure that each refuge fully evaluates, develops and achieves its long-term vision and goals. Once a CCP is approved, the refuge must follow the management priorities provided in the approved CCP. The procedural provisions in the Council on Environmental Quality's Regulations for Implementing NEPA require all Federal agencies to integrate the NEPA process with other planning as early as possible. In accordance with these regulations, the refuge planning policy states that each CCP will comply with the provisions of NEPA by concurrently preparing an EA or Environmental Impact Statement (EIS) to accompany or be integrated with the CCP. The purpose of integrating the two processes is to provide a systematic, interdisciplinary approach; identify and analyze the environmental effects of the proposed actions; describe appropriate alternatives to the proposal; involve the affected state and Federal agencies, Tribal governments and public in the planning and decision-making process; and fully integrate all refuge proposals that may have an effect on the environment.

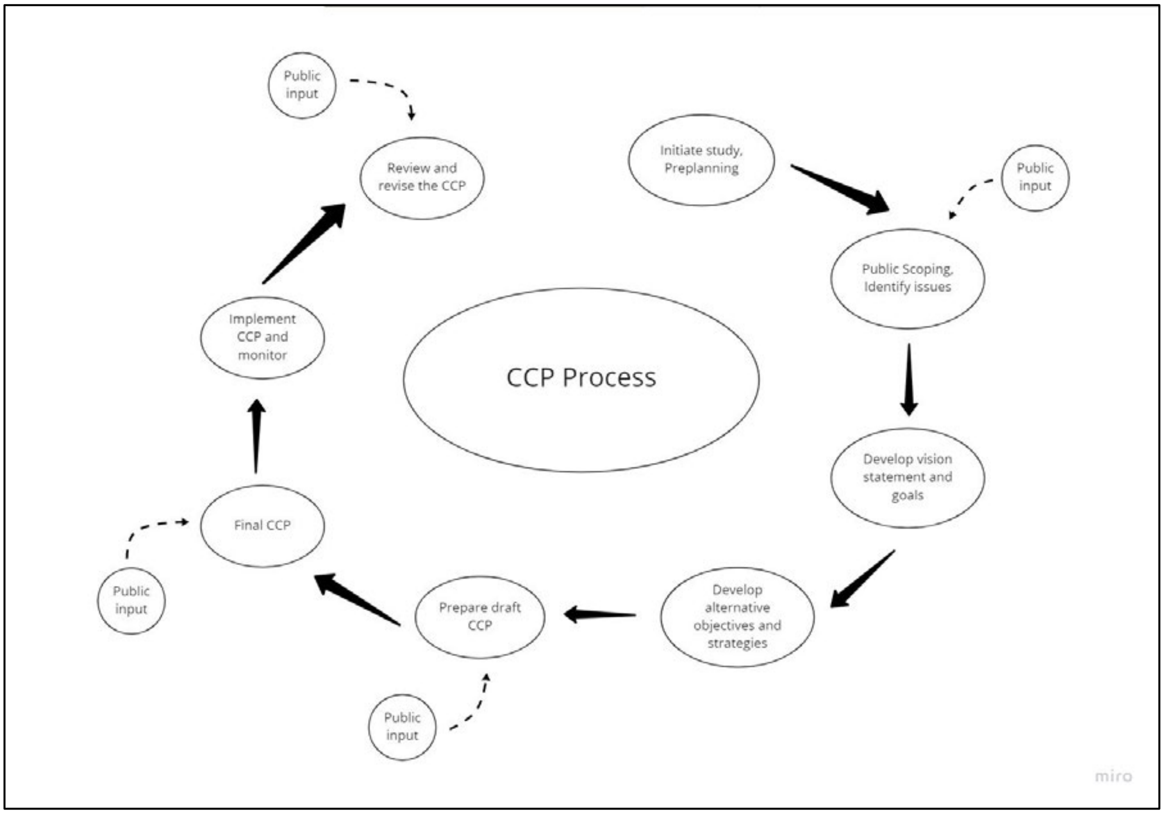
The Planning Process

This Draft CCP and EA (CCP/EA) for the San Luis and Merced NWRs and the Grasslands WMA is intended to comply with the requirements of the 1997 Refuge Improvement Act and NEPA. Refuge planning policy guides the process and development of the CCP, as outlined in Part 602, chapters 1, 3 and 4 of the Service Manual.

Service policy, the 1997 Refuge Improvement Act and NEPA provide specific guidance for the planning process, such as seeking public involvement in the preparation of the NEPA document, in this case the EA. The development and analysis of "reasonable" management alternatives within the EA include a "no action" alternative that reflects current conditions and management strategies on the refuge. Management alternatives developed as part of this planning process can be found in Appendix D: Environmental Assessment and Response to Comments.

The comprehensive conservation planning process for the San Luis and Merced NWRs and Grasslands WMA, which began in the fall of 2008, is summarized in Figure 2-1 and is described in the following sections.

Figure 2-1. CCP Planning Process Diagram



Timeline and Planning Team

The CCP process began in 2008 but was paused in 2014 for staffing and other priority planning concerns. In 2021, the CCP was revisited for final release. As such, the timeline and staffing for this project have changed significantly since 2008.

The CCP process requires close teamwork with refuge staff, planners and other partners to accomplish the necessary planning steps, tasks and work to generate the CCP document and associated EA. Two teams were formed: the core team and the expanded team. Although the exact people in these teams changed throughout the lifetime of the project, the roles of staff members did not.

Core Team

A core planning team was established to prepare the CCP/EA. The core team is the working/production entity of the CCP; the members are responsible for researching and generating the contents of the CCP document and participating in the entire planning process. The core team consists of refuge staff and planners in the Natural Resources Division of the

Sacramento Regional Office. The core team met periodically to discuss and work on the various steps in the process and sections of the CCP. The team members also worked independently to produce their respective CCP sections, based on their area of expertise. Work on the CCP occurred in addition to their regular workload.

Expanded Team

The expanded planning team is the advisory and coordination forum of the CCP. It is significant because of the Complex's history of working in close partnership with other local, state, Federal, Tribal and private agencies and organizations concerned with the San Joaquin Valley and its watershed. The CCP expanded team consists of the core team, other Service and Federal specialists from various relevant disciplines and State of California personnel to provide overview, discussion and coordination during the planning process.

Meetings are held with the planning teams throughout the process to discuss various planning issues and develop vision statements, goals, alternatives, objectives and strategies, as well as to share information about the Complex.

Pre-Planning

Preliminary CCP planning began with information gathering in the fall of 2008. The official process began on September 8, 2008, when a Notice of Intent (NOI) to prepare a CCP/EA and request comments was published in the Federal Register (Volume 73, Number 174, pages 52,063–52,064). Pre-planning involves forming CCP planning teams, developing the CCP schedule and gathering data. The teams determined procedures, work allocations and outreach strategies. In addition, the Refuge Complex created a preliminary mailing list for CCP outreach. Members of the planning team also identified a preliminary list of issues, concerns and opportunities that were derived from wildlife and habitat monitoring and field experience with the past management and history of the refuge.

Wetland. Photo: Rick Lewis

Public Involvement

Public involvement is an important and required component of the CCP and NEPA processes. During the planning process, the refuge staff continues to actively participate with the various working groups and agency teams concerning the San Joaquin River and surrounding area. Information letters called *Planning Updates* were also mailed to the public. These periodic publications are created to provide the public with up-to-date refuge information and progress on the CCP process and to request input. In July 2008, the first Planning Update introducing the refuges and CCP process was mailed to over 200 members of the public, elected officials, organizations, media and agency representatives. The NOI to prepare the CCP/EA was published on September 8, 2008.

Public scoping meetings allow the Service to provide updated information about the Refuge System and the refuges themselves. Most importantly, these meetings allow Complex staff to hear the public's comments about concerns and opportunities at the refuges. These public meetings provide valuable discussions and identify important issues regarding the refuges, the WMA and the surrounding region.

During the fall of 2008, public scoping meetings were conducted, news releases were circulated, website information was posted and informational mailings were sent to interested parties to gather input and comments. The public had opportunities to attend two public scoping meetings in Los Banos (on September 24, 2008) and one meeting in Merced (on September 25, 2008). Approximately 32 people attended the three meetings. Staff from the California Department of Fish and Wildlife (CDFW) and the California State Parks attended the public scoping meeting in Los Banos.

Prior to public scoping meetings, the Complex issued a press release to many local media outlets, including local newspapers *Merced Sun-Star, Los Banos Enterprise, The Paper, Fresno Bee, Modesto Bee, Stockton Record, San Jose Mercury News* and the *Fresno Associated Press Bureau*; and local television stations including Los Banos Community Access Channel 96 (community calendar). A Planning Update was distributed in September 2008 to interested stakeholders that had been identified through prior planning processes. An issues workbook also was distributed to the mailing list and at public meetings to help focus public input on issues relevant to the CCP.

Public Scoping Comments Received

Verbal comments were recorded during the 2008 public scoping meetings, and additional comments were received in response to the issues workbook distributed by the planning team. Over 100 comments were received, including written comments by mail or email and verbal comments provided in personal conversations with refuge and planning staff during the scoping meetings. The scoping comment period ended October 23, 2008.

A complete list of public comments received orally and in writing during the public scoping process appears in Appendix J: Public Scoping Process.

Dunlin. Photo: Lee Eastman

Development of Complex Vision

A vision statement is developed for refuges as part of the CCP process. Vision statements are grounded in the unifying mission of the Refuge System and describe the desired future conditions of the refuge unit in the long term (more than 15 years). They are based on the refuge's specific purposes, the resources present on the refuge and any other relevant mandates. Please refer to Chapter 3 Section 3.2 for the Merced NWR, San Luis NWR and Grasslands WMA vision statement.

Development of Complex Goals and Objectives

The 1997 Refuge Improvement Act directs that the planning effort will develop and revise the management focus of the refuge within the Service's planning framework, which includes the Service mission, the Refuge System mission, ecosystem guidelines and refuge purposes. This is accomplished during the CCP process through the development of goals, objectives and strategies.

Goals

Goals describe the desired future conditions of a refuge in succinct statements. Each one translates to one or more objectives that define these conditions in measurable terms. A well-written goal directs work toward achieving a refuge's vision and ultimately the purpose(s) of a refuge. Collectively, a set of goals is a framework within which to make decisions.

Objectives

Objectives are incremental steps taken to achieve a goal. They provide a foundation for determining strategies, monitoring refuge accomplishments and evaluating success. The number of objectives per goal will vary but should be sufficient to satisfy the goal. When many objectives are established, an implementation schedule may be developed. Objectives should be SMART: specific, measurable, achievable, results-oriented and time-bound.

Development of Complex Management Alternatives

The development of alternatives, assessment of their environmental effects and the identification of the preferred management alternative are fully described in the EA (Appendix D). Alternatives were developed to represent reasonable options that address the specific Refuge issues and challenges. A "no action" or continuation of current management alternative is required by NEPA and is the basis for comparing the other alternatives.

Red-winged Blackbirds. Photo: Mike Peters

Public Review of the Draft CCP/EA

The Draft CCP/EA is available for public comment for a period of 45 days. Once the comment period has closed, all written and oral comments received on the Draft CCP/EA will be reviewed and analyzed. Written responses will be prepared for all substantive comments and the CCP/EA will be modified as appropriate. The Final CCP/EA will identify the selected alternative, which could be the proposed action, the "no action" alternative, another alternative, or a combination of actions or alternatives discussed in the Draft CCP/EA.

Selection of the Proposed Action

The alternatives were analyzed in the EA (Appendix D) to determine their effects on the refuge environment. Based on this analysis, we have selected Alternative C as the proposed action because it best achieves the refuge goals, purposes and Refuge System and Service missions. Please refer to Chapter 5, which describes this proposed management approach in detail.

Refuge Management

Land Ownership and Acquisition History

The approved acquisition boundary for the Merced NWR, San Luis NWR and Grasslands WMA is over 200,000 acres in size; approximately half of these lands are either Service-owned fee-title lands or perpetual conservation easements.

The San Luis NWR Complex comprises lands that have been acquired in both fee title (outright purchases) and through easements. All acquisitions, whether fee title or easements, were on a willing-seller basis. The three refuge units—Merced NWR, San Luis NWR and Grasslands WMA—total 117,027 acres of land for wildlife and make up one of the largest collections of Service lands in the contiguous United States.

Fee-title lands are owned by the Service and serve as the core of NWR lands. These fee-title lands (37,140 acres) include the Merced NWR and San Luis NWR and are managed primarily for wildlife.

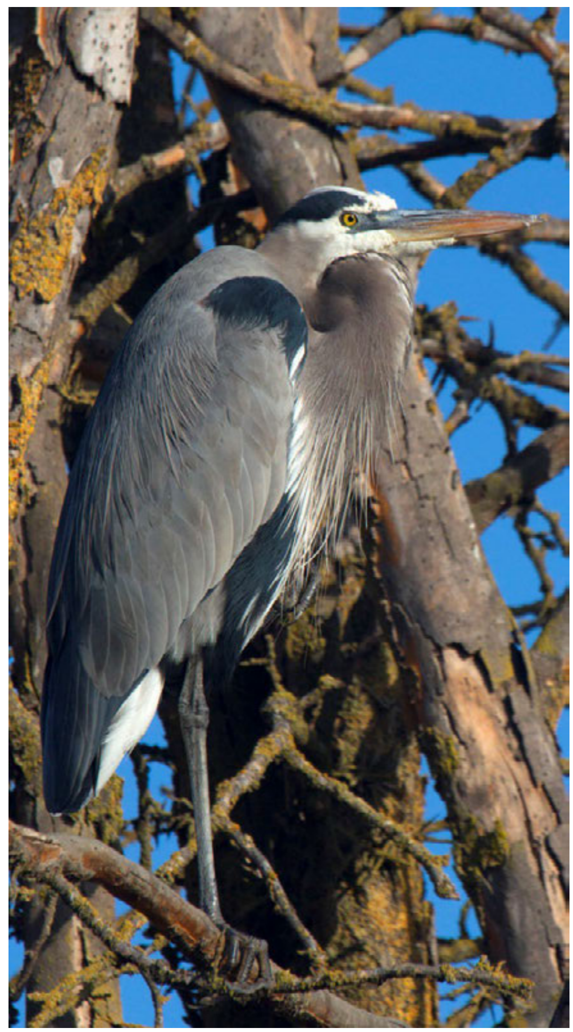
Easement lands are privately owned lands, where a willing owner has sold restricted land-use rights to the Service to protect or enhance wildlife habitats on these private lands. The Grasslands WMA is primarily composed of conservation easements on private lands (80,027 acres). Typically, Service easement lands occur in proximity to fee-title lands. The Service's conservation easements were established to protect existing resource habitat values while retaining land in private ownership.

Purchase of lands for the San Luis NWR Complex began in 1951 and is ongoing. Fee-title land acquisitions have been most active during the 1950s, 1960s, 1990s and 2000s whereas easement acquisitions have been steadily active through the past four decades. Sources of acquisition funds have included the Land and Water Conservation Fund, Migratory Bird Conservation Act Fund, CALFED Bay-Delta Program, emergency flood control appropriations and the State of California.

Merced NWR Acquisition History

The first parcel of the Merced NWR was acquired in 1951—the first acquisition for any part of the San Luis NWR Complex. This parcel was 2,561.54 acres in size and straddled Sandy Mush Road. This parcel included wetland units, croplands, irrigated pastures and grasslands. This initial land was acquired under the Lea Act, the purpose of which was to protect surrounding agricultural lands from waterfowl depredation; in essence the origin of the refuge was to attract waterfowl from neighboring croplands to reduce potential agricultural damage.

Since the original land acquisition in the 1950s, no other acquisitions to the refuge were made until the 1990s. In the early 1990s, the refuge acquired 636-acre and 956-acre properties from John Reininghaus through The Nature Conservancy on October 26, 1990, and April 15, 1992, respectively. The Land and Water Conservation Fund provided the funding, with additional funding made available from the Migratory Bird Conservation Fund (MBCF). The ranch was originally targeted for inclusion in the Service's easement program, but Mr. Reininghaus decided he would rather sell the property outright. The area contains a combination of agricultural lands, native uplands and wetland areas that provided excellent opportunities for restoration, enhancement and management activities to benefit migratory birds and other plant and wildlife species.



Great Blue Heron. Photo: Rick Lewis

On June 19, 1992, the 2,464-acre Sunrise Ranch (Arena Plains unit) was purchased from Bert Crane through the Trust for Public Land with the MBCF. The Arena Plains unit supports at least nine different natural communities, including vernal pool, freshwater marsh and native grassland habitats, as well as a remnant of the Merced River Alluvial Dune Ecosystem. It is a vital wintering ground for migratory waterfowl, sandhill cranes (*Grus canadensis*) and numerous other shorebirds of the Pacific Flyway. Because it has never been cultivated or irrigated, it supports a tremendous diversity of endemic, rare and endangered plant and animal life once abundant throughout California's Central Valley.

On June 28, 1994, MBCF made funding available for the purchase of 417.32 acres from Mr. John Shaw of the Newhall Land and Farming Company. The acquisition of the Newhall Ranch secured a vital wintering habitat for lesser Sandhill cranes (*Grus canadensis*) and arctic nesting geese, as well as a productive breeding habitat for resident mallard (*Anas platyrhynchos*), gadwall (*A. strepera*), cinnamon teal (*A. cyanoptera*) and other waterbirds. It also prevented the potential reclamation of native wetland and grassland habitat to agriculture.

Through a donation from the National Fish and Wildlife Federation, the 80-acre Randol property known as the Fowl Play Duck Club was acquired on March 23, 1999. The parcel was essentially an inholding and was negating efforts by the refuge to fully restore a semi-permanent wetland and associated native grassland. Since its inception, the wetland has been restored and is one of the more productive waterfowl brooding areas in the GEA.

The last two parcels, both large, were acquired in 2000 and 2004. The first was the Lonetree unit (1,242.28 acres), which is contiguous with the original refuge parcel and consists of wetland and grassland habitats. The most recent parcel—the Snobird unit—is 1,905.00 acres in size and consists of grasslands, wetlands and vernal pools. The Snobird unit is located immediately to the west of the Arena Plains unit and acts as a bridge on fee-title lands between the Merced and San Luis NWRs.

The 1,242.28-acre Lonetree unit was acquired from John Shaw on November 23, 1999, under the authorities of the Endangered Species Act (16 USC 1531-1543); the Migratory Bird Conservation Act (16 USC 715-715b, 715e, 715f-715r: Stat. 1222); the Fish and Wildlife Act of 1956 (16 USC 742a-742j; 70 Stat. 1117) as amended; and the Refuge Recreation Act of 1962. The MBCF provided the funding. The Lonetree Ranch maintains habitat that is vital to protecting grassland and seasonal wetlands from external threats associated with urban and agricultural development. The Ranch also was identified in the *Recovery Plan for Upland Species of the San Joaquin Valley, California* (1998) to "develop a chain of habitat islands on the valley floor; that together will establish a linkage through agricultural lands, refuge and state lands, between the northeastern and northwestern edges of the San Joaquin Valley." The Lonetree unit was transferred to the Service with a 30-year Natural Resources Conservation Service (NRCS) Wetland Reserve Program easement.

On February 2, 2004, the 1,904.25-acre Snobird Ranch was acquired by way of court order from Michael Toth using MBCF. The Snobird Ranch was originally included as a privately owned property within the Service conservation easement program. However, after repeated violations to the conditions of the easement, Mr. Toth was forced to sell the ranch to the Service. The Ranch supports a significant vernal pool ecosystem with its associated native grassland habitat. It is an important wintering ground for migratory waterfowl, sandhill cranes (*Grus canadensis*) and numerous other shorebirds of the Pacific Flyway. Because large portions of the property have never been cultivated or irrigated, it is representative of a declining diversity of endemic, rare and endangered plant and animal life once common to the area.

In total, the Merced NWR consists of 10,262.32 acres of land in four discrete parcels: Merced unit, Snobird unit, Lone Tree unit and Arena Plains unit (see Figure 2-2).

Figure 2-2. Management Units of the Merced NWR

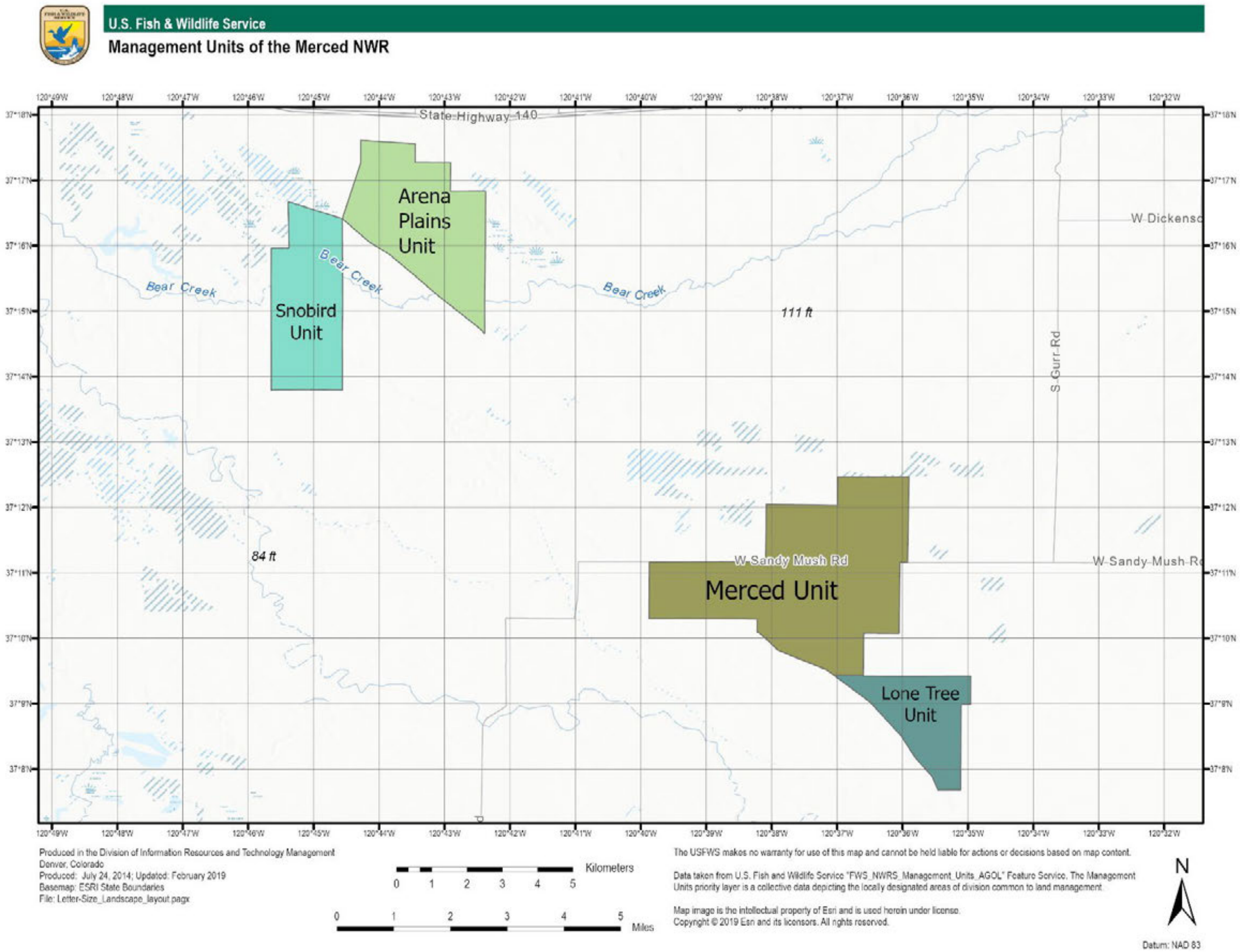


Figure 2-3. Management Units of the San Luis NWR

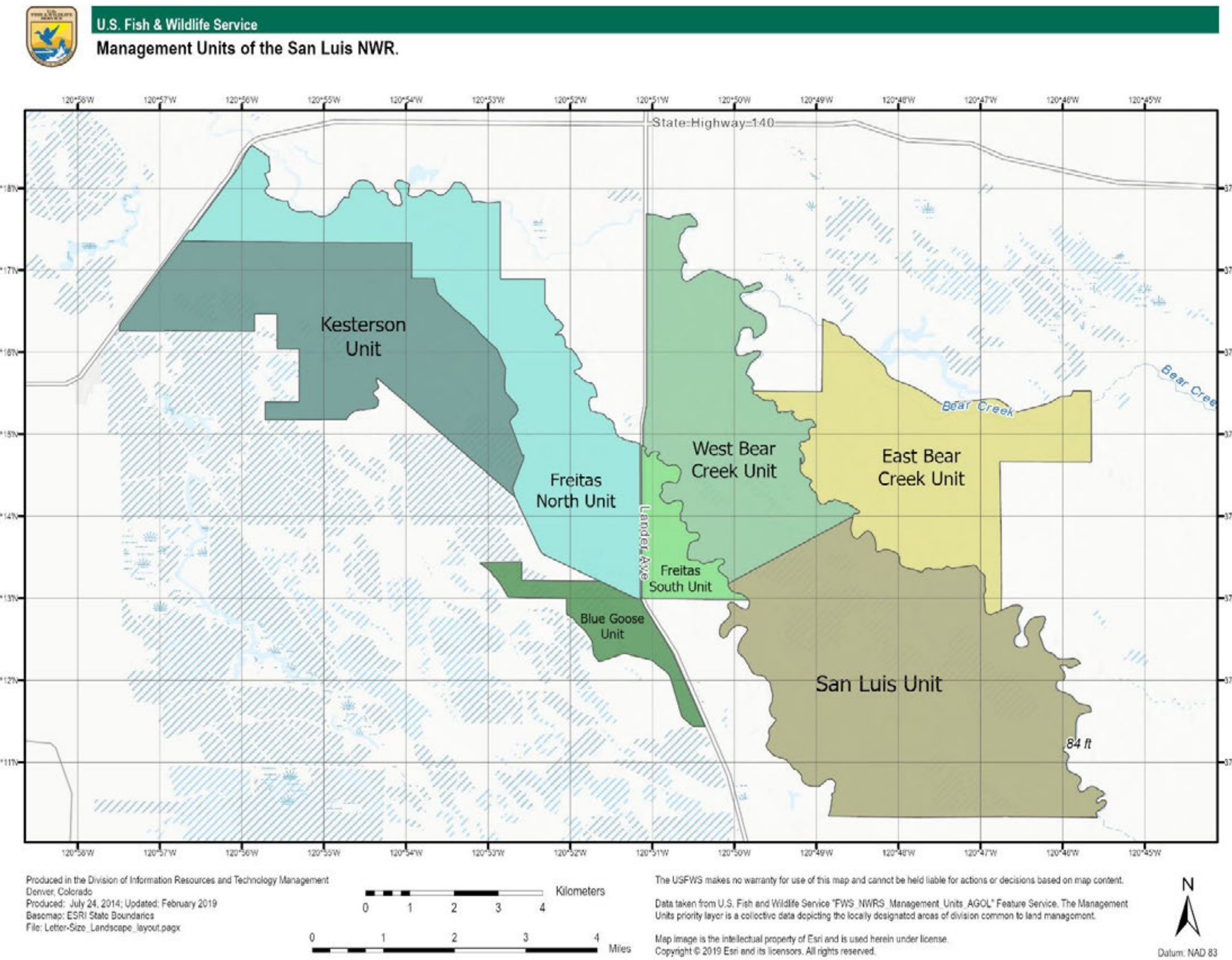
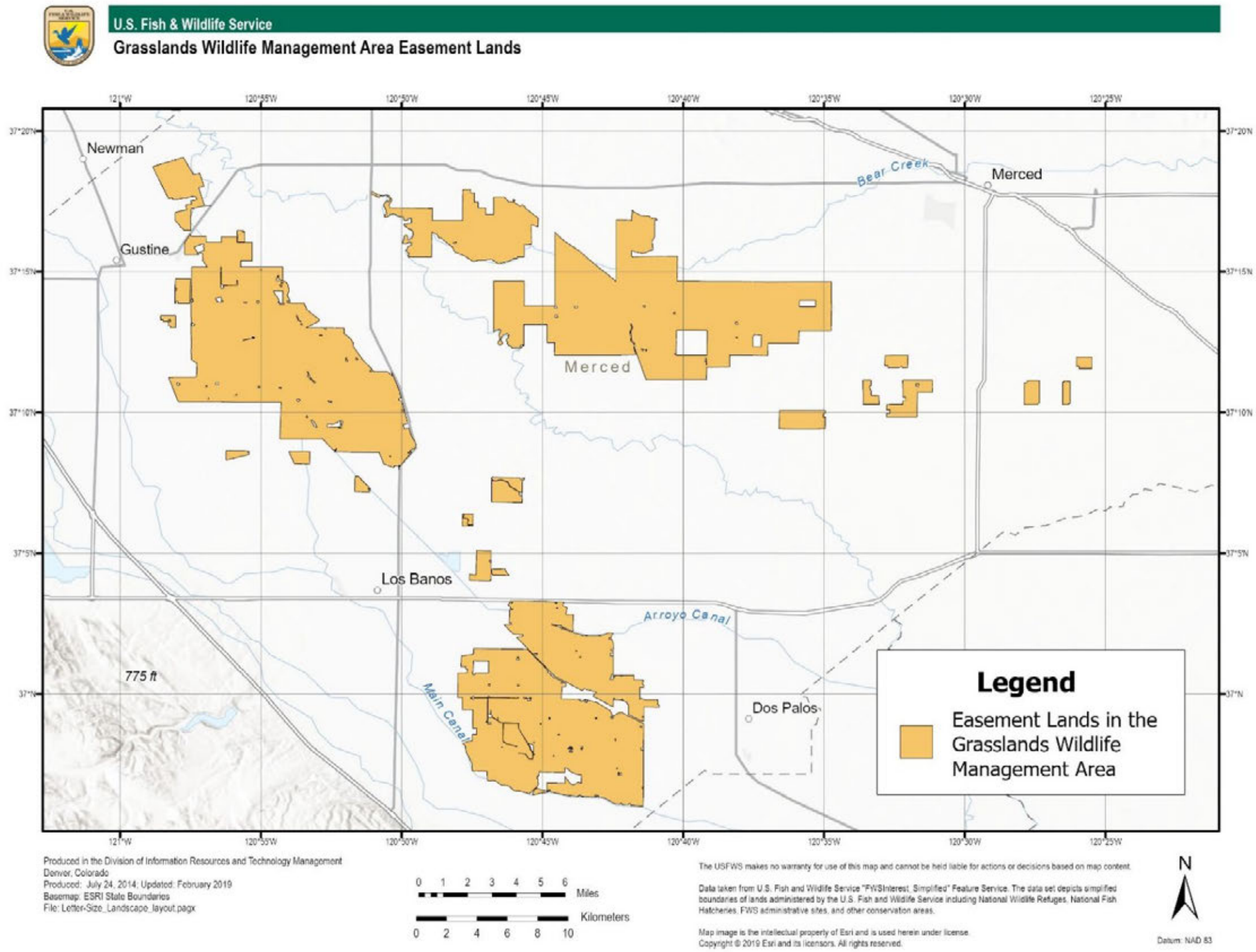


Figure 2-4. Easement Lands of the Grasslands WMA



San Luis NWR Acquisition History

The San Luis NWR was established in 1967 and consisted of one 7,422.41-acre unit (San Luis unit) consisting of wetlands and uplands (principally grasslands). The unit was acquired to provide habitat for migratory birds. A second unit, 4,700.0 acres in size, was purchased in 1968. Known as the Kesterson unit, it became the Kesterson NWR. It also consists of mostly wetland and grassland habitats but also includes a component of vernal pool habitats. The Kesterson unit is located three miles from the San Luis unit. Although originally designated as its own refuge, the Kesterson unit was managed by staff from the San Luis NWR. During the 1970s and 1980s, no further land acquisitions were accomplished for the San Luis NWR, which remained at a size of 12,122.41 acres with two discrete units.

During the 1980s, the issue of agricultural drainwater and its disposal received widespread media and public attention in the Central Valley due to documented die-offs of birds at the U.S. Bureau of Reclamation's (USBR) Kesterson evaporation pond(s). These USBR pond(s) received drainwater from agricultural lands to the south and provided an area for this water to evaporate. However, this process concentrated contaminants—such as selenium and other salts and compounds—in the pond(s) that impacted breeding by migratory birds and other wildlife and it also caused mortality. Legal issues and public attention surrounding these contaminant issues of USBR lands increased incentive for acquiring additional land for the San Luis NWR. Five units—Freitas, Claus, Eight Gun Club, Chee and Bear Creek—were acquired for the refuge during the early to mid-1990s. These units (more than 14,000 acres) increased the acreage of the San Luis NWR to 26,609 acres. Habitats within these units included annual grasslands, vernal pools, wetlands and riparian corridors. These units also provided a physical connection between the San Luis unit and the Kesterson unit, which led to combining them under one contiguous area that is now known as the San Luis NWR.

In 2000, two additional units (mainly annual grasslands) totaling 269 acres were added to the San Luis NWR, increasing the total acres to 26,878. The San Luis NWR is the largest contiguous national wildlife refuge in California's Central Valley.

Grasslands WMA Acquisition History

The Grasslands WMA was established in 1979. In 1978, the Migratory Bird Conservation Commission approved the West Grasslands WMA acquisition boundary at 48,000 acres, allowing Complex staff to officially offer monetary compensation to private landowners within that boundary in exchange for perpetual conservation easements on their lands. Because acquisition funding was generated through the sale of Federal Duck Stamps, potentially protected lands as part of the easement program must benefit migratory birds and specifically waterfowl. Existing duck hunting clubs located west and south of the San Luis NWR and adjacent to state wildlife areas were sought after properties due to their great benefit to wintering waterfowl. The easement lands, while remaining under private ownership, perpetually offer waterfowl habitat while also protecting core state and Federal lands from urban and agricultural encroachment.

The first conservation easement for the Grasslands WMA was 880 acres, purchased at $286 per acre on August 17, 1979. Within the first year of the easement program, nine easements were acquired. By 1988, almost half of the approved acres within the west Grasslands easement acquisition boundary were purchased, totaling 95 easements and 26,192 acres that were acquired at an average cost of $307 per acre (Table 2-1).

With the overwhelming success of the conservation easement program, it became evident that an expansion eastward of the approved acquisition boundary was necessary. By 1985, the easement program staff began this boundary acquisition expansion process.

Because of the need for additional protected wetlands in the Grasslands WMA and the success of the initial program, easement program staff requested expansion of the acquisition boundary by 36,550 acres, which was approved on March 27, 1990. The first eastern expansion would continue focusing on the growth of high-quality protected wetland habitat that buffer the core Federal and state fee-title lands. Additional consideration was placed on protecting the irrigated pasture lands that are used by geese and cranes. The original western (north and south Grasslands WMA) and the new eastern acquisition boundaries were merged and became what is now known as the Grasslands WMA, with a total acquisition boundary of 84,500 acres.

Although the total number of easement acquisitions decreased by more than half in the second decade of the program (from 95 to 46), the average number of acres per easement nearly tripled (276 to 746 acres) and the average cost per acre increased by approximately $200 ($307 to $525) (Table 2-1). From 1989 to 1998, an additional 34,291 acres were added to the conservation easement program, bringing the Grasslands WMA total to 60,483 acres within the 84,500-acre acquisition boundary. From 1999 to 2008, 14,743 acres were acquired at an average of $762 per acre. The most recent addition to the conservation easement program was in 2016. This brought the total acreage of the conservation easement program on the Grasslands WMA, excluding fee-title lands managed by San Luis and Merced NWR, to 80,027 (Table 2-1).

As the easement program entered its third decade, the number of easement acquisitions began to fall off as the existing acquisition boundary neared capacity and market values increased for grazing lands and waterfowl habitat. Although payments for easement acquisitions increased, farmers and ranchers were unwilling to burden their lands with an easement when fee-title market values were frequently exceeding $6,000 per acre.

On June 27, 2005, the Service expanded the acquisition boundary of the Grasslands WMA by 46,400 acres to the east. This was the second eastern expansion, which is known as the East Grasslands Expansion. This area is dominated by vast fields of row crops, irrigated pastures and tracts of native vernal wetland/upland complexes. This area marks a shift in the focus of the easement program from traditional waterfowl hunting properties to native grazing pastures (i.e., native grasslands). These potential easement lands provide important habitat requirements to wintering migratory bird populations and serve as a critical east-west corridor for wildlife. A third expansion in 2007 added 40 acres to include the San Felipe Ranch addition, bringing the total Grasslands WMA acquisition boundary to 130,990 acres.

Table 2-1. Easement Acquisition in the Grasslands WMA, 1979–2016

Date	# Easements	Total Acres	Average Easement Acreage	Cost	Average Cost/Acre	Most Acreage Easement	Least Acreage Easement
1979-1988	95	26,192	276	$8,041,350	$307	1,596	35
1989-1998	46	34,291	746	$18,003,211	$525	3,979	<1
1999-2008	26	14,743	567	$11,232,898	$762	3,283	33
2009-2016	25	4,801	192	$10,974,474	$2,286	769	1
TOTAL	192	80,027	n/a	$48,251,933	n/a	n/a	n/a

Management History and Past Complex Actions

Merced NWR

The Merced NWR was established under the Lea Act of May 18, 1948 (62 Stat. 238; 16 USC 695-695c), which made provisions to fund, acquire and maintain wildlife management and control areas in the State of California to address the problem of agricultural depredation. The Lea Act also includes provisions to permit hunting. The initial purposes for the refuge were to provide natural feeding grounds for waterfowl and thereby reduce their depredations upon farmers' crops, to provide a refuge for migratory waterfowl on the Pacific Flyway and to provide public waterfowl hunting opportunities.

During the refuge's first year, a 200-acre wetland impoundment was constructed on Mariposa Slough. Additionally, 430 acres of barley and 175 acres of millet were planted and flooded to benefit migratory waterfowl. The refuge continued to convert fallowed farm fields to waterfowl-friendly crops throughout the 1950s until 1957, when a total of 1,080 acres of crops (200 acres of barley, 110 acres of milo and 60 acres of yellow proso millet) were grown and managed for wintering waterfowl. Subsequently, the peak waterfowl numbers decreased from 175,000 ducks and 125,000 geese in 1951 to 546,000 ducks and 66,250 geese in 1958.

Hunting has been permitted (albeit in limited capacity) since the refuge's inception and has continued to present day. The Merced Wildlife Management Area Lea Act Advisory Committee, whose primary purpose was to determine the date when waterfowl hunting would be permitted on the refuge, agreed that the California Department of Fish and Game (now known as the California Department of Fish and Wildlife or CDFW) would administer the public hunt program after the first week of November when the rice harvest was complete on private lands. During that first year, 683 hunters took 701 ducks, 59 coots (*Fulica americana*) and 62 geese. During the 1958/59 season, 1,524 hunters bagged 3,461 ducks, 58 coots and 65 geese. Limited hunts for ring-necked pheasants (*Phasianus colchicus*) also were allowed. Other recreational activities occurring to a lesser degree included picnicking, swimming, sight-seeing, birdwatching and trapping.

As intended by the Lea Act, refuge staff often provided aid to private landowners conducting waterfowl population control activities. In addition to coordinated hunting, refuge personnel attempted to manipulate waterfowl-foraging behavior away from private rice and dry-crop fields by providing private landowners with barley (out-of-the-sack) to feed ducks on the west side of the refuge. They also supplied pyrotechnics (flares and rifle grenade materials) to nearby farmers to flush geese away from crops. The pyrotechnics did not work with coots. Additionally, the refuge-sponsored black-tailed hare (*Lepus californicus*) hunts helped control their population size.

Grazing permits began to be issued in the 1950s during the summer months to graze cattle (*Bos* spp.) on 1,610 acres of the refuge to maintain a low vegetative structure in the grasslands to benefit wildlife.

During the 1960s, the refuge's infrastructure continued to develop. Road construction continued to provide better management and access to wetland/agricultural impoundments. The San Joaquin Flood Control Project constructed a levee along both sides of the Mariposa Slough, now referred to as the eastside bypass. A bridge was also constructed on Sandy Mush Road to cross the new flood control bypass. The refuge developed two additional deep wells with a concrete pipeline to irrigate the newly converted 400 acres of its eastern portion to barley. The Glory Hole wetland was enlarged from 30 acres to 70 acres.

Farming operations consisted of 435 acres of millet, 260 acres of millet, 292 acres of barley and 110 acres of fallow acres. In 1968, four hundred acres of permanent pasture were planted, adding to the 850 acres of range land already grazed. In 1969, the refuge conducted an experiment to see if short forage could be maintained on the irrigated pasture with grazing—as opposed to mechanical mowing—until goose use started.

By the 1970s, the refuge operations and infrastructure were well-developed and an increased emphasis was placed on improving management practices. Millet and barley fields were still being grown and flooded as forage for migratory waterfowl. In 1971, the refuge experimented with planting alternating strips of common vetch/sweet clover/oats mixture with barley and quail brush to provide food and cover for pheasants. Furthermore, a cooperative farming program was implemented to grow corn to provide adequate feed for geese—158 acres of former pasture were planted by a private farmer in silage corn; the farmer's share of the crop was two-thirds with one-third left as feed for geese. The cooperative farming program was eventually expanded and the responsibility for all farming on the refuge, with the exception of the millet crop, was entrusted to a farming cooperator. In subsequent years, rotation cycle of corn-fallow-barley-corn would be alternated between fields under the cooperative agreement. The cooperative agreement saved the refuge the costs of soil amendments, labor and seed required to raise these crops.

Waterfowl use at Merced showed a tremendous decline in 1971 and 1972. At this time, the refuge stopped recording peak number of waterfowl use and began recording in waterfowl use days as its measure. In 1973, duck use days were 4,763,910 and goose use days were 154,500. During the 1970–71 waterfowl hunting seasons, 2,484 hunters took 4,511 ducks, 148 coots and 279 geese. From 1974 to 1979, the refuge converted 1,585 acres, including 603 acres of cropland (approximately 62 percent of the refuge), to seasonal wetlands and the waterfowl hunting program expanded to include the entire refuge in 1978 and 1979. As a result, waterfowl use decreased dramatically on the refuge. However, due to the corn-planting that went into rotation, both goose and sandhill crane (*Grus canadensis*) use days increased. From 1981 to 1983, the refuge made significant changes to the waterfowl hunting program to improve hunter experience and balance management for sanctuary areas. These changes included limiting the number of hunters to 60, increasing the number of fixed blinds, limiting hunter movement, the use of decoys and reducing hunting hours to Wednesdays and Saturdays from dawn until noon. To minimize conflicts with waterfowl hunters, pheasant hunting was confined to Wednesdays and Saturdays and it occurred from noon until sunset. To protect the endangered Aleutian cackling goose (*Branta canadensis leucopareia*), hunting of all Canadian-type geese was banned for the 1975–76 and 1976–77 waterfowl seasons.

In the 1980s, there were budget decreases, refuge staffing decreases, rising utility costs and the limiting effects of an inadequate water conveyance system. Simultaneously converging, these factors made it difficult to meet the management and resource needs of the refuge. Until the late 1980s, the majority of Merced NWR’s water was supplied via 21 deep groundwater wells. However, with rising utility costs associated with the energy crisis of the 1970s, utility costs began to make it prohibitive to continue to pump water from deep wells for wetland and agricultural purposes. Wetland habitats on the refuge were reduced in 1976 from 1,280 acres to 590 acres, a decrease of 54 percent. In 1986, only 682 acres were flooded with 5,978 acre-feet of water. In 1987, negotiations began to reduce refuge utility costs by obtaining Central Valley Project preference power and by obtaining surface water from the Merced Irrigation District (MID). In 1989, the Federal Energy Regulatory Commission (FERC) ruled that the MID was required to build the facilities necessary to deliver and provide 15,000 acre-feet of water to offset the loss to wildlife habitat caused by the construction of the New Exchequer Project in 1964.

During the 1990s, migratory bird consumption of refuge crops drastically increased due to reduced availability of food on neighboring farmlands, which were caused by drought, low commodity prices and unsustainable farming practices. However, low commodity prices and restrictions on pesticide use also caused the collapse of the cooperative farming program at the refuge when the cooperative farmer pulled out of the program in 1993. Other potential cooperative farmers declined to participate. A review of the farming program led to the incorporation of all pasture units into the grazing program, the replacement of alfalfa with green browse provided by winter wheat on grazed pasture units only, and the farming of the winter wheat program contracted by a local dairy farmer.

A new waterfowl hunting program cooperative agreement was signed on March 29, 1990, by the Service and CDFW, which included the Merced NWR. In 1991, the pheasant hunting program was eliminated due to its impact on waterfowl use during the initial buildup of waterfowl numbers at the refuge. The number of geese harvested increased considerably due to these changes, with 220 hunters harvesting 254 geese in 1993, compared to 181 hunters harvesting 78 geese in 1991.

An experimental grazing program that resulted in excellent goose and crane use was initiated in the late 1990s to manage 104 acres of permanent pasture on the Merced unit and 562 acres of annual grassland. These acres were previously managed through prescribed burning. By 1997, the grazing program encompassed 904 acres, including 640 acres of native grassland and 264 acres of irrigated pasture.

Today, the Merced NWR is managed with an emphasis on conserving migratory birds, endangered species and endemic, rare or key species native to the diverse habitats of the northern San Joaquin Valley.

San Luis NWR History

When the refuge was established in 1967, the refuge consisted of 7,422.41 acres consisting of approximately 3,000 acres of wetlands and 4,000 acres of uplands. It was described as an *inland island* and known as *San Luis Island* due to being surrounded almost entirely by water bodies: the San Joaquin River to the east, Salt Slough to the west and a large water conveyance canal to the south.

In July 1969, the Kesterson NWR was established as an overlay refuge (fee-title land not held by the Service) on 5,900 acres of USBR fee-title land. The land was purchased by the USBR to construct a series of storage and evaporation ponds planned at approximately 1,300 acres (USFWS 1969) for the purpose of holding agricultural drainwater brought to the site in the USBR's San Luis Drain—a concrete-lined drain built to convey drainwater from the San Joaquin Valley to the San Joaquin River delta (USFWS 1969). At inception, the Kesterson NWR consisted of 878 acres of wetlands with the remainder native uplands that had never been converted to agriculture. The refuge was opened to waterfowl hunting during the 1969–1970 waterfowl hunting season, when 1,414 hunters harvested 3,587 birds for an average of 2.5 birds per hunter per day. The Service operated the hunting program during its first year of operation. Thereafter the program was operated at San Luis NWR and Kesterson NWR by the CDFW under a cooperative agreement with the Service.

Management and monitoring efforts started at the refuge shortly after the acquisition of San Luis Island, now one of six units of the San Luis NWR. Management objectives were focused on the primary purpose to provide habitat and "management opportunity" for "waterfowl common to the Pacific Flyway." Specific targets were established for migratory, wintering and nesting duck populations and migratory geese while general qualitative goals were made for "marsh and waterbirds," mourning doves (*Zenaida macroura*), furbearers, upland game birds and fish. Recreational objectives for the refuge at that time included waterfowl hunting, fishing, sightseeing, nature study, photography, conservation education and picnicking—uses that closely mirror priority wildlife-dependent uses outlined for the Refuge System today.

The period from 1967 through the 1970s was a period of intense activity at the San Luis and Kesterson NWRs, as staff worked to maintain and improve the existing road and water conveyance infrastructure. All water used by the refuges during this period was obtained from surface water rights and from two wells on Kesterson NWR (USFWS 1969 and 1974). This is in contrast to the situation today, where almost 90 percent of all wetland units are managed as seasonal wetland basins. All managed wetland units were kept flooded through the summer to provide waterfowl production habitat into the 1970s. During this period, priority public use activities such as waterfowl hunting and fishing received considerable attention. Monitoring activities focused on acquiring annual waterfowl harvest data and duck, goose and gallinule population data.

Early waterfowl number estimates for the refuge (USFWS 1968) reveal that both light and dark goose numbers on what is now the San Luis unit were very high when compared to today. For example, numbers peaked at 36,000 in mid-February with snow geese (*Chen caerulescens*), cackling geese (*Branta canadensis minima*), greater white-fronted geese (*Anser albifrons*), Ross's geese (*Chen rossii*) and western Canada geese (*Branta canadensis moffitti*) in order of decreasing abundance.

Notable achievements in improving priority public use infrastructure on San Luis NWR during the 1970s included applying gravel to four miles of the Salt Slough (fishing access road); the creation of a waterfowl-viewing-oriented auto tour route (1973); and the construction, by force account, of a 5.3-mile tule elk enclosure (1974). Notable single species management achievements included the reintroduction of 18 tule elk (*Cervus elaphus nannodes*) in cooperation with CDFW and the release of a pair of San Joaquin Valley kit foxes (*Vulpes macrotis mutica*) at the San Luis NWR (USFWS 1970). There also were regular sightings of small numbers of kit foxes (USFWS 1974).

The 1990s was a period of rapid size expansion for the San Luis NWR, and a great deal of wetland restoration work was coordinated with the modification and creation of new water conveyance facilities. At least five large canals and ditches were created on what is now the San Luis unit of the San Luis NWR (USFWS 1981 and 1989). These actions greatly improved the quality of wetland habitat, as it allowed for the careful manipulation of water levels to produce moist-soil forage species desirable to migratory waterfowl.

Tule Elk Cow with Calf. Photo: Karl Stormayer

During this decade, greater attention shifted to monitoring and assessing the status of key, threatened and endangered species.

There was a mass die-off of waterbirds and waterfowl in 1984/1985 on the Kesterson NWR as a result of selenium contamination. This contamination was caused by concentrated agricultural drainwater in wetlands at the Kesterson Reservoir (USFWS 1981). This resulted in refuge management and monitoring initiatives aimed at supplying higher quality water supplies to the managed seasonal wetlands. Though less widely reported, the high levels of selenium detected at the San Luis NWR legal diversion point (12 parts per billion) led to the complete cessation of the use of Salt

Slough water for a period of four years (USFWS 1989). These dramatic events also sparked significant long-term water quality research studies that continue to the present day.

During the 1990s, there was a focus on wetland habitat restoration on the San Luis NWR. Throughout this decade, some 3,656 acres of wetlands and wetland-associated riparian habitats were restored or enhanced on the Freitas and East and West Bear Creek units of the refuge. These projects restored wetland basins and slough channels that had been laser-leveled and managed as crop fields on the East and West Bear Creek units, wetland units and a compromised water conveyance infrastructure on the Freitas unit. In addition, native grassland and riparian habitats were restored. For example, on the East Bear Creek unit, 597,000 cubic yards of dirt were moved to restore wetlands and around 3,500 native trees and shrubs (valley oak [*Quercus lobota*], Fremont cottonwood [*Populus fremontii*], black willow [*Salix nigra*], red willow [*S. laevigata*], sandbar willow [*S. sessilifolia*], coyote bush [*Baccharis pilularis*] and quail brush [*Atriplex lentiformis*]) were planted on a restored oxbow of the San Joaquin River and in the nearby degraded riparian corridor by volunteers led by Complex staff (USFWS 2003).

Since the 1990s and continuing up to the present, many achievements have been made to secure adequate water deliveries to meet wetland habitat management goals. For example, 1996 marked significant progress in improving the quality of water delivered by the Grassland Water District to the Blue Goose, Freitas and Kesterson units. Part of the San Luis Drain, which is a water conveyance system originally constructed by the USBR to convey irrigation drainwater from the Westlands Water District, was reopened to allow for the transfer of locally generated irrigation drainwater into the drain and away from the San Luis, Fremont and Santa Fe canals—which had functioned and alternated as water delivery canals or drains depending on user and Water District needs. Under this project, which continues to the present day, the San Luis drain discharges into Mud Slough on the refuge, bypassing the refuge's wetlands. Since the initiation of the Grassland Bypass Project, the refuge has assisted the Services Contaminants Division with the monitoring of selenium levels in invertebrates and fish downstream of the San Luis Drain and in nearby Salt Slough.

Refuge studies in the 1990s focused on documenting water particulate and chemical quantities, measuring the amount of salts entering and leaving refuge lands (e.g., Quinn et al. 2005), dissolved oxygen (USFWS 2004), organic carbon flux and methylmercury. Anecdotal evidence from refuge narratives (USFWS 1990) suggests that species assemblages of desirable aquatic plants noticeably increased in number and diversity along with improved quality of delivered water during this period. This observation occurred soon after the 1985–1989 suspension using Salt Slough water to flood refuge wetlands due to poor water quality (USFWS 1989). From 1989 to the present, Salt Slough (riparian) water was used only to augment delivered water of better water quality. Anecdotally, it was suspected that specific species of plants increased in abundance due to this management shift, including water plantain (*Alisma plantago aquatica*), roundleaf bacopa (*Bacopa rotundifolia*), water pennywort (*Hydrocotyle* spp.) and arrowhead (*Saggittaria* spp.).

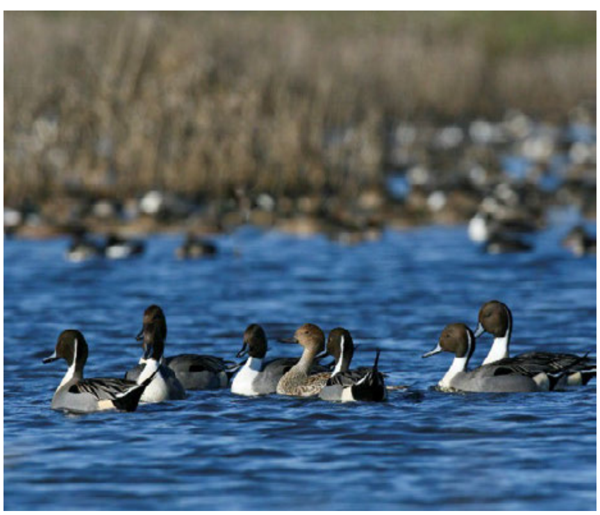
This period also saw a steady rise in the cost of delivered water to the refuge. In 1993, the annual cost to the refuge of obtaining delivered water supplies from the San Luis Canal Company

(Henry Miller Reclamation District) was $123,735. This cost climbed to $202,834 in 1993 and to $511,298 in 2008.

During the 1990s, Complex maintenance staff continued to enhance refuge water delivery infrastructure while also putting in considerable effort towards improving wetland habitat diversity and management. For example, the 216-acre Sousa wetland unit on the San Luis NWR was divided into nine cells of approximately equal size when the refuge was acquired. These basins were uniform and varied in depth from 2 to 18 inches. A project in 1996 (USFWS 1996) produced four larger units with water depths varying from 3 inches to 6 feet (USFWS 1996). The enhanced wetland units also were re-contoured to include low flow channels to improve the ability of staff to rapidly draw down water levels and to provide timed irrigations to maximize appropriate moist soil management values.

Significant flood events occurred in the winters of 1997–1998 and 2005–2006; in both cases, extensive flood damage occurred to managed wetland units lying between the San Joaquin River and Mud Slough. In both floods, water control structures and dikes were compromised and needed replacement. Each time this phenomenon occurred, an effort was made to modify replacement structures to allow water to flow through without causing catastrophic damage, because otherwise this cycle would predictably repeat itself.

Waterfowl surveys—which had been conducted regularly (usually at two-week intervals) since the inception of refuge management activities in 1967—were suspended in February 1993 in favor of occasional aerial surveys conducted in cooperation with CDFW (USFWS 1993). Ground counts of waterbirds on all seasonal wetland basins on the refuge were reinitiated in the fall of 2007 to provide more pertinent waterfowl and waterbird use data for management purposes. In addition, an intensive study concerning moist soil wetland plant composition, structure and seed production was initiated in 2007. This was a first step in quantifying wetland plant productivity across all seasonal wetland basins on the refuge.



Northern Pintail. Photo: Mike Peters

Upland habitat management efforts on the San Luis NWR also increased during the 1990s. In 1989 (USFWS 1989), large-scale sheep- and cattle-grazing agreements were initiated with refuge cooperators under Cooperative Land Management Agreements (CLMA). The agreements were initiated to assist with combating yellow starthistle (*Centaurea solstitialis*), perhaps the major invasive exotic weed on the refuge, and to produce short-statured upland habitat with a vegetation structure of 5 inches or less to manage for a suite of species—including the long-billed curlew (*Newmenius americanus*), San Joaquin Valley kit fox (*Vulpes macrotis mutica*), arctic nesting geese and vernal pool-associated flora and invertebrates. Repeated mowing as a means of controlling yellow starthistle was conducted in

1996 and 1997, and a series of experimental plots was established to compare the effects of domesticated livestock, elk-grazing, mowing and different prescribed burn treatments. The first attempt to implement a bio-control of this species was conducted in 1990 with the assistance of the Merced County Agricultural Commission, when seed head weevils (*Bangasternus orientalis)* were released in the Yokuts uplands of the San Luis NWR (USFWS 1990).This release was followed by a much larger release in the refuge elk enclosure in 2002 under a grant provided by the Rocky Mountain Elk Foundation.

Pepperweed (*Lepidium latifolium*), an invasive plant that first colonized the refuge from Salt Slough, has also rapidly spread along water delivery canals and into disturbed sites.

A considerable amount of research went into studying the diversity, distribution and abundance of land and waterbirds in the 1990s. Annual estimates of duck and goose use days were conducted annually starting in 1967. Certain studies focused on individual species and their ecological importance on refuge lands. Examples include a study of survival and habitat use of northern pintails (*Anas acuta*) wintering in the San Joaquin Valley (1993); a radio telemetry study on green winged teal (*Anas crecca*) to establish estimates of population numbers and distribution; and an annual banding study of nesting ducks, including wood ducks (*Aix sponsa*), to acquire productivity and survival rates on refuge lands (e.g., USFWS 1989, 1998). Annual surveys of wintering lesser sandhill crane (*Grus canadensis*) and nesting heron numbers on the San Luis and West Bear Creek units also were conducted in the 1990s and into the 2000s. Shorebird studies during this period include spring and fall surveys of species diversity and abundance conducted by Point Reyes Bird Observatory (PRBO) (USFWS 1990). These surveys suggested that use of refuge wetlands by migrating shorebirds was heaviest in the month of April.

Research on land birds has included systematic surveys of species numbers in the San Joaquin River corridor—73 species of 33 families detected (USFWS 1990)—as well as raptor surveys, which detected 12 species with greatest numbers found during the month of December (USFWS 1990). Annual breeding bird surveys of passerine species in the San Joaquin River riparian zone also were conducted by Complex staff for a period of six consecutive years in the 1990s.


Black-tailed Deer. Photo: Lee Eastman

Initiated in 2002, a black-tailed deer (*Odocoileus hemionus*) reintroduction project was implemented under a cooperative agreement with CDFW. The deer reintroduced under this effort have established a self-perpetuating herd with approximately 175 individuals indicated from 2015 survey results. The San Luis NWR elk population also has thrived since introduction. The herd has been reduced by capture and translocation efforts to keep the population suitable for the available native range, at 50–80 animals. It is also notable that there has been a lack of verifiable San Joaquin Valley kit fox (*Vulpes macrotis mutica*) sightings on refuge lands since 1997. The last known badger (*Taxidea taxus*) sighting occurred on the West Bear Creek Unit of the refuge in 1999. The lack of sightings suggests there may be undetected problems with maintaining populations of mid-level predators in the San Joaquin Valley.

Today, the San Luis NWR comprises 26,878 acres of fee-title lands with an emphasis on the protection and management of migratory birds, endangered and threatened species and key endemic species native to the diverse habitats of the northern San Joaquin Valley.

Grasslands WMA History

The Grasslands WMA was initiated from an easement program designed to protect additional wetland habitats adjacent to and in the vicinity of the San Luis NWR.

As neighboring wetland habitat became threatened by urban and agricultural encroachment, Complex staff recognized the need to purchase and manage sufficient land to accommodate the concentrations of wintering migratory birds using adjacent lands from August through May. However, limited budgets and staffing constrained management options. With the reauthorization of the Wetlands Loan Act in 1976, additional funds became available for migratory bird habitat acquisition, enabling Complex staff to pursue a conservation easement acquisition boundary for San Luis NWR—the Grasslands WMA.

The passage of the Wetlands Loan Extension Act in February 1976 increased the loan ceiling to $200 million and extended the loan through September 30, 1983, paving the way for easement purchases on prime waterfowl wintering areas in California. The Grasslands was one of the largest areas under consideration in California, as it encompassed 50,000 acres of privately owned and operated duck clubs, which were managed to provide wintering habitat for waterfowl. As Complex staff drafted the ascertainment report on the feasibility of an easement program within the Grasslands, intense interest in the program burgeoned. Virtually all inquiries from landowners within the Grasslands were of a positive nature. By the end of the report period, the easement program had the support of the Grasslands Water District Board of Directors, various local city governments, conservation organizations and most individual landowners.

Development of the easement acquisition program moved forward during 1977, aided by the approval of a Service-Wide Conservation Easement Program. Complex staff were challenged by delays in the processing of official paperwork, limited Federal Duck Stamp funds and continuing rapid loss of wetlands due to agricultural and urban development.

In 1978, the Migratory Bird Conservation Commission approved the Grasslands WMA acquisition boundary at 48,000 acres, allowing Complex staff to officially offer private landowners monetary compensation for perpetual conservation easements of their wetland habitats. The first conservation easement for the Grasslands WMA was 880 acres in 1979; an additional nine easements were acquired that year for a total of 5,120 acres.

As the easement program gained momentum during the 1980s, Complex staff had difficulties keeping up with the increasing workload. In 1981, a full-time easement program manager was hired. With dedicated staff for easements, additional functions beyond the absolute minimum for the program could be pursued. In addition to acquisition and basic management, technical assistance (TA) was provided on an as-needed basis for waterfowl plant production, control of undesirable vegetation, water management, livestock management, wetland and associated upland improvements and restoration grant opportunities.

Since the 1990s, there have been two dedicated staff working on the Grasslands WMA, although the exact positions and periods during which they are filled vary according to budgets. Their main duties, which have continued to the present, include prioritizing easement acquisitions, purchasing easements, performing easement compliance checks, resolving easement compliance issues, providing TA on natural resources to private landowners and conducting habitat restoration projects.

Visitor Services

As the San Luis and Merced refuges have expanded in scope and size since their establishment, so have the public use programs. The types of activities offered to the public (hunting, fishing, wildlife observation, environmental education, photography and interpretation) have remained constant over the years; however, public use infrastructure and public participation in activities have changed considerably.

Waterfowl hunting has been a constant at the San Luis and Merced refuges and was a dominant public use (by program management focus and public participation) during the early years of each refuge. Both refuges, beginning with Merced in 1951 and San Luis in 1968, managed public waterfowl hunting programs during their first several years of establishment. The early hunting programs were rudimentary and became more regulated and structured in the following decades. The first two decades of the Merced NWR hunt program featured a free-roam style shoot. In the 1980s, due to a trend of poor hunter success, the hunt program at Merced was reevaluated, and major changes were made to improve the quality: the daily hunter capacity was reduced and fixed blind sites were established. Later, hunting days per week at Merced were reduced to Wednesdays and Saturdays only, with half-day hunts (shooting time ending at noon). As with the Merced NWR, hunt areas and boundaries at San Luis changed over the years to improve hunting opportunities and facilitate other public uses, which were increasing in popularity. In 1980, the hunt area was consolidated on the western side of the refuge. This change allowed the waterfowl auto tour route, part of which was previously in the hunt area, to remain open for wildlife observation on waterfowl hunt days. Today, hunting remains a priority public use and several additional hunting units have been incorporated into the programs at the San Luis and Merced refuges.

The early emphasis was on hunting, but other public use activities such as wildlife observation and picnicking also occurred, though usually they were not allowed on hunt days. By the mid-1970s, both refuges were becoming more widely known and public visitation was increasing, especially following the introduction of a tule elk herd at the San Luis NWR. Auto tour routes for wildlife observation had previously been closed during waterfowl hunt seasons but began opening year-round in 1980. Although fishing has never been allowed at the Merced NWR, fishing received significant use in the early years at San Luis NWR, second in participation only to hunting. For many years, fishing at San Luis was only allowed seasonally during the non-hunting period but began opening year-round during the early 1980s. Wildlife observation was becoming more prevalent and by 1985, most refuge visits were for non-consumptive uses, such as wildlife observation and nature photography. During the 1990s, major public use infrastructure for wildlife observation was established, including interpretive panels along the auto tour routes, elevated wildlife observation platforms and interpretive kiosks.

In the early years of the San Luis and Merced refuges until the early 2000s, visitor services programs were conducted by a diverse assortment of staff primarily as collateral duties. In addition to managing the hunting, fishing and wildlife observation programs, staff also organized tours, school fieldtrips, public presentations and volunteer events, depending on availability. When public use, especially wildlife observation, began to increase during the 1980s through 1990s, refuge managers discussed in annual narratives the need for public use personnel to formalize the visitor services program. In 2005, the Complex hired its first outdoor recreation planner to manage the visitor services program. In 2014, a park ranger was added to the Refuge Complex's organizational chart to assist with conducting visitor services activities.

Fire

Prescribed Burn. Photo: USFWS

Fire management programs are necessary on all wildlands for public and natural resource protection; the program at the San Luis NWR Complex has evolved and grown during the last half century. The Complex's fire program has two main components: suppression, which involves putting out unplanned ignitions on wildlands to protect the public, infrastructure and natural resources; and fuels management using mechanical means or prescribed burns (reduction, habitat management and/or ecological process) to manage fuels.

During the 1950s and 1960s, the refuge (then consisting only of Merced NWR) experienced fire only as periodic accidental events sparked by downed electrical power lines or the activities of visiting fishermen or hunters. The local climate (an extended hot dry season) and a landscape of vast grasslands and uplands made the refuge particularly susceptible to these “natural” fire events from early spring through fall each year.

During the 1970s, Complex personnel began using fire as a management tool to achieve multiple goals. Prescribed fires were used for vegetation control—to remove dense litter, rank growth of weeds and other plants such as rushes (*Juncus* spp.), cattails (*Typha* spp.) and bulrush (*Scirpus* spp.) in marsh units, and to control target exotic species such as yellow starthistle (*Centaurea solstitialis*). Prescribed fires enhance habitat quality by opening loafing and feeding areas for geese and sandhill cranes (*Grus canadensis*); opening up grassland areas hunted by raptors; improving pasture foraging conditions for tule elk (*Cervus elaphus nannodes*); and revitalizing grassland and upland plant communities, especially native wildflower communities. Prescribed fires also were used to mitigate hazardous fuel accumulations and reduce wildfire potential in parts of the refuge units adjacent to public-use areas, such as roadsides along auto tour routes and areas adjacent to fishing and hunting access points.

In the 1950s through the 1970s, the Complex employed no personnel specifically trained in fire management or suppression. In the early 1980s, Complex staff started receiving specialized fire training by participating in regional activities, such as prescribed fire workshops and fire behavior courses. By the mid-1990s, the Refuge Complex hired its first Zone Fire Management Officer (FMO), whose fire-related responsibilities extended to other refuges within the Region: the Sacramento, San Francisco, Kern and San Diego Refuge Complexes. The objective of the FMO position was to assist in writing prescribed fire burn plans and to implement prescribed burns, with the assistance of collateral personnel trained in firefighting at the refuges throughout the zone. By the late 1990s, the Refuge Complex hired its first fire crew consisting of three wildland firefighters. In 1999, the refuge hired its first fire crew captain, and a second fire captain was hired in 2000. By 2009, the fire crew for the Refuge Complex consisted of 11 members: three permanent full time, four permanent seasonal and four temporary crew members.

The first firefighting crew was stationed at the Blue Goose unit on the San Luis NWR. Its quarters consisted of a double-wide trailer with a car port serving as an engine bay for the refuge’s first fire engine, a type 6 engine (light engine) with a 250-gallon slip-on pump package. Early firefighting equipment on the refuge consisted of small extinguishers, shovels and gunny sacks. By the end of 1999, a new fire program facility was completed at the Blue Goose location, consisting of a three-bay station with a training room and connected office. A new fire bunkhouse was constructed in 2004.

Along with the new fire station, the fire program acquired its first new fire apparatus—a 1,500-gallon water tender, and as a second type 6 engine. By 2009, the refuge fire program had at its disposal two type 6 engines, two type 3 engines (heavy engine), one water tender and four support vehicles (pickups used primarily for overhead and personnel transport).

In addition to firefighting and fire management activities at the San Luis NWR Complex and other refuges within the Zone, the San Luis crew has been dispatched to locations as far-reaching as Washington, Hawaii, Florida, Montana, Texas, West Virginia and Australia to assist with project burns and fighting wildfires.

Law Enforcement

Collateral duty officers conducted most law enforcement activities on refuges from the 1950s through the 1990s. These officers were Service staff consisting of refuge managers, assistant refuge managers, wildlife biologists and equipment operators that were trained to conduct law enforcement on refuges. Training consisted of an 11-week course at the Federal Law Enforcement Training Center (FLETC) and an annual law enforcement refresher course that lasted one week. Typically, these collateral officers spent a quarter of their time on law enforcement duties, although for some it was much less. During this period at the San Luis NWR Complex, there were usually two to five collateral officers on the staff. This coverage was considered adequate to deal with most of the law enforcement issues, which typically consisted of hunting violations and, to a lesser extent, trespassing into closed areas violations. Early hunting violations occasionally included shooting non-game species on the refuge units. Approximately 25 violations were issued per year. Perhaps the most high-profile case during this period was a tule elk poaching incident at the San Luis NWR.

During the 1990s, a shift occurred in refuge law enforcement programs, directed by the Service's national office, which focused on greater need for policing skills, procedures and techniques. This shift resulted in a decreased emphasis on game warden-type skills. Stations began receiving heightened law enforcement training; mandatory physical training and requirements; equipped law enforcement vehicles, radios and body armor; and access to law enforcement dispatch systems. The direction also aimed to focus on full-time refuge law enforcement officers (i.e., park rangers) instead of collateral duty officers. At the San Luis NWR Complex, this initiative resulted in the law enforcement program shifting from two to five collateral officers to one collateral officer and one full-time officer. The initiative resulted in two fully equipped law enforcement vehicles for the station. During the 2000s, the Complex typically issued 50 violations per year and documented another 100 incidents mainly for hunting and trespass violations. However, other crimes such as theft, dumping, marijuana cultivation, methamphetamine production and dumping, environmental crimes and arson have become more prevalent on refuge units. In 1999, the Complex obtained a police dog to work with the full-time officer. There has been no police dog in use on the Complex since 2008.

Current Management Activities

Prescribed Burn. Photo: USFWS

Most of the past habitat management, wildlife management, biological monitoring and research at the Complex are focused on migratory birds and wetland management. As the Complex's landbase increased and additional support staff became available, these activities were expanded to include additional wildlife species and other resource concerns. Currently, the Complex is actively managing upland and wetland habitats, as well as restoring riparian and other habitats, generally for the benefit of threatened and endangered species, migratory birds and resident wildlife species.

Habitat Management

Habitat management—the manipulation of vegetation, water and soil—is a major focus of the day-to-day management activities of the staff employed at the San Luis NWR Complex. The loss of the natural hydrology in the Central Valley coupled with land development for agriculture and human-dominated landscapes have resulted in the loss of many natural ecological processes that once maintained habitats and wildlife. Because of this fragmentation and disconnection from landscape scale processes, active management is necessary to maintain wildlife habitats to benefit wildlife populations at the Complex.

Wetland Management

Due to the large-scale alteration of the natural hydrology of California, wetlands in the Central Valley represent some of the most intensively managed habitats within the entire Refuge System. Active management is required for nearly all of the regularly flooded wetlands on San Luis NWR, Merced NWR and Grasslands WMA. The primary goal of wetland management is to produce a variety of high-quality habitats for migratory birds and other wetland-dependent wildlife. These include mudflats for foraging shorebirds; shallow wetlands with moist soil forage plants for waterfowl and wading birds; open water interspersed with emergent vegetation for resting and thermal cover; cattail/bulrush stands for nesting and roosting; summer wetlands for resident birds and other water-dependent wildlife; and deeper water habitats for diving ducks, grebes, cormorants and pelicans. Water for managed wetlands is supplied through various water irrigation districts, deep groundwater wells and lift pumps. It is conveyed via irrigation district canals and Complex-owned or privately owned canals, pipelines and other infrastructure. The canals are engineered so that most of the water moves by gravity flow. In some instances, lift pumps are used to move water from a channel or recirculation pond to another canal. The individual wetland basins (units) are linked to the conveyance systems with inlet structures; they have staff gauges installed to measure water levels and outlet structures to dewater the unit when necessary. These wetland units comprise a mix of artificial impoundments, modified/reshaped basins, former basins restored from leveled agricultural fields and natural basins. All of the artificial and most of the modified/reshaped or restored basins have constructed levees surrounding them but the natural basins do not. Most units can be managed independently; however, some units are linked in that the water from the outlet structure on one unit flows into another down-slope in a stair-step fashion and must be managed together. After filling the wetland units, adequate flows of water through the outlets are maintained to promote water quality.

Because of the importance of the Complex to wintering waterfowl, and the necessity of providing food for the hundreds of thousands of waterfowl and shorebirds that use these refuge units each winter, seasonal marshes make up the dominant wetland type (85–90 percent). Individual seasonal wetlands are dewatered on a staggered basis from late February through May to germinate moist soil plants and provide mudflat foraging habitat for shorebirds through the spring. They are irrigated one to three times in the spring and summer, depending on management objectives, and then flooded on a staggered basis from early September through late November. The timing of drawdowns, number of irrigations, duration of irrigations, soil type and other conditions determine the resulting composition of moist soil plant species and robustness of growth and seed production. In the Grasslands, managed seasonal wetlands are subdivided into several types based on the dominant species of moist soil plants present. These subtypes consist of swamp timothy (*Crypsis schoenoides*) units, watergrass units and mixed marsh units—which typically have a mix of smartweed (*Polygonum* spp.), watergrass and swamp timothy (*Crypsis schoenoides*) and are not strongly dominated by any one species. Other food-producing moist soil plant species associated with these subtypes include sprangletop (*Leptochloa fascicuaris*), spikerush (*Eleocharis* spp.) and ammania (*Ammannia coccinea*). These units are also usually vegetated with varying amounts of alkali bulrush (*Scirpus robustus*), hardstem bulrush (*Scirpus acutus* var. *occidentalis*), cattail (*Typha latifolia*), cocklebur (*Xanthium* spp.), aster (*Aster subulatus*), yellow sweet clover (*Melilotus officianalis*) and rush (*Juncus* spp.). These plant species are less desirable from a food production standpoint but provide thermal and escape cover for wetland birds.

Disked Wetland. Photo: USFWS

Semi-permanent wetlands are typically kept inundated from November through August to provide summer water for locally breeding waterbirds, such as grebes, coots (*Fulica americana*), ducks, common moorhens (*Gallinula chloropus*), herons, egrets and tricolored blackbirds (*Agelaius tricolor*). The wetlands are drawn down in late summer to germinate plants such as arrowheads (*Saggitaria* spp.), burrhead (*Echinadorus bertornoi*) and pondweeds (*Potamogeton* spp.) to provide a greater diversity of food resources for migratory birds. Although most of the semi-permanent wetlands occur in marshland environment, several oxbow ponds adjacent to the San Joaquin River and Salt Slough are connected to the Complex's water supply and can be managed under the same regime. Planned inundation periods for these ponds (December through July) have been chosen to emulate the natural period of flooding that occurred in the area prior to water diversions for agriculture and the damming of the rivers.

Permanent wetlands are inundated year-round and are used by the same breeding birds found in semi-permanent marshes. These ponds are generally deeper than seasonal and semi-permanent wetlands. The cattail/bulrush stands generally provide nesting and roosting cover, and the submerged aquatic vegetation, invertebrates and associated fish provide foraging habitat. Although they usually have a lower density of breeding birds, permanent wetlands typically have greater numbers of cormorants, pelicans, western (*Aechmophorus occidentalis*) and Clark's (*A. clarkii*) grebes and molting ducks. Productivity of permanent wetlands declines after the first two or three years of inundation and the numbers of most species using those ponds decrease. Therefore, they are drained about once every three to five years to oxidize the soils/sediments to re-stimulate productivity and to eliminate populations of common carp (*Cyprinus carpio*) and bullheads (*Ameiurus* spp.), whose presence reduce growth of submerged aquatic vegetation.

In addition to water manipulation, wetland management also includes mowing, disking, burning and herbicide spraying. Objectives for these actions are to maintain biodiversity, maintain desirable proportions of emergent vegetation in wetlands, enhance desirable species, reduce undesirable species and prepare for habitat restoration projects. Many of the seasonal wetlands are mowed each year after the irrigations with a farm tractor pulling a large disking implement. Much of this mowing takes place to control cocklebur (*Xanthium* spp.), an undesirable species that can overtake seasonal wetlands and crowd out desirable moist soil food plants. Mowing also is used to reduce encroachment of cattail/bulrush stands, open feeding areas and remove vegetation from islands and parts of levees to provide loafing habitat for waterbirds. In addition to annual mowing, the different wetland types must undergo physical disturbance every several years to keep the units in the desired habitat conditions. Wetlands under a stable management regime tend to lose productivity over time and become overgrown with emergent cattail/bulrush stands or other undesirable perennial plants such as Bermuda grass (*Cynodon dactylon*) and aster (*Aster* spp.). Seasonal and semi-permanent wetland basins are disked with heavy farm equipment every five to seven years. This replicates the periodic scouring flood events that occurred prior to the river being constrained by flood control levees. Cattail/bulrush stands and other undesirable plants are reduced, nutrients are more quickly recycled and soil is made bare to promote growth of pioneer species such as swamp timothy (*Crypsis schoenoides*), smartweed (*Polygonum* spp.) and watergrass. Greatest productivity of these moist soil plants generally occurs during the first one to two years after rehabilitation of the units. Prescribed burning is sometimes done in combination with disking as part of wetland unit rehabilitation. This is done most often in units with heavy stands of cattail/bulrush that would require multiple passes with a tractor and disk to control. Herbicide spraying is sometimes used when the unit is dewatered as a spot treatment to reduce and/or eliminate persistent stands of Bermuda grass and joint grass (*Paspalum distichum*) that are difficult to control solely by disking.

Wetland management techniques and practices are somewhat standardized across the units of San Luis NWR, Merced NWR and the Grasslands WMA. However, there are some differences in how wetlands management is accomplished based on location, development or restoration history, soil types, water supplies and management objectives. Differences in the management emphasis and overall description of the resultant managed wetlands of the individual units are described below.

San Luis NWR—San Luis Unit

The original portion of San Luis NWR lies between the San Joaquin River and Salt Slough (Figure 2-5). It is characterized by oxbows and overflow areas of the river and has heavy clay soils. Many of the existing wetland basins were enlarged or reshaped prior to or soon after Service acquisition. The majority of seasonal units are managed as mixed marsh or watergrass units with a heavy component of smartweed (*Polygonum* spp.). Many of the managed sloughs and oxbows have a corridor of willows and other riparian vegetation associated with them. Only a small portion of this unit had been leveled and converted to row-crop agricultural fields prior to refuge acquisition.

After the refuge was established, the roads around those fields were made into levees and the fields managed as monotypic watergrass units. In the mid-1990s the levees were reconfigured or removed, and the five rectangular watergrass units were de-leveled and reshaped into two more natural and diverse wetland basins that are now being managed as mixed marsh. The primary water supply to manage the San Luis unit wetlands is delivered water provided via the San Luis Canal Company. This delivered water is supplemented by lift pumps along channels off of Salt Slough and by groundwater from deep wells. C Canal is the main on-refuge conveyance facility and is linked both to individual wetland units and distribution canals that route water across the unit. Most of the drainage from the wetland units is routed through natural channels and excavated canals to Deadman Slough. This functions as a recirculation basin, and water is lifted from the slough and put back into distribution canals for reuse in other wetland basins. There are a total of 59 managed units (2,645 acres) consisting of seasonal, reverse cycle, permanent and semi-permanent wetlands on the San Luis unit. Maintenance flows and discharges from the wetland units ultimately are routed into Salt Slough, where the water helps maintain riparian habitats.

Figure 2-5. Wetland Units of the San Luis Unit of the San Luis NWR

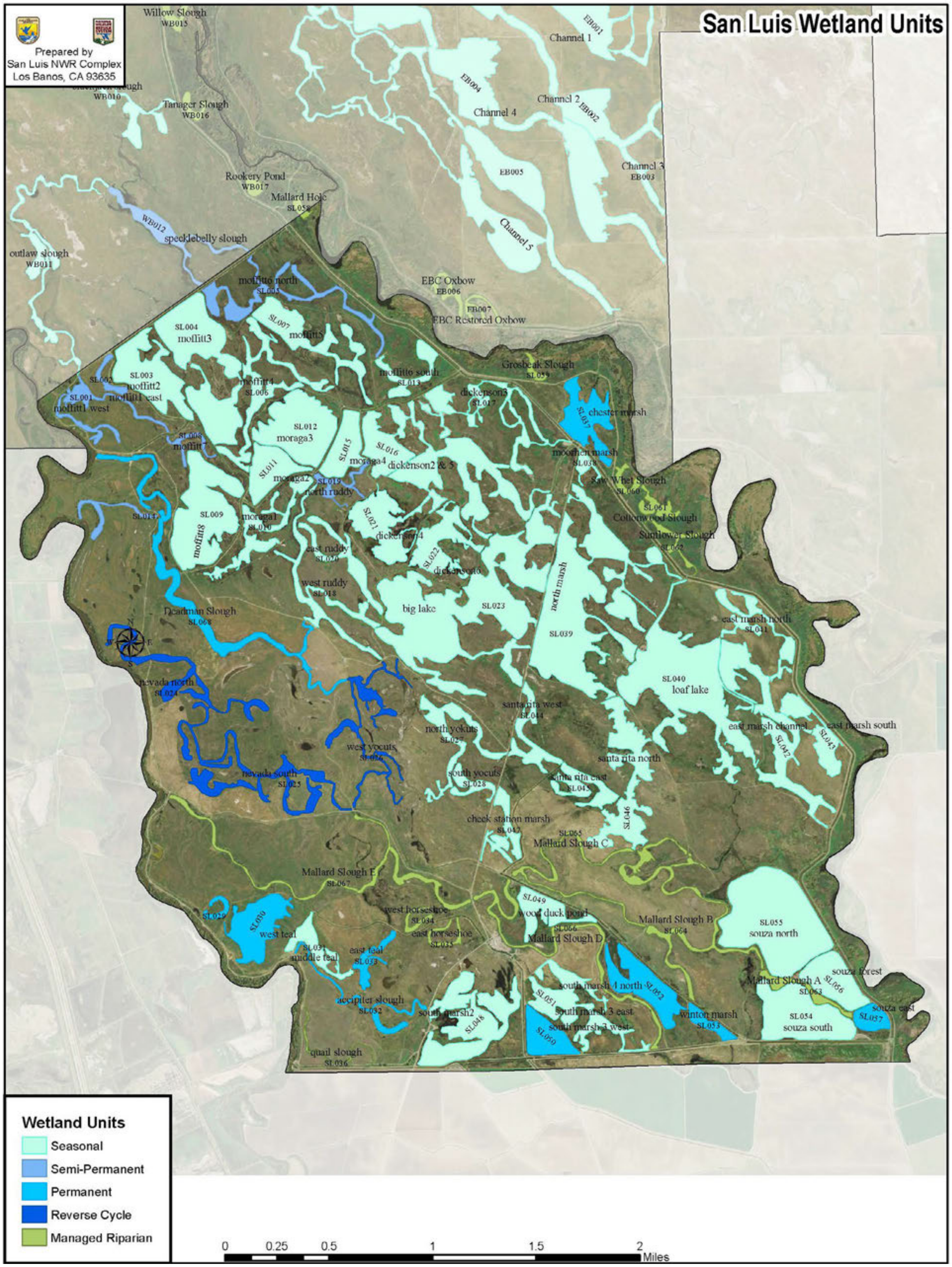
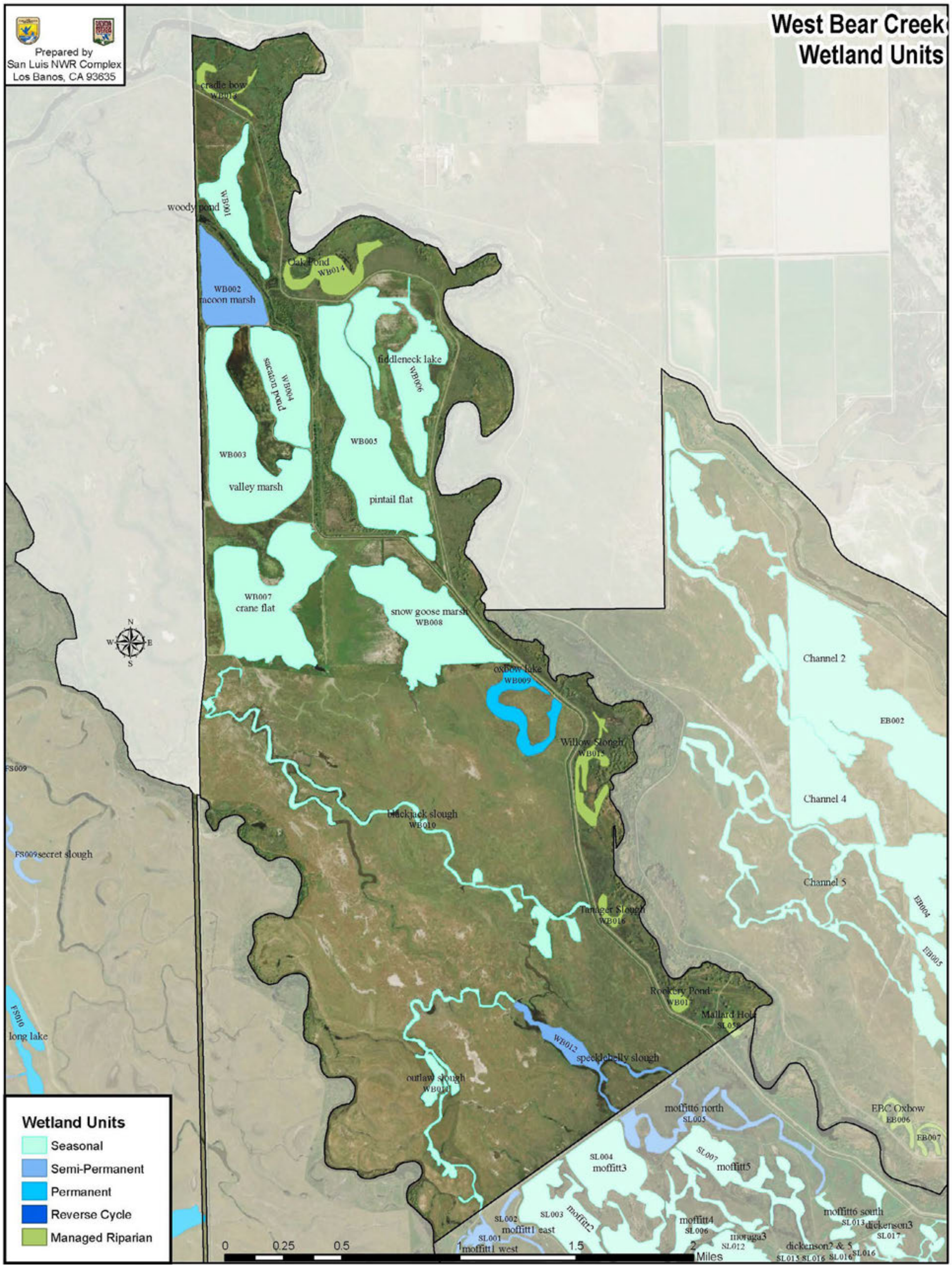


Figure 2-6. Wetland Management Units of the West Bear Creek Unit of the San Luis NWR



San Luis NWR—West Bear Creek Unit

The 3,995-acre West Bear Creek unit is a northward extension of the San Luis unit and is bounded on the east side by the San Joaquin River and Salt Slough and Highway 165 on the west (Figure 2-6). The north half had been converted to leveled row-crop farm fields by the previous landowner prior to Service acquisition. The south half remained as natural floodplain uplands, but the floodplain channels had been cut off from any flows from the river. The north half was restored back to a mosaic of wetlands, riparian forest and grasslands during 1995–1997.

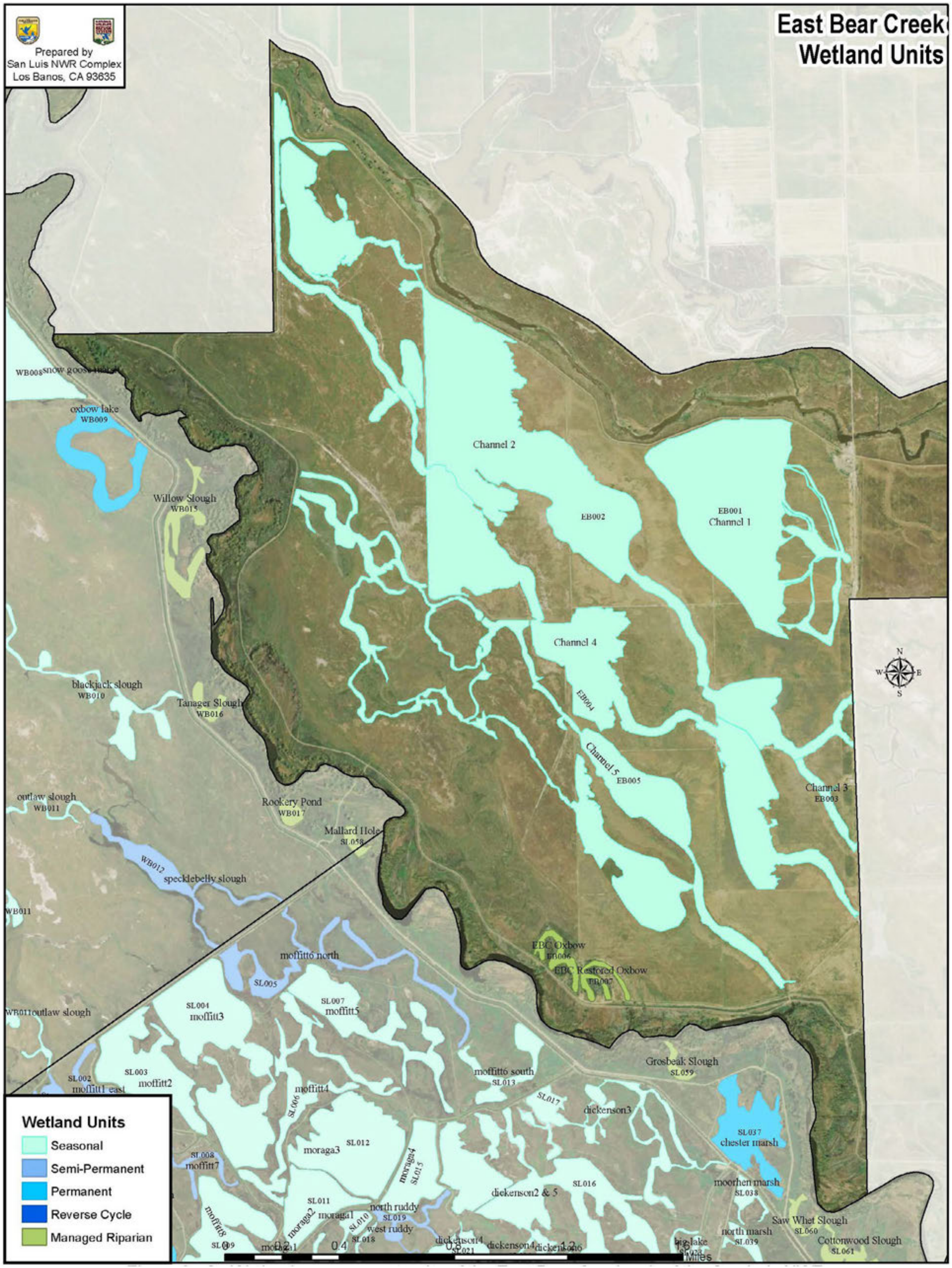
C Canal was extended from the northeast corner of the San Luis unit and is used to convey water to the floodplain channels on the south half and the wetland basins on the north half of the unit. The delivered water supply is supplemented by deep wells on the north half of the unit. Management objectives and practices differ between the restored wetlands in the north half of the unit and the floodplain channels of the south half. The seasonal wetlands in the north half are under a traditional management regime of spring drawdowns and subsequent irrigations to maximize moist soil food production for ducks and other migratory birds. Flood-up of those seasonal wetlands, however, is generally later in the fall (Oct–Nov) than at the San Luis unit due to limited capacity of C Canal and the desire to flood the San Luis unit first. The floodplain channels in the south half receive no summer irrigations and are flooded in early December through mid-June to replicate historic high-water flows of the San Joaquin River and Salt Slough. Those channel basins are not fenced off so that cattle grazing can occur up to the waters' edge to create short grass conditions and promote use by geese, long-billed curlew and sandhill cranes (*Grus canadensis*). Riparian oxbows on both the north and south sides of the unit are flooded from later November through June to also replicate historic flow regimes. There are a total of 21 managed units (758 acres) consisting of seasonal, permanent and semi-permanent wetlands on the West Bear Creek unit. Maintenance flows and discharges from the wetland units are routed through oxbows and restored riparian forest and ultimately into Salt Slough and the San Joaquin River.

San Luis NWR—East Bear Creek Unit

The 4,000-acre East Bear Creek unit is immediately east of the San Joaquin River from the San Luis and West Bear Creek units (Figure 2-7). It is bounded on the north by Bear Creek and on the west/southwest sides by the San Joaquin River and is a floodplain of the river and its tributary. Prior to Service acquisition, the east half had been converted to leveled irrigated pasture whereas the west half retained its natural topography. Part of the floodplain channels in the west half received tailwater from the pastures, but all were cut off from natural flows. The pastures were de-leveled and historic floodplain channels restored as part of a major habitat restoration project in 1998–1999. The water supply for the unit is delivered down Bear Creek, pumped out of the creek by a USBR-constructed lift pump facility and conveyed to the individual wetland channels via a pipeline along the east side of the unit. Habitat objectives are similar to that of the south half of the West Bear Creek unit and other floodplain areas throughout the East unit of the Grasslands WMA. Maximum flood-up of the floodplain channels occurs late in autumn and early winter and continues through early summer to create a mosaic of shallow wetlands with short grass to the water's edge. Focal species for this shallow open water management regime include geese, sandhill cranes (*Grus canadensis*), ducks such as northern pintail (*Anas acuta*) and American wigeon (*Anas americana*) and shorebirds. There are a total of seven managed units (more than 900 acres) consisting of seasonal and semi-permanent wetlands on the East Bear Creek unit. This is a newly restored unit and has inconsistent and unsecured water sources for management; the Complex is still finalizing its management including total size of its wetland management units. Maintenance flows and discharges from the floodplain channels and basins flow into the San Joaquin River and East Bear Creek, where the water helps maintain riparian habitat.

Wetland Habitat Management. Photo: USFWS

Figure 2-7. Wetland Management Units of the East Bear Creek Unit of the San Luis NWR

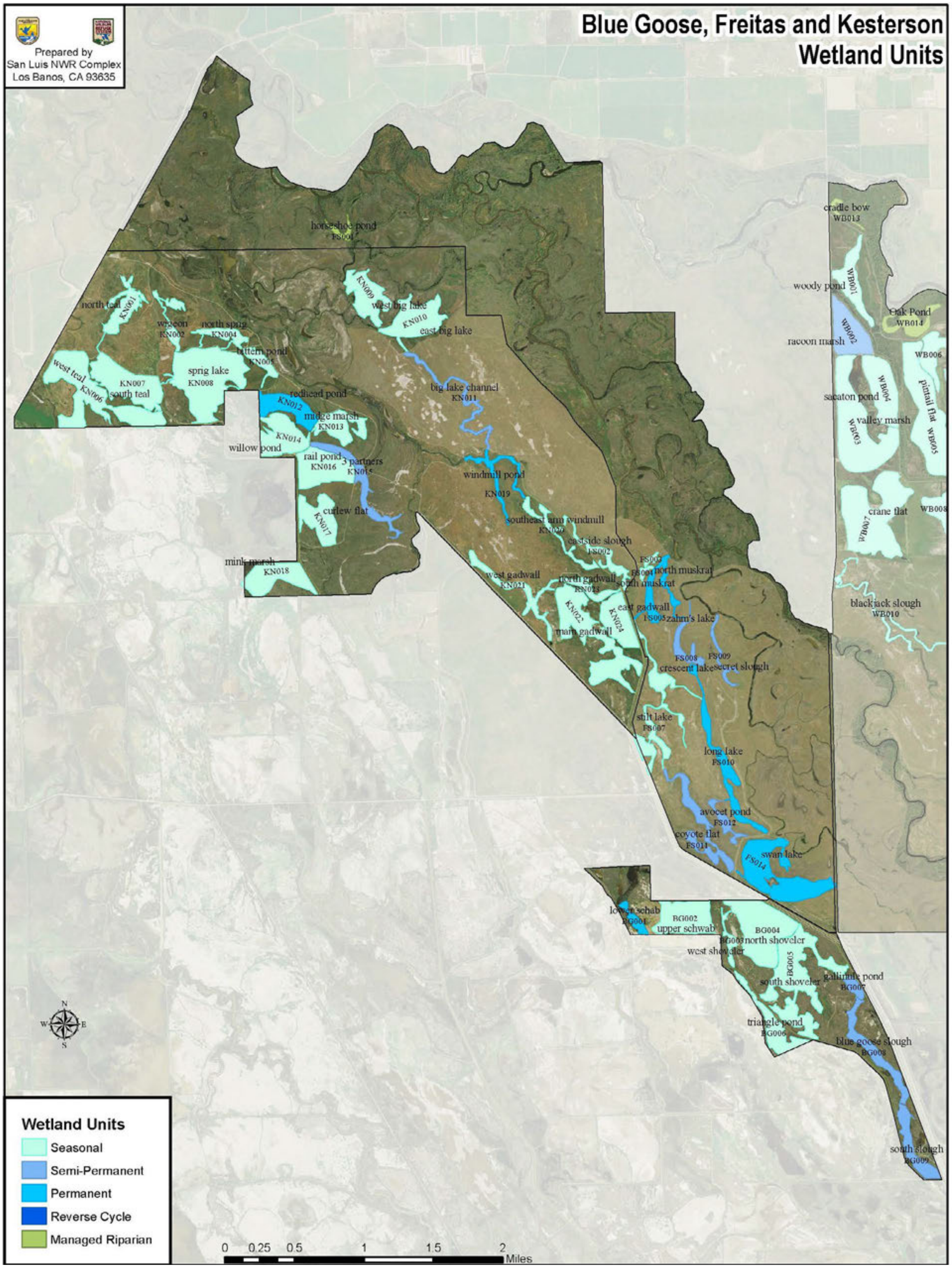


San Luis NWR—Kesterson/Freitas/Blue Goose Units

These units are bounded on the east by Salt Slough and on the north by the San Joaquin River and have Mud Slough and Los Banos Creek entering the unit(s) from the southwest and west sides, respectively (Figure 2-8). There is a great diversity of managed wetland habitats on these units. The wetlands on the Freitas unit are widely spread and mostly comprise oxbows and floodplain channels/basins associated with Salt Slough and the San Joaquin River. Water for these managed wetlands is provided by deliveries from the San Luis Canal and two on-refuge production wells. This area has a higher proportion of its managed wetlands providing summer water than elsewhere on the unit, with four units and a floodplain channel (162 acres) as permanent, semi-permanent, or reverse-cycle wetlands. The Blue Goose and Freitas units are situated on a terrace of higher ground than the Kesterson unit or the San Luis unit and have more alkaline soils. Because of this, most of the seasonal wetlands are managed as swamp timothy (*Crypsis schoenoides*) units and have a more open aspect than wetlands in the San Luis unit. However, extension of a delivery canal to allow summer irrigations, improvements in water quality of delivered supplies and increasing drainage capability since the early 1990s have allowed management for smartweed (*Polygonum* spp.) and watergrass on some units. Water for wetland management on the Kesterson and Blue Goose units is provided by deliveries from the San Luis Canal, Santa Fe Canal and Fremont Canal supplemented by two on-refuge wells. There are a total of 47 managed units (1,630 acres) consisting of seasonal, reverse cycle, permanent and semi-permanent wetlands on the Kesterson, Freitas and Blue Goose units. Maintenance flows and discharges from the wetlands of these three units are routed into tributaries and sloughs and ultimately into the San Joaquin River, where the water helps maintain riparian habitat.

Red-tailed Hawk. Photo: Rick Lewis

Figure 2-8. Wetland Management Units of the Western Units of the San Luis NWR

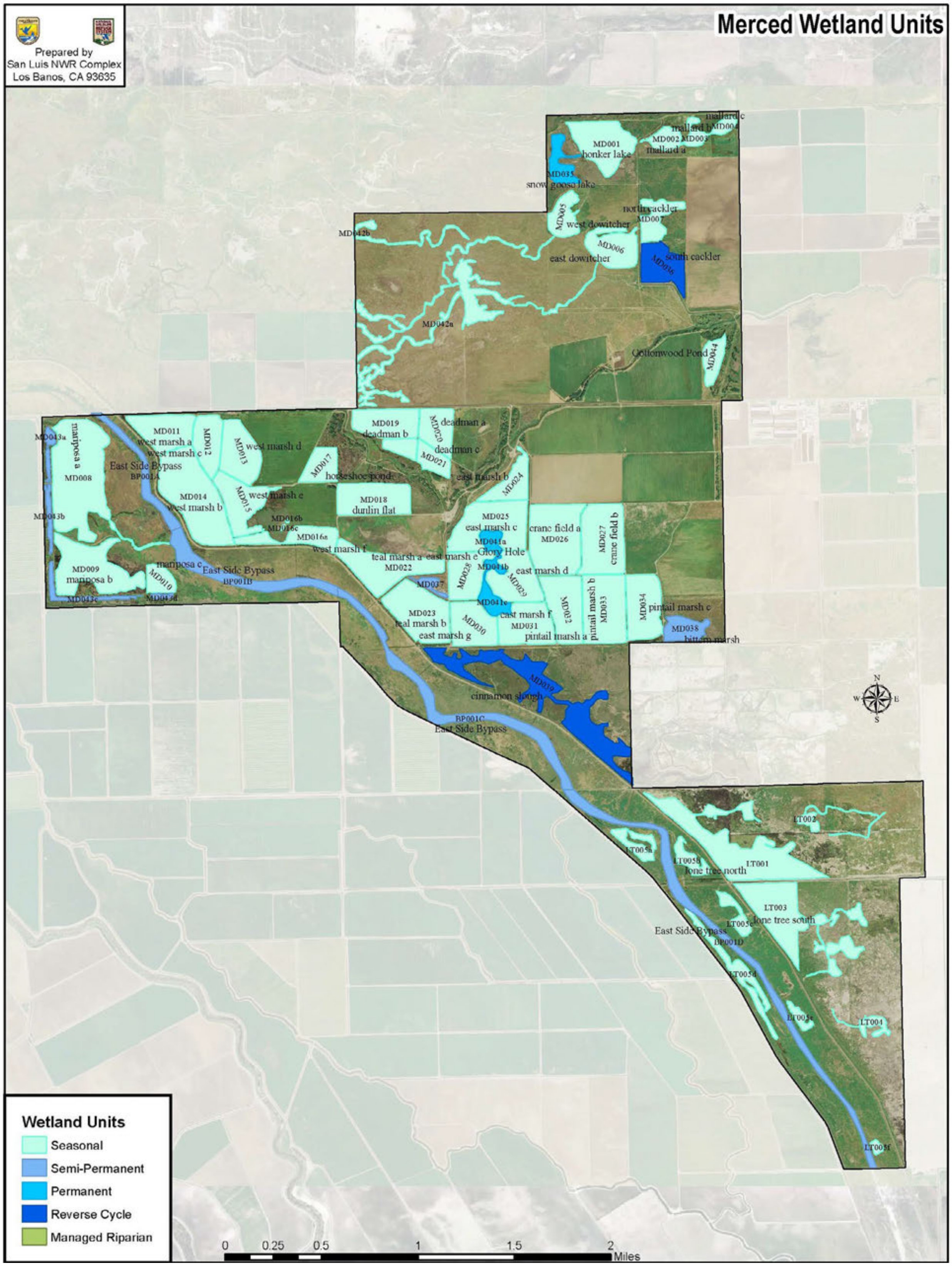


Merced NWR—Merced Unit

American Kestrel. Photo: Rick Lewis

Wetlands were developed on the original Merced unit by creating levees around the existing agricultural fields and installing structures to flood and drain the new units (Figure 2-9). This resulted in rectangular or otherwise artificial-looking wetland basins separated by levees and was further exacerbated by large-scale leveling of the pond bottoms and removal of most of the emergent cattail/bulrush stands in the late 1970s through funding provided by the Bicentennial Land Heritage Program. This allowed management for maximum production of watergrass and swamp timothy (*Crypsis schoenoides*) stands for dabbling ducks, but these monotypic habitats lacked diversity in plant species, water depths and significant use by other wildlife. By the early 1990s, efforts were initiated to de-level and reshape those wetland units to create more diverse wetland habitats. Wetland restoration on newly acquired lands was largely restricted to areas of wetland soils and basins designed with more natural shapes. The Merced unit is heavily used by arctic-nesting geese, sandhill cranes (*Grus canadensis*), northern pintails (*Anas acuta*) and shorebirds. Many of the seasonal wetlands are managed as large open-aspect swamp timothy (*Crypsis schoenoides*) units to accommodate the needs and habitat preferences of those species. However, there also is a diverse mix of watergrass units, mixed marsh with emergent cattail/bulrush stands, shallow floodplain basins and reverse-cycle wetlands as well as permanent and semi-permanent wetlands. Water to manage Merced unit wetlands is provided by MID deliveries to Deadman Creek, flows from Duck Slough and on-refuge wells. Because the irrigation district usually ceases water deliveries through its system by November 1, Merced unit wetlands tend to be flooded earlier in the fall than those in the San Luis NWR. Most seasonal wetland units are flooded by the end of October, which maximizes use of the refuge's water allotment and provides habitat for early arriving northern pintails. These wetlands then must be maintained by wells until spring. The Merced unit has a total of 44 managed units (approximately 1,637 acres) consisting of seasonal, reverse cycle, permanent and semi-permanent wetlands. Maintenance flows and discharges from the Merced unit wetlands are routed into the Mariposa Bypass and ultimately the San Joaquin River, where the water helps maintain riparian habitats.

Figure 2-9. Wetland Management Units of the Merced Unit of the Merced NWR



Sandhill Cranes on Tour Route. Photo: Rick Lewis

Merced NWR—Arena Plains Unit

Managed wetlands on the Arena Plains unit occur on a much lower density than those on the Merced unit and are surrounded by large expanses of short-grazed annual grasslands (Figure 2-10). They are almost all natural basins that historically were maintained through artesian flows and remained flooded all year. Those flows ceased after local development and drainage projects lowered the water table in the surrounding area. Subsequently, water control structures were installed to link the basins to water sources from the Atwater Drain and on-refuge wells. Most of the basins are managed as seasonal wetlands. However, the units are not irrigated. This is because the management focus for wetlands at Arena Plains is not maximum moist soil food production but rather roost/loafing habitat for sandhill cranes (*Grus canadensis*), arctic nesting geese and other waterfowl adjacent to short-cropped grassland habitat. This is partly due to the lack of a water supply and lack of funding to operate wells. The Tricolored Slough unit has a management objective as a permanent wetland, but attainment of that goal varies by year depending on adequacy of flows from the Atwater Drain and activities of beavers that persist in damming the channel leading to the slough. There are a total of five managed units (344 acres) consisting of seasonal and permanent wetlands on the Arena Plains unit.

Merced NWR—Snobird Unit

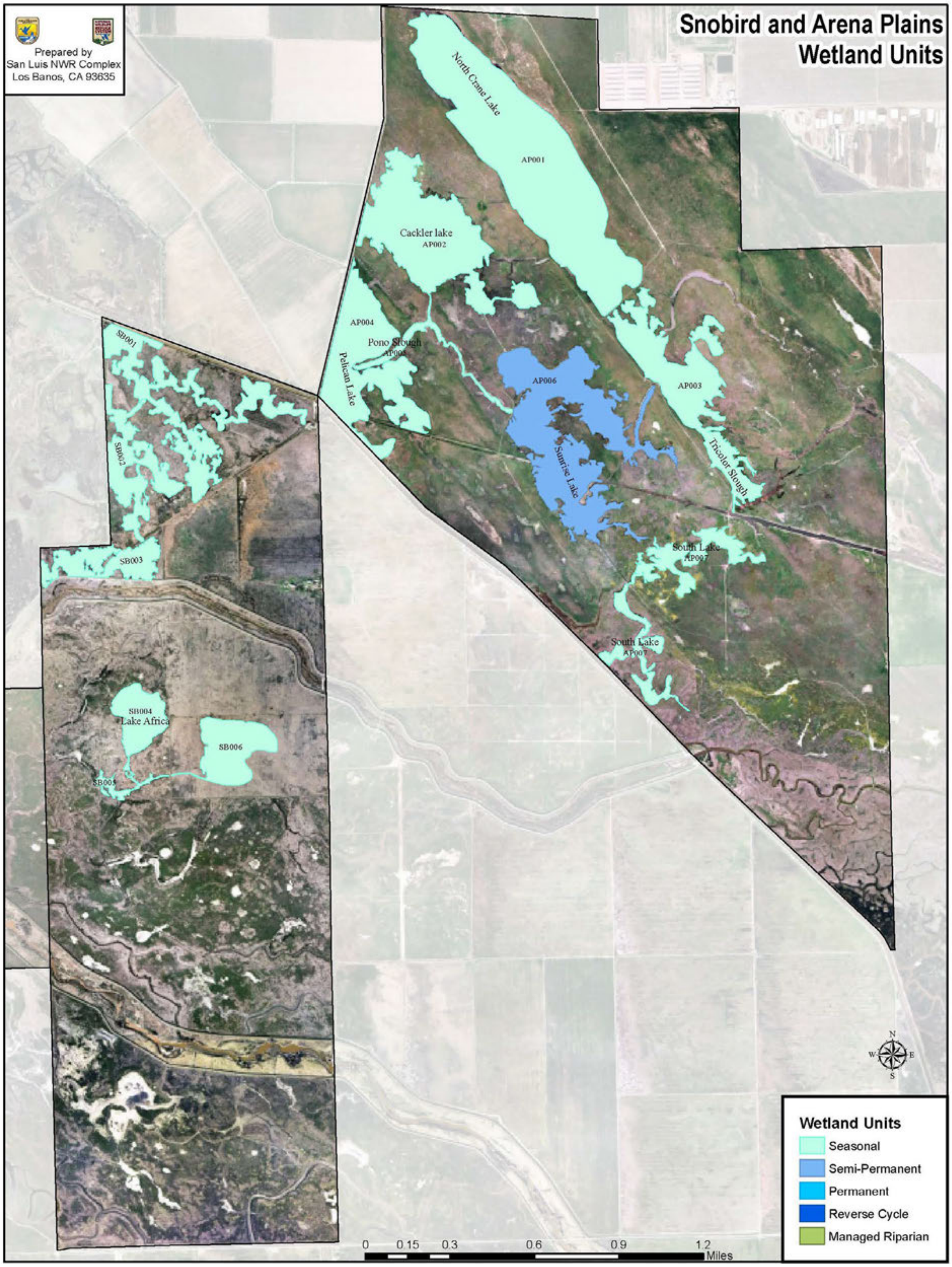
Because of inoperable wells, lack of funding to repair them and lack of funding to run wells, there has been minimal active wetland management on the Snobird unit. However, an opportunity arose due to actions by the San Joaquin River Restoration Program (SJRRP). The

SJRRP compelled the removal of two weirs in the Eastside Bypass in the middle of Merced NWR. Although these weirs allowed the refuge to back water up and create up to 175 acres of shallow wetlands for waterbirds, they were viewed as obstructions to fish movement through the Eastside Bypass, where SJRRP restoration flows are currently diverted.

To replace these 175 acres of shallow wetlands, the Snobird unit was targeted because it has existing—but dry—wetlands, no water supply and no funding to repair or power wells for the water supply. In fiscal year (FY) 22, the SJRRP funded the repair of three wells and the construction of a 200-kW photovoltaic array to power them. The photovoltaic array is expected to go under construction in early 2023.

The previous landowner installed berms that caused artificial flooding of several high-quality vernal pools, destroying their integrity and function, and ultimately prompted a lawsuit filed by the USFWS to protect USFWS interests associated with a purchased conservation easement. Complex staff later completed a major restoration project to remove the berms installed by the previous landowner to allow management of wetland basins and floodplain channels where appropriate. Once restored and flooded, the wetlands in the northern portion of the unit are primarily managed for moist soil plant food production as mixed marsh, and those in the middle and southern portions primarily as floodplain channels and basins.

Figure 2-10. Wetland Management Units of the Snobird and Arena Plains Units of the Merced NWR



Grasslands WMA

The privately owned wetlands in the Grasslands WMA are managed by individual duck clubs or landowners, and management varies widely in terms of the intensity of management applied. Historically, many of the duck clubs were flooded just prior to waterfowl hunting season, drained immediately after the season concluded and grazed by cattle until the following fall. However, in recent years, landowners have been improving water management infrastructure and implementing summer irrigations, disking, mowing, burning and other wetland management practices. Some use contract or resident habitat managers and receive TA from Service or CDFW biologists. In some instances, the intensity and effectiveness of management rivals that of the NWRs and State Wildlife Management Areas. More than 95 percent of the private wetlands are managed as seasonal wetlands, but a few of the properties manage permanent and semi-permanent wetlands. The overall habitat characteristics and management emphasis vary within the Grasslands WMA based on location. The area south of Los Banos (South unit) is dominated by alkaline soils. Wetlands there are typically large open-aspect swamp timothy (*Crypsis schoenoides*) units having both alkali (*Scirpus robustus*) and roundstem bulrush (*Scirpus acutus* var. *occidentalis*) as dominant emergent vegetation. The area north of Los Banos and west of the San Joaquin River (West unit) has more variable soil types and is bisected by historic slough channels. Although many of the seasonal wetlands there are large, open-aspect swamp timothy units, others are managed for watergrass and mixed marsh. There is an overall greater amount of emergent cattail/bulrush stands, and scattered willow corridors occur along slough channels. The area east of the San Joaquin River (East unit) is the floodplain of Bear Creek, Gravel Slough, Mariposa Creek and other tributaries of the San Joaquin River. Soils are generally less alkaline than those of the West and South units but range from sand to heavy clay soils. Many of the landowners manage their wetlands in conjunction with seasonal cattle grazing, and some have begun to implement prescribed fire regimes. Those wetlands, often floodplain channels and sloughs, are managed as a variety of seasonal wetland types but generally retain an open-aspect character. Wetlands where cattle grazing is excluded often develop into mixed marsh with dense stands of cattail/bulrush.

Vernal Pool Management

Vernal pool management is much less intensive than wetland and upland habitat management. No artificial flooding or other water management techniques are conducted in vernal pool habitats. Primary management of vernal pools consists of strict protection of sites and avoidance of all forms of soil disturbance. This maintains the hydrological integrity of the sites by allowing precipitation to travel across uplands and fill individual pools. Any disruption to hard claypan soils breaks up their impermeable layers and allows water to percolate into the ground. Vernal pools and alkali meadows are allowed to fill and dry naturally, based on annual precipitation, flood events and evaporation. Artificially alterations of this hydrologic regime would threaten the abundance and diversity of rare and endemic plants and animals that exist on these sites.

Invasive species present a significant threat to native plants and animals in vernal pool communities. Cool season annual grass species are widespread in vernal pool communities in the

San Luis NWR Complex and create thick layers of thatch. These layers can suppress native grasses and forbs that germinate in the late winter and early spring along the edges of vernal pools. These weed species also can choke flooded vernal pools, thereby decreasing the amount of open water and altering water chemistry for native invertebrates. Seasonal cattle-grazing during the winter months is used to decrease invasive species cover, reduce thatch layers and ensure vernal pool basins remain open. Cattle feed on the non-native annual grasses all winter and are removed as native grasses and forbs begin to develop in the late winter and early spring. Prescribed fire is also used to reduce weed and thatch cover adjacent to vernal pools. Several pilot projects have been initiated to quantify the effectiveness of these techniques.

Tule elk (*Cervus elaphus nannodes*) and pronghorn antelope (*Antilocarpa americana*) historically grazed the vernal pool landscapes of the Central Valley until being extirpated and replaced by domestic cattle and sheep. The grazing function performed by the elk and antelope are now carried out on the refuge Complex with controlled grazing by cattle and sheep. Grazing, along with prescribed fire, is used to control the excess growth of exotic grasses and forbs, and protect existing vernal pool habitats from invasion.

Uplands Management

Grazing Program Cooperator Herding Cattle on Horseback. Photo: USFWS

Management of upland habitats (grasslands, irrigated pastures and croplands) includes grazing by cattle and/or sheep, planting and seeding native plant species, prescribed burning, invasive weed control and custom farming by cooperators. These habitat management techniques, as well as some limited disking and mowing, are implemented each year to benefit resident and migratory wildlife populations. Figures 2-11 and 2-12 provide the maps of management units for the San Luis and Merced NWRs, respectively.

Figure 2-11. Upland Management Units of the San Luis NWR

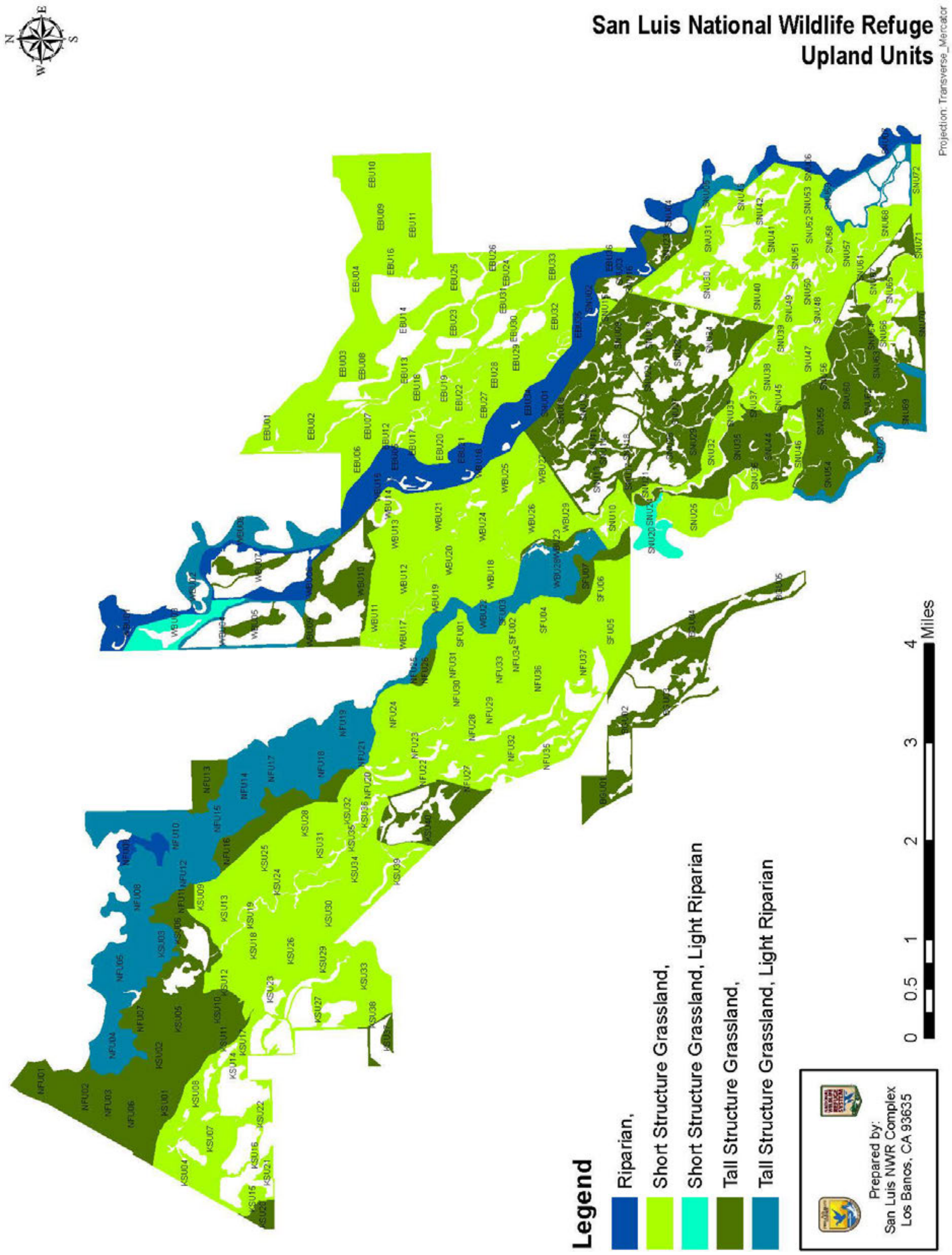


Figure 2-12. Upland Management Units of the Merced NWR

Native Grasslands. Pursuant to the refuge vision to conserve, protect and enhance native wildlife populations and the ecological processes on which they depend, the Service has acquired lands and conducted grassland restoration to benefit the State of California's grassland ecosystems and species that depend on those ecosystems. Currently, 70 percent of Complex land is managed as grasslands with 4,961 acres at Merced NWR and 15,284 acres at San Luis NWR.

Grasslands in the Complex are grazed with the primary objective of providing short grass foraging habitat for wintering geese, sandhill cranes (*Grus canadensis*) and other migrating species. These grasslands also are treated with prescribed fire to enhance habitats for resident and migratory wildlife. Fallow fields, considered a type of grassland, are planted with native grasses and forbs, and grazed to enhance the diversity of the biological community. Invasive weed management (herbicide application) is used to combat non-native noxious weeds that otherwise diminish the habitat value for wildlife. Grazing, prescribed burning and herbicide applications are the primary tools used to enhance grassland communities in the Complex. Where appropriate, supplemental seeding and planting of native grasses and forbs is applied to enhance the habitat conditions for wildlife including migratory birds.

In 2006, the Complex conducted a vegetation survey on the San Luis and Merced NWRs to determine abundance, habitat use and grazing impacts to grassland birds on the refuges. The study indicated that the grasslands of San Luis and Merced NWR are dominated by a few, non-native annual grass species with very few native forbs and grasses interspersed throughout. Native forbs and grasses identified during the survey were alkali heath, salt grass, spike weed, creeping wildrye, rush spp. and gumplant. Non-native species occurring in surveyed areas were yellow starthistle (*Centaurea solstitialis*), prickly lettuce (*Lactuca serriola*), little mallow and black mustard. The introduced annual grass species included ripgut brome (*Bromus diandrus*), wild oats (*Avena fatua*) and cheat grass (*Bromus tectorum*).

Newly restored and existing native uplands are currently managed with grazing, herbicide application, mechanical treatments and prescribed fire. These treatments are implemented to control invasive weeds; reduce non-native annual grass growth and cover; increase native perennial grass growth and cover; encourage the growth of native forbs; maintain the grass as short grass forage for arctic nesting geese, sandhill cranes and other migratory birds; reduce vegetative structure for kit fox and burrowing owls; and maintain vernal pool communities.

Herbicides often are considered as the most cost-effective method for large-scale control of invasive weedy plants; however, when used alone, they are ineffective for long-term control, necessitating their use in conjunction with other management techniques like fire, grazing and mechanical treatments.

Irrigated Pasture. Irrigated pastures of the Merced NWR are under a year-round rotational grazing regime such that cattle graze individual pastures for approximately eight months of each year. Over time, irrigated pastures need to be rehabilitated to restore habitat value to wildlife. Several habitat techniques are used in sequence, including prescribed burning, disking and/or mowing and invasive weed control. A wildlife-friendly mix of pasture grasses are planted using a seed drill into the pasture and allowed to grow before placed in the grazing rotation again.

Croplands. Croplands at Merced NWR are farmed to provide winter forage for geese, sandhill cranes (*Grus canadensis*) and other migratory birds. Corn and winter wheat are the primary grain crops grown. To optimize the benefits to wildlife, croplands are rotated between corn and winter wheat on a two- to three-year basis. Disking and mowing are primary wildlife management techniques used to make the crop available to targeted wildlife species. Under certain circumstances, a prescribed fire is used to remove heavy thatch of weeds and other residue remaining after the growing season is completed.

Riparian Forest Management

Riparian forests are managed at a much lower level of intensity than other habitat types at San Luis and Merced NWRs. Active habitat manipulation of riparian forests generally has been limited to exclusion of grazing, herbicide application, wildfire suppression and restoration planting. Riparian corridors along the San Joaquin River, Salt Slough and Mariposa Creek are fenced off with permanent barbed wire or temporary electric fencing to exclude cattle or sheep grazing in adjacent uplands. This has allowed recruitment of new trees and establishment of understory and mid-story riparian vegetation. Herbicide spraying is used to a limited extent in some riparian areas to control non-native invasive weeds, such as perennial pepperweed (*Lepidium latifolium*), and to promote the establishment of native plants. Riparian planting has been conducted to increase species diversity in existing riparian corridors and to reestablish riparian forest in newly acquired lands. These riparian plantings generally have been done as part of larger habitat restoration projects or challenge cost-share and implemented by Complex staff and volunteers. Some of the larger efforts have included planting projects at the West Bear Creek unit of San Luis NWR and at the Merced unit of Merced NWR.

Management activities of riparian habitats at the Complex include protection and restoration. All riparian areas are protected from livestock-grazing and physical disturbance. Active habitat restoration is also periodically conducted, particularly at the San Luis NWR, by planting suitable riparian vegetation along water courses.

Habitat Management Techniques

This section covers the specific techniques (such as disking, mowing, planting/seeding, prescribed burning and grazing) that are used to manage habitats in the Complex. Water management as a habitat management technique is described in its own section.

Ground Squirrel. Photo: Lee Eastman

Disking. Disking vegetation is an important wetland management technique that has a variety of uses, and is commonly used in managed wetlands to reduce vegetation that has exceeded beneficial quantities or distributions required for wildlife-use objectives. Reduction and partial control of bulrushes (*Scirpus* spp.), cattails (*Typha* spp.) and other plant species are the benefits of a wetland disking program. Caution must be exercised in some wetlands where disking can enhance or spread undesirable vegetation, such as perennial pepperweed (*Lepidium latifolium*) or cocklebur (*Xanthium* spp.). In addition to reducing vegetation and controlling undesirable plants, disking also creates a seedbed conducive to germination and seed production of desirable moist soil plants. Seasonal wetlands at the Complex—usually as part of the standard moist soil management regime—are disked for seedbed preparation once every five to 10 years. Disking in wetlands is also used to create openings near islands and levees to benefit loafing wildlife.

Disking vegetation also is an important upland management technique, although only used on a limited basis at the Complex. Disking along primary roads and fencelines is important to reduce wildfire danger or to prevent the slop-over of a prescribed burn. Disked fuelbreaks are used to protect life and property from the spread of a fire off and onto refuge lands. Disking also is used for management of the Complex's croplands on an as-needed basis.

Mowing. Mowing vegetation is an important habitat management technique used to enhance wetlands, control a variety of invasive species within wetlands and uplands, reduce fire risk and accomplish general weed maintenance near facilities. It is usually conducted with a tractor pulling a large mowing implement but may also be accomplished with all-terrain vehicles (ATVs) pulling small landscape mowing equipment. Weed-eaters and hand-mowers are used to control the growth of non-native invasive species near recently planted native vegetation. In wetlands, mowing is the primary habitat management technique used for controlling undesirable plant species such as cocklebur (*Xanthium* spp.). By mowing prior to the plants setting seed, cocklebur (*Xanthium* spp.) can be reduced to a more manageable area and density, thus allowing for a greater diversity of desirable species within the managed wetlands. Mowing is used for keeping islands and levees clear of vegetation to benefit wildlife use. Whenever the benefits to wildlife are equal, mowing is used instead of disking to minimize erosion and invasive species expansion.

Tractor Disking Wetland. Photo: USFWS

Mowing vegetation also is an important habitat management technique used to manage invasive species and reduce the spread of a wildfire in uplands. Grazing and prescribed burning are preferred habitat management techniques. Where grazing and/or burning is not attainable, consecutive mowing of non-native plant seed heads will reduce the soil seedbank. Also, mowing roads, roadsides and levees around facilities help reduce the risk of a wildfire spread through vegetation reduction during the growing season.

Grazing. Grazing is an important habitat management technique used on refuge lands. Benefits include the reduction of plant material, reduction of non-native invasive weeds, increases in native plants—including Special Status plants due to reduced competition for sunlight, water and nutrients—and increases in native wildflowers in vernal pools. Grazing provides optimal foraging habitat for migrating avian species by reducing grass height and contributing organic matter for the prey base. Grazed areas support increased numbers of primary burrowing mammals such as ground squirrels (*Spermophilus beecheyi*) and secondary burrowing animals, such as burrowing owls (*Athene cunicularia*) and various species of snakes.

Grazing also can impact some wildlife and habitat in a negative way by reducing nesting cover for some waterfowl, shorebirds and harriers. These impacts are considered minimal due to the seasonality of the grazing program and the amount of refuge lands not grazed.

Primary long-term benefits from grazing include annual native plant production, non-native invasive plant species control and maintenance of annual and seasonal use of refuge lands by migratory birds and resident deer. Short-term impacts of grazing on local ground-nesting birds would be mitigated by the long-term improvements on plant species composition and structure.

Grazing is facilitated through cooperative agricultural agreements (CAAs) with local cooperators. Benefits of the CAA program are the cooperators' shared responsibilities in maintaining corrals, fences, gates, cattle water systems and invasive weed control. In consultation with the cooperators, the Complex develops annual grazing plans to produce the desired habitat conditions and maintain the long-term viability of the grassland community. Grasslands are generally grazed from December 1 through June 1. Cattle are rotated between separate grazing units to avoid overgrazing. In wet springs, grazing may be extended through June to control noxious weeds from invading these grasslands.

Planting/Seeding. Planting/seeding to establish native vegetation is an important habitat management technique used to enhance refuge uplands. Uplands, in particular fallow fields, are restored frequently through direct planting of cuttings, nursery stock or the spread of native seed. Trees are restored along historic slough channels using direct cuttings or potted stock grown locally. Shrubs are restored from seeds or locally sourced seedlings. Grasses are drilled into the ground or planted as plugs in clusters over most of the restored area. Tree, shrub and grass species are all used to meet habitat and wildlife objectives on refuge lands. These are common methods for restoring or enhancing habitat for the benefit of wildlife. The use of the most local genetic stocks for any plantings helps to increase the chance of success.

Prescribed Burning. Annually, 3,000 to 7,500 acres of wetland, vernal pools and grassland habitats are burned on the Complex. Prescribed burns are conducted in accordance with both DOI and Service Fire Management Policy (621 FW 1-3 of the Service Manual) and the Interagency Standards for Fire & Aviation Operations. Use of prescribed burns for habitat management and hazardous fuel reduction is consistent with both the approved habitat and fire management plans for the Complex. Individual prescribed burn plans are written, reviewed and approved for each unit as outlined in the Interagency Prescribed Fire Guide. The burn plans include a variety of information detailing how the burn will be conducted, considerations for safety and measures to minimize impacts to sensitive species and air quality. All prescribed burns are conducted in compliance with the Clean Air Act and associated state permitting requirements.

Prescribed burning is a tool that managers use to recreate natural conditions on the landscape under controlled conditions. Using a variety of tools, such as computer modeling and spot weather forecasting, fire mangers can predict the direction, intensity and rate of spread of a prescribed fire. Using these tools, fire managers can determine if the objectives of a prescribed fire can or will be met given the predicted conditions.

At the San Luis NWR Complex, prescribed burning is used on upland, wetland, riparian areas and vernal pool habitat for a variety of reasons. In general, prescribed fires reduce the overall amount of vegetation in an area and therefore reduce the probability and lessen the intensity of future wildfires. At the San Luis NWR Complex, hazard fuel reduction is an objective of all prescribed burns. However, this is not the sole reason or benefit for conducting prescribed fires. There are many resource benefits to implementing prescribed fires, including removing invasive plant species, reducing the overall amount of vegetation for wildlife improvement, enhancing desirable species and recycling nutrients.

All prescribed fires generally are implemented in a similar fashion. A fire break or line is established around the burn unit. This fire break can be established by a tractor with a disk or mower. It also can be a natural or man-made barrier such as a stream or a road. A test fire is conducted to determine if the conditions on the ground represent what was predicted using computer modeling. Spot weather forecasts help ensure that the fire will not escape the burn unit. If the burn boss interprets the test fire to suggest that the objectives of the project can be met, the prescribed fire continues. Firing is done in such a way to allow for wildlife to escape through back firing or letting the fire back into the wind and leaving gaps in the ignition sequence. After the project is completed, an After Action Review (AAR) is conducted that includes all personnel who participated on the project. The intent of the AAR is to discuss what went right with the project and ways to improve safety and implementation in the future. Upon the completion of the AAR, the remaining personnel stay onsite for mop-up or until there is little to no smoke showing on the control lines. The frequency of these projects is determined by the monitoring of the results to see if the resource objectives are being met.

Water Management

The management of the Complex's wetlands, irrigated pastures and croplands is dependent on the availability and efficient management of water each year. Water management demands the greatest level effort from the staff and requires the highest level funding for any activities at the San Luis NWR Complex. Water management is conducted by the Complex staff at the Merced and San Luis

NWRs as well as independently by private landowners on the easement lands composing the Grasslands WMA. Large quantities of water are required to manage wetland habitats in this semi-arid region. During a typical year, eight acre-feet of water per year is needed to manage one acre of seasonal wetland; 10 acre-feet of water per year is needed to manage one acre of permanent wetland; and two acre-feet of water is needed per year to manage one acre of irrigated pasture. The source, quantity and quality of water used on the Complex for wildlife management has varied during the history of the different refuge units (Figure 2-13).

Merced NWR

Historically, the lands that now constitute the Merced NWR were once made up of a mosaic of perennial grassland and wetland habitats. These wetlands varied from slough and river channels winding their way through the landscape, often inundating the uplands with floodwaters to seasonal wetlands and vernal pool complexes during the late winter and spring. With the increased interest in water reclamation projects to supply irrigation water for agriculture during the 1940s and 1950s, and the subsequent construction of flood control levees and diversion of rivers and sloughs in the northern San Joaquin Valley, natural hydrologic functions have been greatly reduced. Today the Merced NWR depends entirely on artificial (man-made) water conveyance systems. Securing adequate water supplies at acceptable water quality levels, while also maintaining the water conveyance system, has been critical to refuge management.

The water conveyance system on Merced NWR comprises deep wells, lift pumps, earthen canals, drainage ditches and a polyurethane pipeline to move water throughout the refuge (Figure 2-13). Most of the refuge is served by a pipeline that transports delivered surface water (primarily from Merced Irrigation District) lifted from Deadman Creek during the irrigation season (April through September) by five lift pumps or via 15 deep wells from October through March. The refuge is working with Merced Irrigation District (MID) to achieve delivered water during the months of March and October to reduce reliance on the groundwater system and reduce operational costs. The pipeline either feeds water directly into wetland basins or agricultural fields through valve inlets or into a canal that then delivers water through water control structures. An additional six deep wells, unattached to the pipeline, supplement wetland management needs. Water control structures regulate the amount of water entering or leaving wetland units. Water control structures are built of either corrugated metal pipe or plastic pipe attached to precast concrete weirs. A final weir component is a metal, cement, or wooden headwall that prevents erosion from occurring around the structures. Wetland basins not supported by the pipeline utilize a weir inlet from a canal and all basins are discharged back into the watershed or recycled into another wetland basin through a weir. The careful manipulation of the extensive system of pipeline, canals, ditches and water control structures allows for the replication of naturally occurring hydrologic processes that elicit specific responses in wetland soils and plants through the maintenance of intensively managed seasonal, semi-permanent and permanent wetland basins.

Figure 2-13. Water Management Areas and Water Districts of the San Luis and Merced NWRs

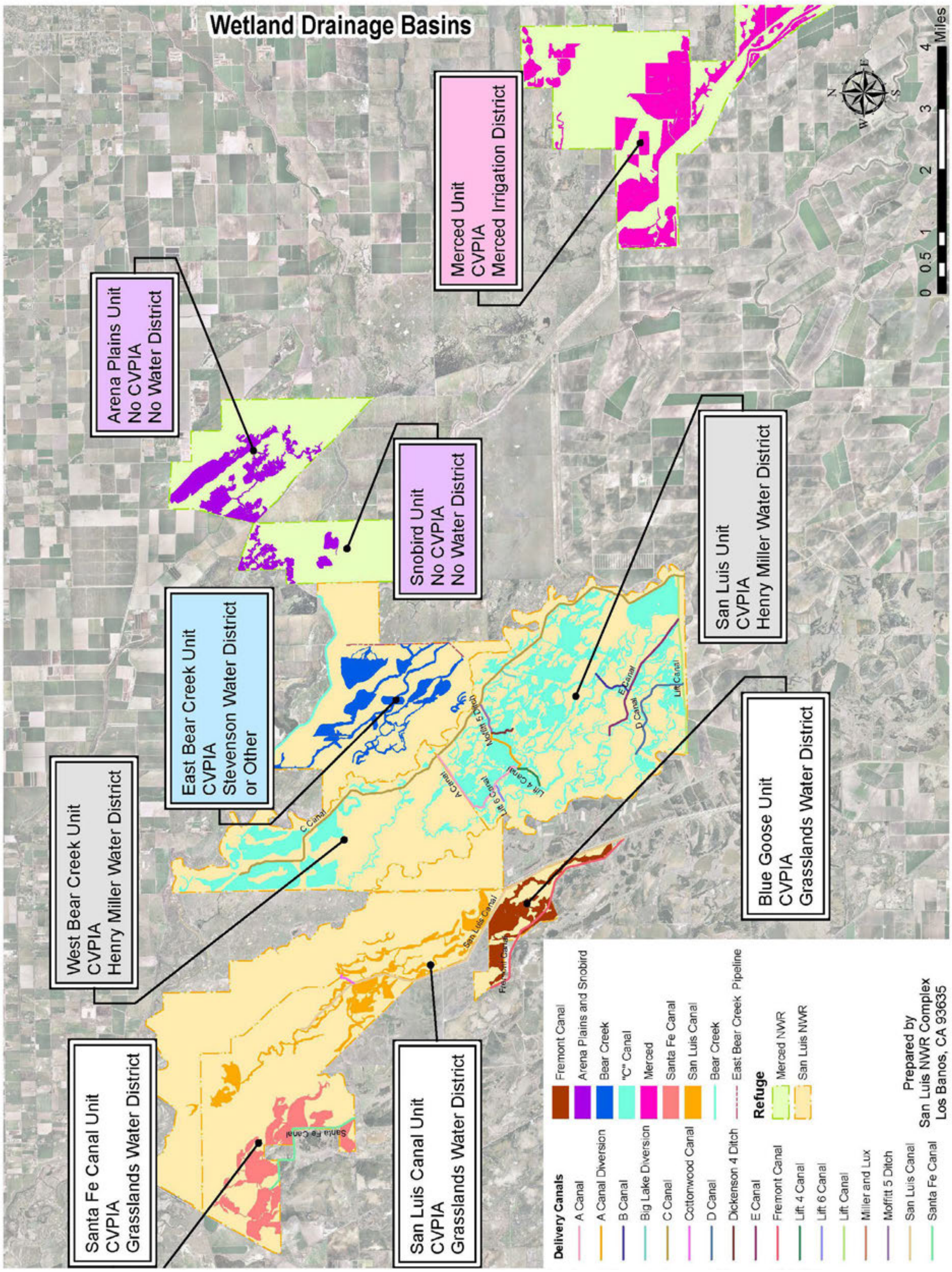
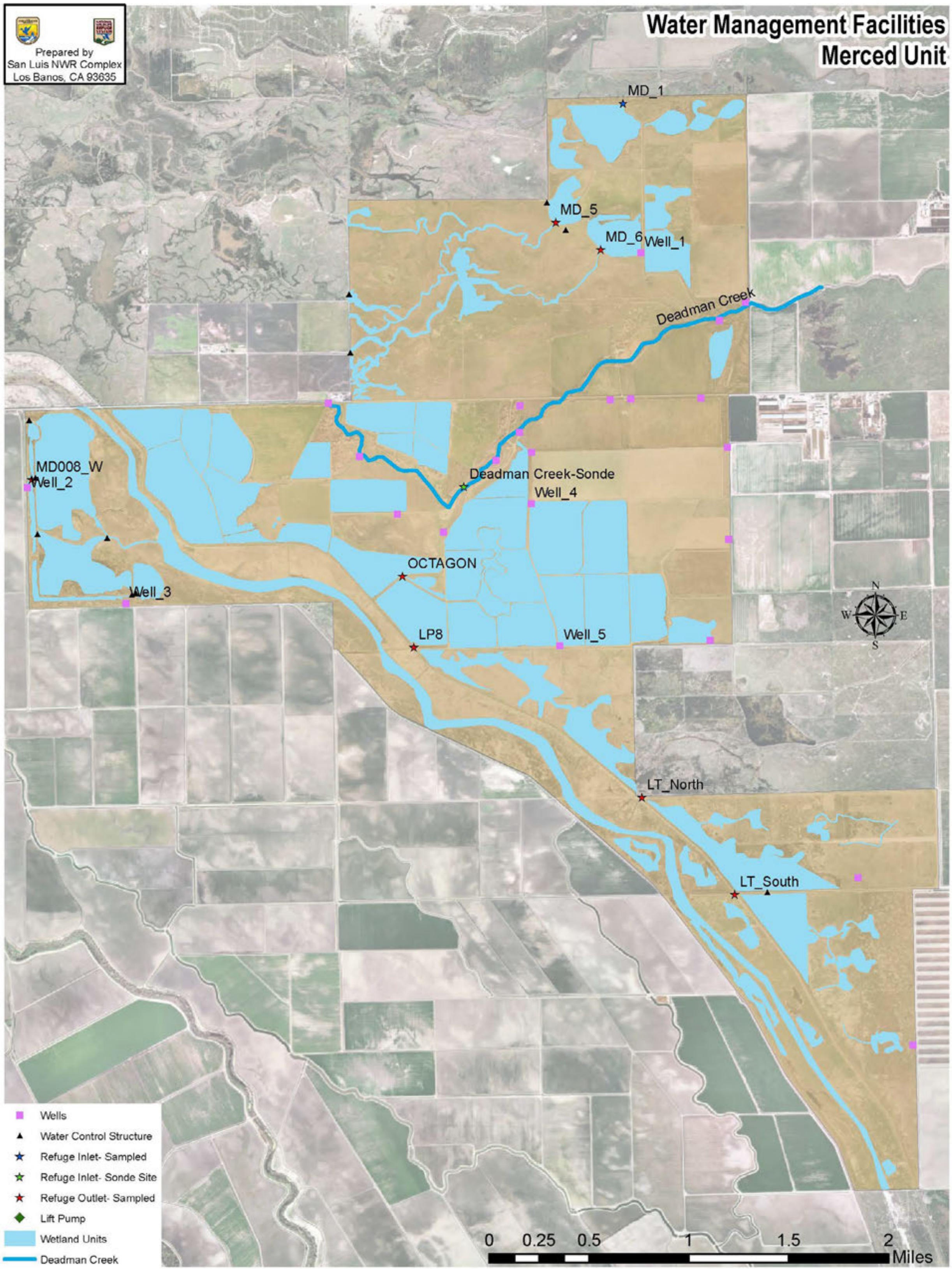


Figure 2-14. Water Infrastructure of the Merced Unit of the Merced NWR



When the refuge was first acquired, it relied solely on deep wells to supply water for management purposes from 1951 through the 1980s. In 1951, the refuge flooded a 200-acre wetland impoundment and 705 acres of cultivated fields with nine deep wells. By 1989, the refuge remained reliant predominately on 21 deep wells for its water supply, with smaller amounts diverted from Deadman Creek and the Eastside Bypass. These Deadman Creek diversions became an annual 3,000 acre-feet of water right in 1985 but were limited to high flows during the December through May period. In April of 1964, the FERC issued a license to the MID for the construction of the New Exchequer Project (Project), intended to provide irrigation, flood control and power. The project involved the construction of a dam and hydroelectric plant, and ultimately stored about one million acre-feet of water on the Merced River in what became Lake McClure. In the process, 4,000 acres of wildlife habitat were inundated, adversely affecting several linear miles of riparian habitat downstream. As a result, Article 45[2] of the FERC license required mitigation for the habitat lost, which amounted to 15,000 acre-feet of the New Exchequer Project water to be delivered to the refuge each year.

The Project was completed in 1967 and operated status quo for 19 years. Apparently, no communication took place between MID and the Service during this period and the license mandates went unmet. The unmet requirements in Article 45 were identified during an inspection of FERC compliance of the Project in 1986. The Service requested that FERC and MID build the facilities and deliver water to meet the Article 45 requirements. However, MID and the Service could never agree on what Article 45 specifically intended. In 1987, MID filed with FERC a request for ruling that asked for a formal interpretation of the license. In February 1989, FERC ruled that MID was required to build the water conveyance facilities and deliver 15,000 acre-feet of water without compensation from the Service. In 1992, the Central Valley Project Improvement Act (CVPIA) was passed, implementing the amounts for Merced NWR delineated at the 1989 Refuge Water Supply Report—a total of 16,000 acre-feet at full Level 4 (13,500 acre-feet of Level 2 + 2,500 of Incremental Level 4), as shown in Table 2-2. With no delivery facilities in place, however, the refuge continued to rely on groundwater to meet both Level 2 and Incremental Level 4 demands between 1992 and 1994.

Table 2-2. CVPIA Water Allocations for the three units of the Merced NWR

Refuge Unit	Acres of managed Wetlands	Level 2 Water Supplies	Level 4 Water Supplies	Total Water Supplies
Merced Unit	1,610	13,500	2,500	16,000
Arena Plains Unit	482	0	0	0
Snobird Unit*	80	0	0	0

*Wetland restoration activities likely to occur at the Snobird unit starting 2023

[2] Specifically, Article 45 reads, "The licensee shall cooperate with the Bureau of Sports Fisheries and Wildlife of the USFWS (Service) to determine means of providing up to 15,000 acre-feet of project water and return flow water to the Merced National Wildlife Refuge."

Conveyance facilities were completed by 1994, and MID began delivering some of its required 15,000 acre-feet of water to the Merced NWR. The facilities included canal-widening outside of the refuge boundary and lift pumps and a new canal inside the refuge boundary. However, despite the new conveyance system, MID water deliveries are still limited to the agricultural irrigation season, with the refuge relying on groundwater during the winter when it needs the bulk of its water for wetland management. The 2022 April–September irrigation season had a particularly negative effect on Merced NWR. Most irrigation districts close down their systems for a just few weeks to conduct maintenance; however, Merced Irrigation District generally shuts down for six months, October through March—the six months when water is most needed by the refuge. This water shortfall is absorbed by the Restoration Fund, which pays for pumping groundwater at an average cost of $35–$50/acre-foot, totaling up to $500,000. When delivered, MID water is delivered at no charge because of the mitigation requirement.

In recent years, surface deliveries from MID have been reduced further. During 2007 through 2013, an average of 11,164 acre-feet was delivered from MID, with 67 percent of the water used. However, during 2014 through 2018—which includes three drought years—water deliveries were reduced to an average of 3,165 acre-feet, or 19 percent of the total water used. Even in the post-drought years starting in 2017, surface deliveries were still reduced to less than 4,000 acre-feet, or about 23 percent of water used. The expense of relying on pumping groundwater has caused a strain on the Restoration Fund managed by the USBR, which in turn diminishes funding available for Level 4 water supplies or facility construction elsewhere in the Central Valley.

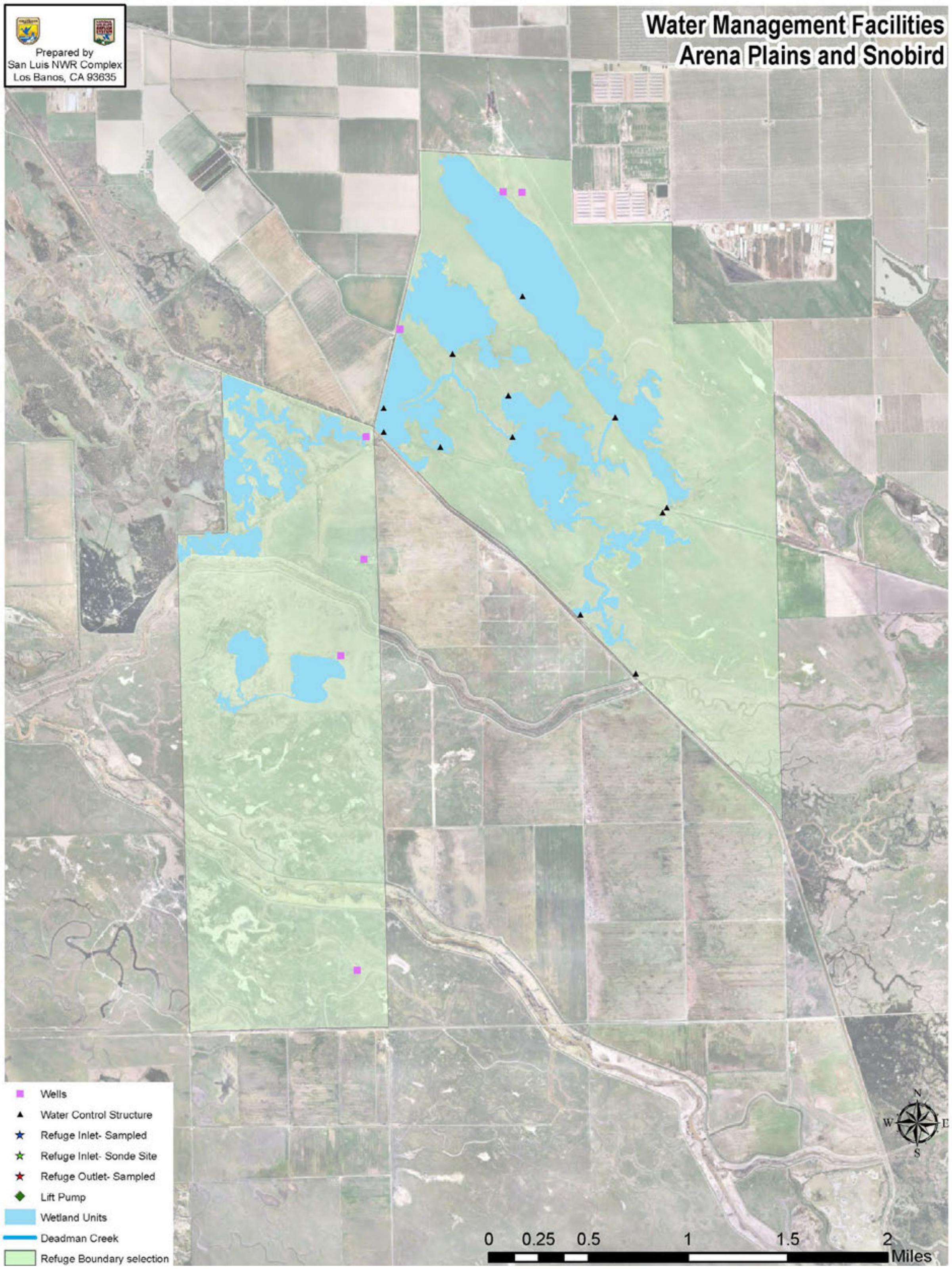
In 2001, a 25-year agreement was reached by the Service with the USBR to pay for these annual pumping costs. These costs are included in the yearly CVPIA Refuge Water Supply budget split between the Service and USBR.

Water Management. Photo: USFWS

Additional land acquisitions for the Merced NWR in the 1990s added very minimal increases to surface water rights. Two minor riparian water rights (Duck Slough with 3 cfs and Deep/Brevel Slough with 31 cfs) came with subsurface water rights. Three of the acquisitions are proving challenging with regards to water management. The acquisition of the Lonetree unit was problematic, as it was a member of the Lone Tree Mutual Water Company, whose bylaws prohibited the transfer of water rights with properties acquired by government agencies. A project by Ducks Unlimited completed in 2021 allows for conveyance of spill water from the Cinnamon Slough unit and Castle Duck Club to the Lonetree unit, but secure and permanent water supply for the unit has not yet been developed.

The Arena Plains and Snobird units are remote properties to the Merced NWR and not included under the auspices of the CVPIA. All of their water costs must be covered by the Complex budget or through the CAA cooperator (Figure 2-15). As a result, the refuge has only been able to actively manage a percentage of the Arena Plains' wetland basins since 2007. An additional percentage of wetlands are a passive recipient of excess water from the Atwater or Peck Drain, whose rights have not been exercised. The Atwater Drain is the drain for the city of Atwater's wastewater treatment plant, which passes through the property and terminates at the Eastside Canal. A siphon under the Eastside Canal also was employed at one time to allow the drainwater to pass under the canal and continue through the northern portion of the Snobird unit into the Bear Creek flood control bypass and empty into the San Joaquin River. The siphon collapsed and the path of the drain breached for some time, resulting in the termination of the drain midway through the Arena Plains unit.

Figure 2-15. Water Infrastructure of the Snobird and Arena Plains Units of the Merced NWR



The Snobird unit within Merced NWR was acquired in 2004 with riparian water right for 31 cfs on Deep/Brevel Slough. Five deep wells and three small lift pumps were included with the property. An inoperable cement tiled pipeline exists but is no longer functional and will not be recovered. Wetland restoration activities are underway and require the water infrastructure and capacity to be fully realized and improved.

San Luis NWR

Prior to the construction of the San Joaquin River levee system by the U.S. Army Corps of Engineers (USACE) and the construction of Friant Dam in the 1940s–1950s, most of what is today the San Luis NWR was prone to seasonal (usually late winter and spring) inundation by floodwaters in wet years. With the construction of levees and the diversion of all significant rivers and sloughs in the northern San Joaquin Valley to supply irrigation water for agriculture, the realization of wetland management objectives at San Luis NWR has become dependent on an entirely artificial (man-made) water conveyance system (Figures 2-16, 2-17, 2-18, 2-19, 2-20). The importance of securing adequate water quantities and acceptable water quality to meet wetland habitat management objectives and maintaining an adequate water conveyance system to distribute the water are critical themes in the past, present and future of the San Luis NWR. In 1968, the first refuge narrative available (USFWS 1968) reported that “Refuge water distribution facilities are old, worn out and inadequate.”

The water conveyance system at San Luis NWR consists of earthen canals and ditches to move water to and then off wetland basins and water control structures that regulate the volume of water entering or leaving wetland units. On San Luis NWR, water control structures are built of either corrugated metal pipes or plastic pipes that are attached by bands to precast concrete weirs (structures that raise water levels and divert water flow). A final weir component is a metal or wooden headwall, which prevents erosion from occurring around the structures. Each wetland basin has at least two weirs—one at the inlet from the canal into the basin and one at the discharge point where water leaving the wetland is discharged back into the watershed or recycled back into another wetland basin. The careful manipulation of the extensive system of canals, ditches and water control structures at San Luis NWR allows for the replication of naturally hydrologic processes that elicit specific responses in wetland soils and plants through the maintenance of intensively managed seasonal, semi-permanent, reverse cycle and permanent wetland basins.

Wetland and Boardwalk. Photo: USFWS

Figure 2-16. Water Infrastructure of the San Luis Unit of the San Luis NWR

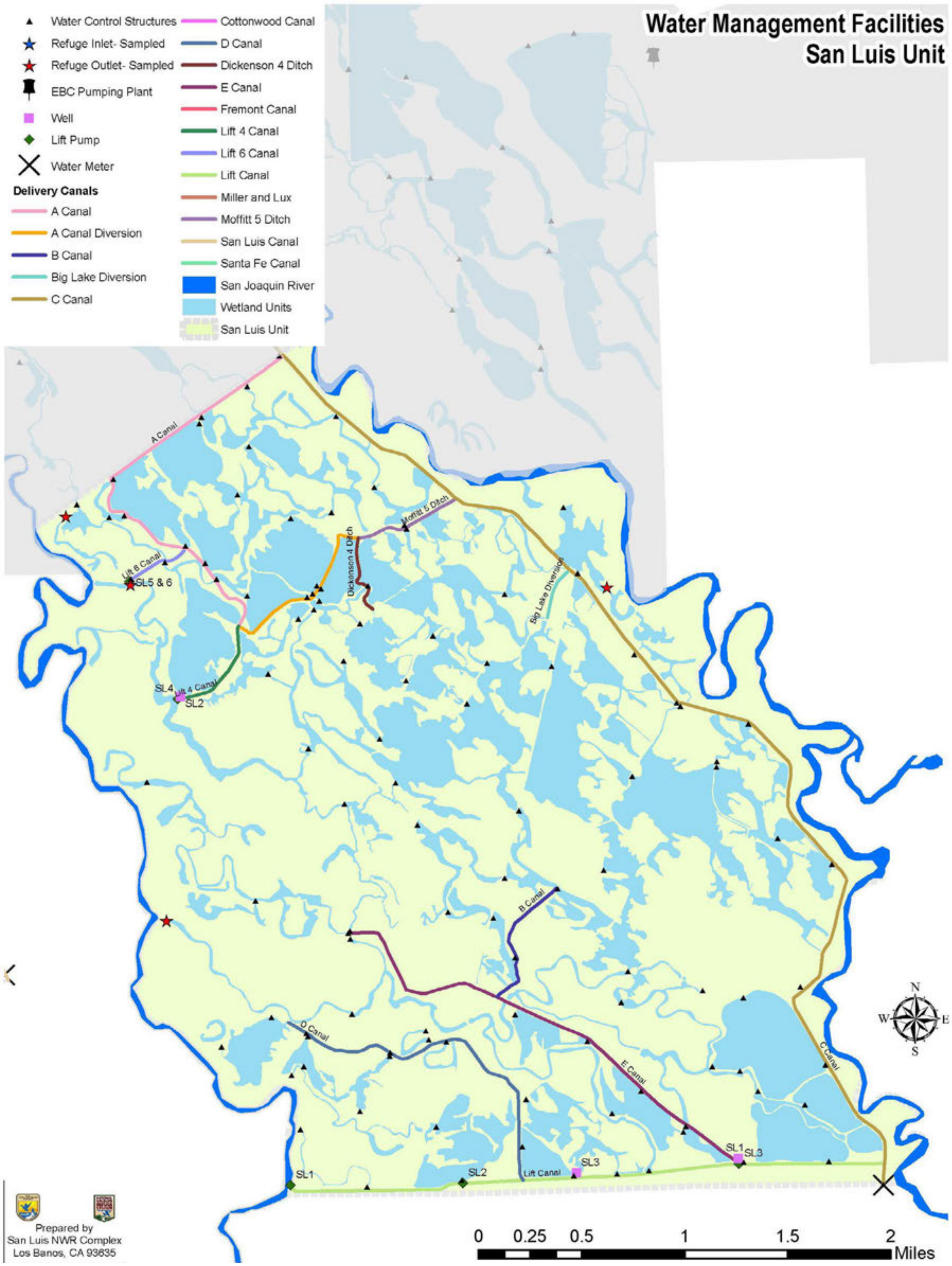


Figure 2-17. Water Recycling System at the San Luis Unit of the San Luis NWR

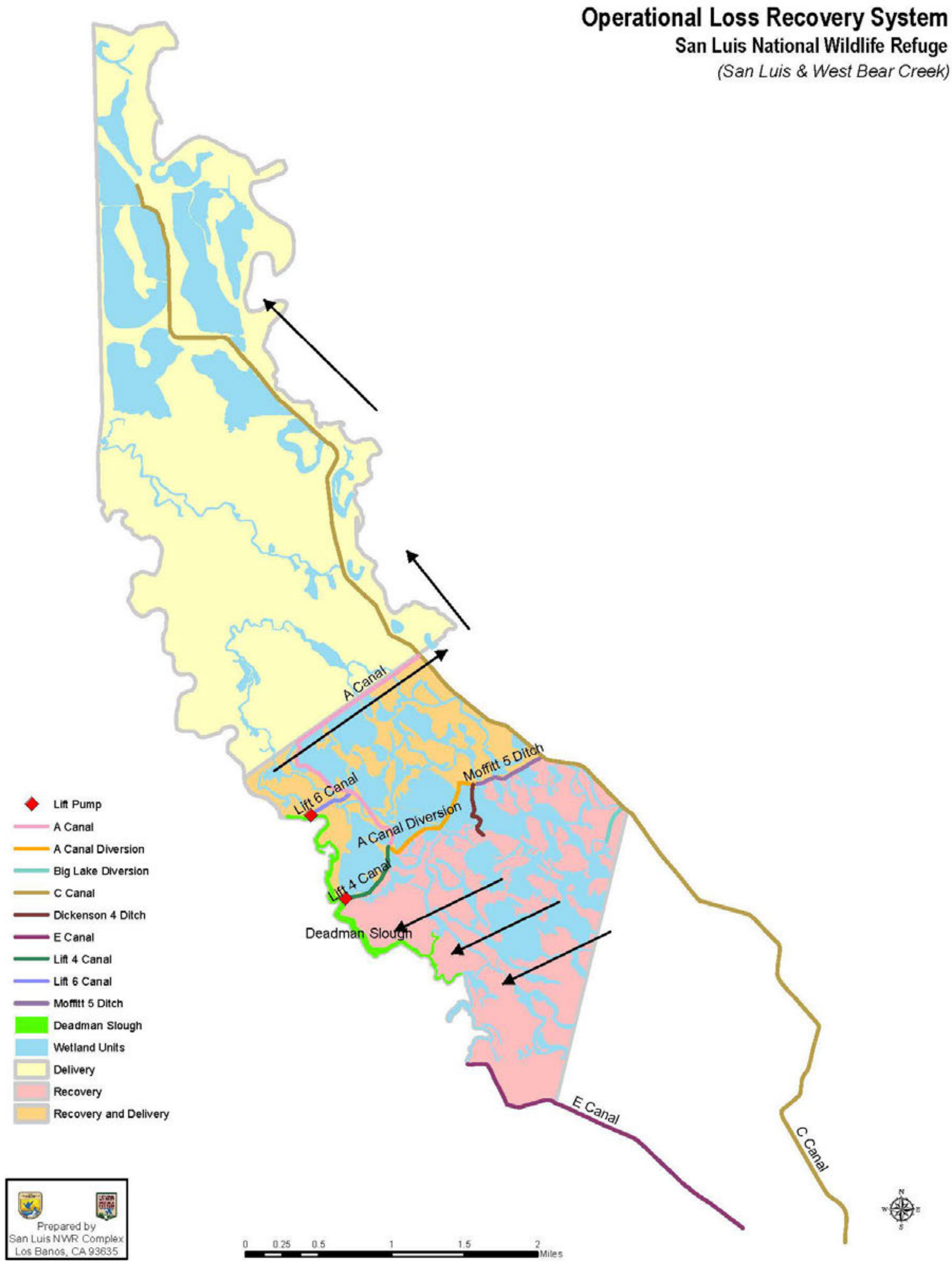


Figure 2-18. Water Infrastructure of the West Bear Creek Unit of the San Luis NWR

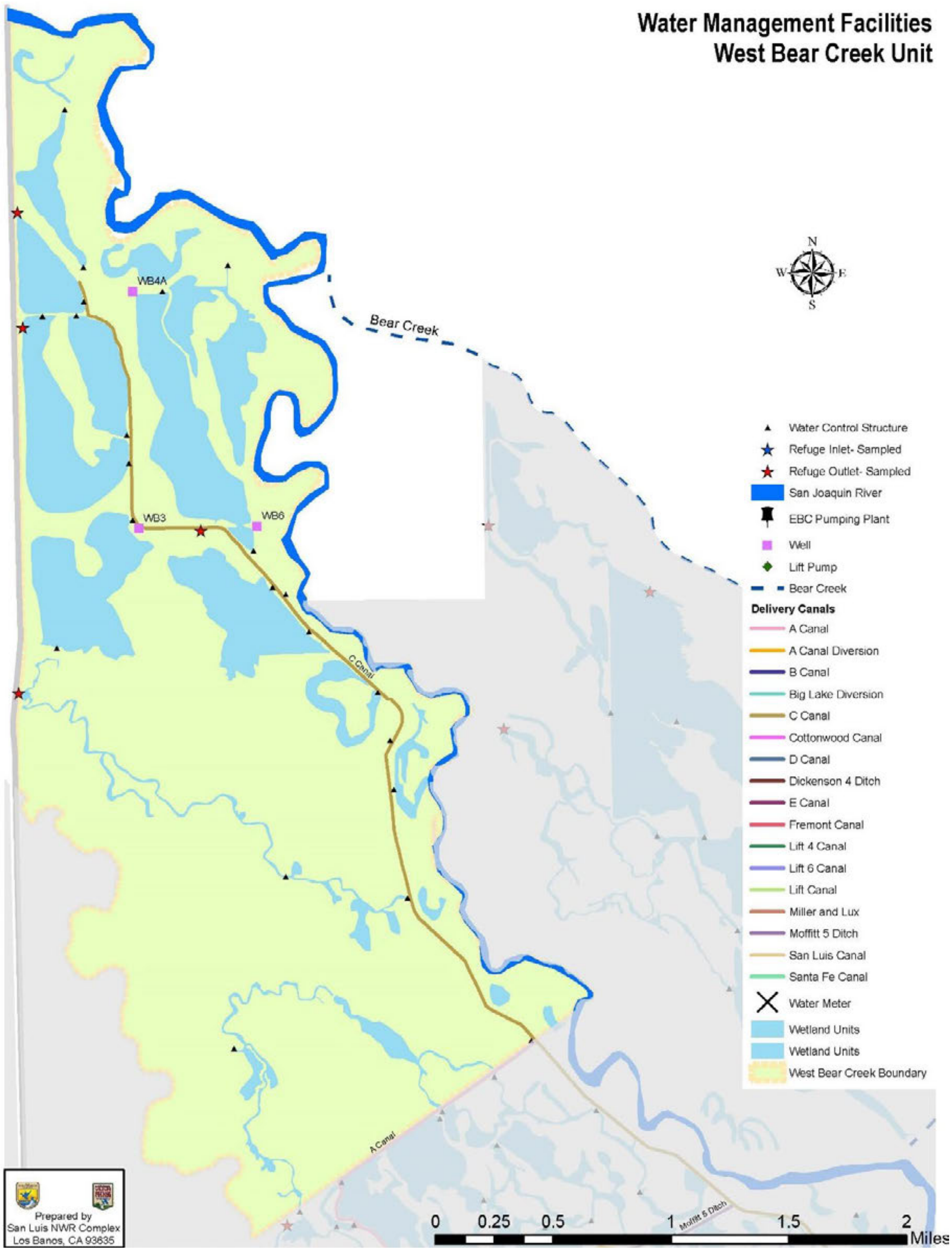


Figure 2-19. Water Infrastructure of the East Bear Creek Unit of the San Luis NWR

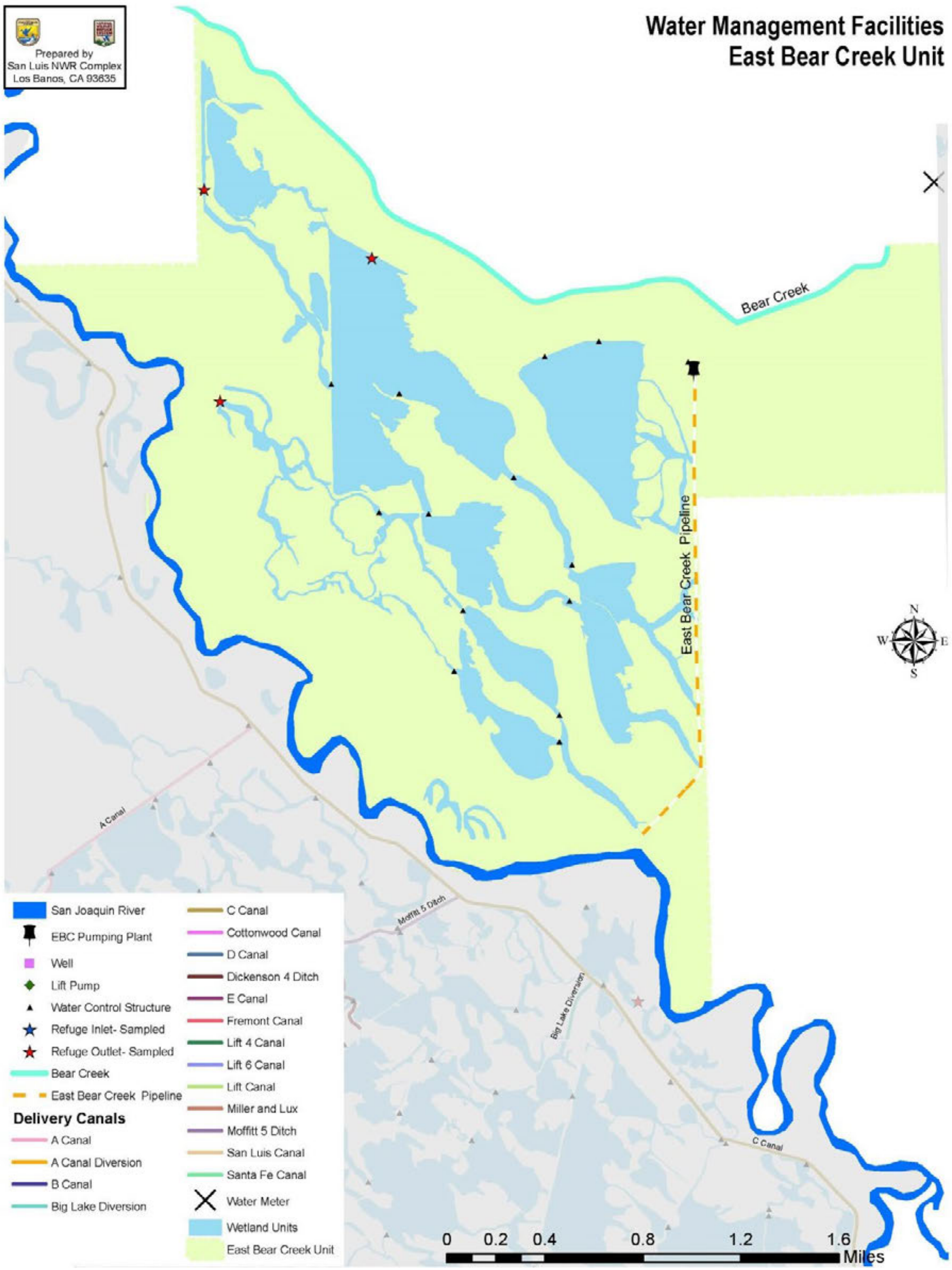
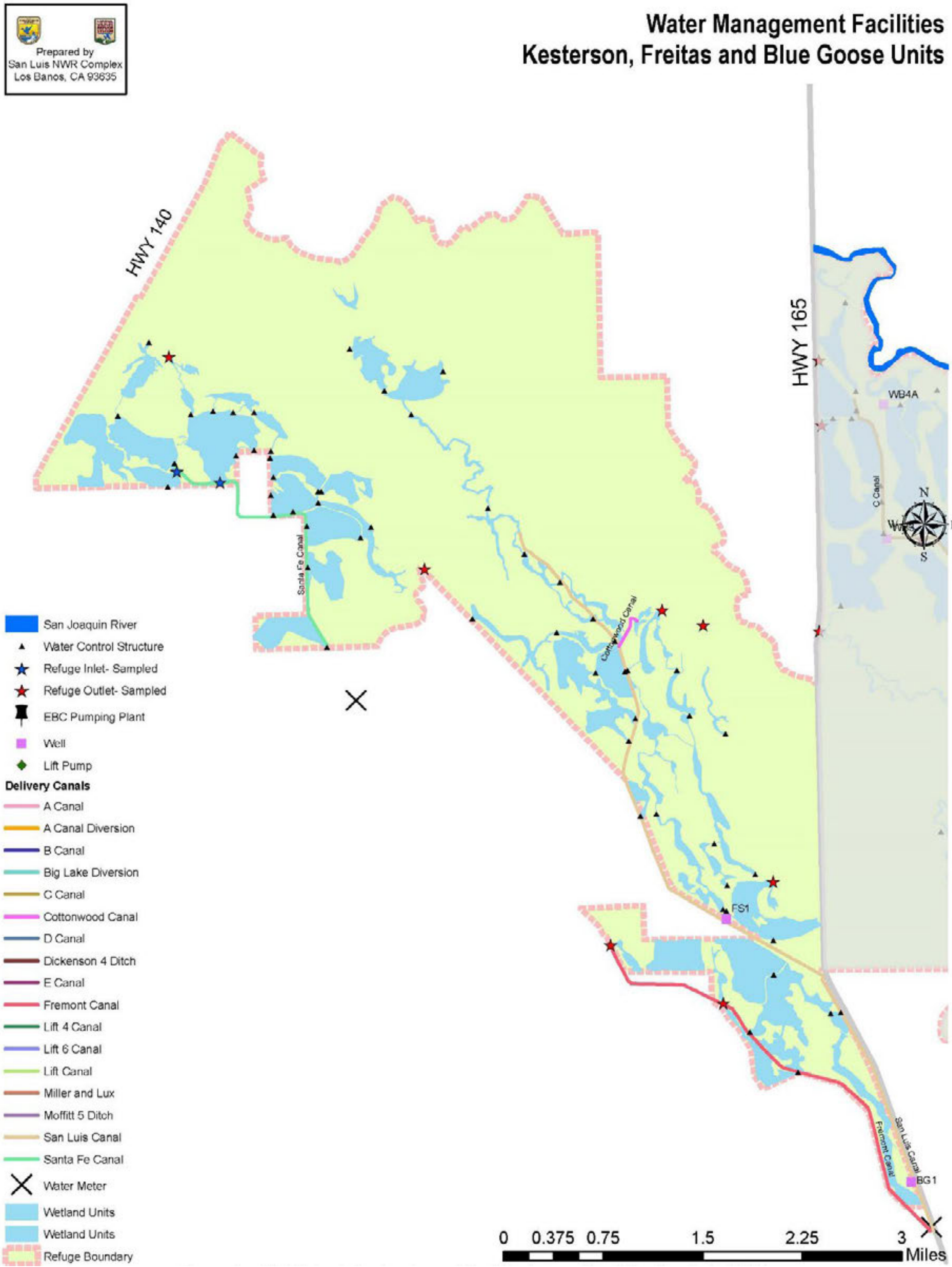


Figure 2-20. Water Infrastructure of the Western Units of the San Luis NWR



When what is today the San Luis unit of the San Luis NWR was acquired, a water right to 19,910 acre-feet of Salt Slough water per year was conveyed with the purchase price and this water was used to supply water to wetland units from 1967–1985 (USFWS 1986). In 1968, the first year for which complete information was available, the San Luis NWR flooded 2,700 acres of wetlands with some 17,400 acre-feet of water taken from Salt Slough—this water right being the only source of water to manage refuge wetlands (USFWS 1968). Some 260 acres of cultivated fields extant when the refuge was purchased were managed for production of wild millet (*Echinochloa crusgalli*). It was noted that the newly created refuge was "saddled" with a special use grazing permit allowing the previous landowners to graze between 700 and 1,200 cattle on the refuge during the fall/winter and spring/summer months annually through the end 1972. The effects of this cattle-grazing regime were documented as being quite detrimental to wetland plant production of emergent and submerged aquatic plants desirable as waterfowl forage species.

After 1985, when a 4-year moratorium was placed on the diversion of Salt Slough water into the refuge due to selenium contamination concerns (USFWS 1986), a series of short-term water contracts were made with the San Luis Canal Company to deliver USBR water up to 19,000 acre-feet per year (USFWS 1986, 1988). This water was authorized but not obligated under Section 2 of the 1992 CVPIA, which gives the Secretary of the Interior discretionary authority to supply approximately 47,000 acre-feet per annum of CVPIA water to refuges and Wildlife Management Areas owned and operated by the United States or the State of California (USFWS 1988). The work to secure dependable quantities of acceptable-quality water for the San Luis unit reached a new level in 1988 with a grant of easement and agreement for the purchase of easement between the Service and the San Luis Canal Company for water deliveries to the refuge to flow and convey a maximum of 33,350 acre-feet of water to the refuge—at a cost of $2,284,000 for improvements to the canal companies water delivery system (USFWS 1988).

A similar pattern emerged for the then Kesterson NWR (now the Kesterson unit of the San Luis NWR), which initially provided water by diversion of agricultural drainwater from the San Luis Drain by the USBR, wells, and water delivered by the Grassland Water District when available (USFWS 1972). These deliveries were augmented by deliveries provided by a Cooperative Agreement between the USBR, USFWS and Grassland Water District of Los Banos, California (USFWS 1981). This evolved into a firm water right by 1988, when the Kesterson unit was allocated 3,500 acre-feet of water to be delivered in September, October and November and not less than 4,000 acre-feet if available from May 1–September 30 (USFWS 1988).

The passage of the CVPIA in 1992 ushered in a new era of water rights and wetland management possibilities for the San Luis NWR. As a direct result of this law, the San Luis NWR was provided secure water allocations for each of six units of the refuge (Table 2-3). Operationally and based on physical proximity and sources of delivered water supplies, these six units are divided into three groups: units west of Highway 165, units east of Highway 165 (excluding the East Bear Creek unit) and the East Bear Creek unit (USFWS 2005).

Delivered water quantities are divided into two categories: Level 2 supplies or “average annual historical supplies” as defined in the USBR’s *Report on Refuge Water Supply Investigations* (1989); and Level 4 supplies—defined in the 1989 report as “the quantity of water needed to fulfill full habitat development.” In practice, the refuge almost never has been provided Level 4 water supplies, as these are only made available for habitat management purposes when all Level 2 and most other Level 4 obligations have been met. In addition to the CVPIA allocations, certain wetland basins on the Blue Goose unit of the refuge are flooded up and provided maintenance flows by the Grassland Water District under an existing annual water allocation that was transferred with the property when it was acquired by the United States.

Table 2-3. CVPIA Water Allocations for the Six Units of the San Luis NWR

Refuge Unit	Acres of managed Wetlands	Level 2 Water Supplies	Level 4 Water Supplies	Total Water Supplies
East of Highway 165 (San Luis and West Bear Creek Units)	2,778	26,207	3,603	29,810
East Bear Creek Unit	1,000*	8,863	4,432	13,295
West of Highway 165 Kesterson, Freitas and Blue Goose Units	1,637	15,310	As and if available	15,310

*This is an estimate as wetland restoration activities at East Bear Creek unit are not yet completed

Invasive Plant Management

Invasive weed control employs several wildlife management techniques, including mowing, disking, grazing, prescribed burning, water management and herbicide application. When mechanical and prescribed fire methods are ineffective and impractical, herbicides are used on refuge lands for invasive plant control. All herbicide use is reviewed and approved through the Services’ Pesticide Use Proposal (PUP) process (7 RM 14 of the Refuge Manual). A PUP is prepared for each chemical used. It identifies target species, reason for application, application rate, timing and method, sensitive areas and species that may be affected and measures to avoid impacts to them. PUPs are reviewed and can be approved by the refuge manager, regional office, or Washington, D.C. office, depending on the chemical to be used.

Monitoring

Evaluation of habitat management programs, techniques and water quality/quantity is conducted to make informed decisions, maximize funding and labor resources and adaptively manage ecosystems on refuge and easement lands. Based on the information that is sought, various monitoring programs are in place to effectively gather data. These programs range from basic inventories and monitoring to research with rigorous experimental designs and controls. Habitat- and water-monitoring efforts are conducted by Complex staff as well as partners from University of California (UC) Davis, UC Berkeley, University of the Pacific, USGS, USFWS-Sacramento Field Office, CDFW, California Department of Water Resources (DWR) and River Partners.

Prescribed Burn. Photo: USFWS

Habitat-monitoring focuses on determining the effectiveness of wetland, riparian and upland management techniques in meeting prescribed goals. Water manipulation, grazing, disking, mowing, herbicide application and prescribed fire are all used to increase native plant and animal populations and decrease invasive species cover. In addition to species composition inventories, vegetative structure (i.e., horizontal and vertical cover) also is assessed. Geospatial habitat layers have been incorporated with Global Positioning System (GPS) data on refuge and easement lands to develop geographic information system (GIS) layers to better manage these areas within the larger landscape and ecoregion. The percent cover of target native and invasive plant species in upland habitats is sampled and mapped annually on large portions of San Luis (4,800 acres in 2008) and Merced NWRs (1,850 acres in 2008). By tracking the changes in the percent cover of these species under current management regimes, the effectiveness of techniques can be evaluated and adapted as needed. Qualitative assessments of grazed pastures and uplands are conducted throughout the grazing season to ensure management prescriptions are followed. More intensive controlled experiments also have been used in vernal pool habitats to assess the effectiveness of prescribed fire and grazing on these communities. Intensive sampling of wetland plant composition and structure has been conducted to determine the productivity of wetland units. This effort is coupled with annual wetland qualitative assessments conducted to schedule water management and rehabilitation needs. Numerous studies focusing on specific wildlife species or groups include measures of wetland, riparian and upland habitat characteristics. These include research on the habitat use of neotropical migrants, fish and invertebrates, long-billed curlew (*Numenius americanus*), waterbirds and grassland passerines. Information from these studies is used to provide habitat management that meets the diverse needs of the many species using the refuge and easement lands.

Water monitoring focuses on assessing the quality and quantity of Complex water supplies with information on concentration and volume of refuge inputs. Monitoring is used to determine the overall load of salt, nutrients and other constituents that make their way into various San Joaquin

Valley waterways. In addition to salt and nutrient loads, other studies have focused on methylmercury, organic carbon and dissolved oxygen levels. A variety of techniques have been used by Complex staff and project partners to sample constituents, including hand-held water-quality sondes, continuous sampling data loggers, grab samples for laboratory analysis and fish sampling (for selenium analysis). Flow into and off of the Complex is sampled using permanent meters on delivery canals, calibrated weir rules and a doppler flow meter that measures velocity and depth in open culverts. Inlets, wells, wetland units and discharge outlets are monitored to accurately describe water quality parameters over time. This information has proven to be valuable in informing strategies to address current and future water challenges facing land managers in the San Joaquin Valley.

Fire Management

The U.S. Department of the Interior (DOI) fire management policy requires that all NWRs with vegetation that can sustain fire must have a Fire Management Plan (FMP) that details fire management guidelines for operational procedures and values to be protected/enhanced. Based on fire danger, number of fire starts and prescribed fire activity, a fire program was established at the San Luis NWR Complex.

Prescribed Burn. Photo: USFWS

The fire program is responsible for fire suppression, preparedness and implementation of hazardous fuel reduction projects on the Complex. Although the San Luis NWR Complex uses prescribed burning to meet natural resource and fuels management goals and objectives, it has a policy of complete suppression of all fires from unplanned ignitions. The Complex's vegetation communities tend to be composed of fine and flash fuels where fire spread, even with a light wind, can consume thousands of acres in hours, destroying and/or damaging natural resources and property as well as jeopardizing public safety.

The Complex has a fire management program of ten employees (six permanent and four seasonal employees), two type 3 engines, two type 6 engines, one 1,500-gallon water tender, a three-bay engine station and a fire crew bunkhouse.

The Complex averaged 12 prescribed fires per fiscal year from 2016–2022, averaging about 199 acres burned per project. Objectives for these burns include hazardous fuel reduction. Additional objectives have included threatened and endangered species management, invasive plant control and reduction, habitat improvement and maintenance and disease prevention. In addition to prescribed fire, the Complex uses mechanical treatments to reduce hazard fuels and improve habitat conditions. From 2016–2022, the Complex has averaged seven mechanical fuels treatment projects per FY, treating an average of 186 acres per project. A mechanical fuels treatment is a reduction of hazardous fuels by mechanical means such as by tractor with disk or mower, grader, or bulldozer. It is generally implemented in areas of high fire danger or where frequent ignitions occur, such as highly traveled roads or trails.

From 2016 to 2022, the Complex averaged 15 wildfires per year on USFWS land, burning an average of 13.9 acres of USFWS land per fire. Many of these fires have started off-refuge. Complex fire crews also have responded to wildfires adjacent to Complex property under local, county and statewide wildfire mutual aid agreements. All wildfires have been human-caused, including escaped prescribed fires. Other causes have included mowers and agricultural equipment, electrical lines, smoking, motor vehicle accidents and intentional/suspicious. The Complex has averaged 17 support actions per year over the last 5 years.

Table 2-4. Summary of Wildfires and Fuel Projects at the San Luis NWR Complex: 2016–2022

Fiscal Year	Number of Prescribed Burns	Prescribe d Burn Acres	Largest Prescribe d Burn	Number of Mechanical Fuels Treatments	Mechanical Fuels Treatment Acres	Number of Wildfires	Total Wildfire Acres*
2022	8	1942.2	886.8	8	1124.3	15	437.6
2021	13	2782.0	438.7	6	658.1	13	99.3
2020	13	2434.0	514.5	6	664.4	5	24.0
2019	16	3273.4	158.9	6	648.1	11	206.7
2018	13	2439.4	737.5	6	656.3	17	229.4
2017	12	1839.2	742.6	8	648.0	22	339.3
2016	12	2616.8	493.2	7	646.0	28	208.6
Totals	87	17327.0	N/A	47	1302.3	111	1544.9

*Total wildfire acres include Threat Acres to Merced or San Luis NWR.

Easement Management

By acquiring a conservation easement, the Service purchases certain property rights over privately owned lands, but the lands remain privately owned and managed. The easement contract represents a perpetual partnership between the landowner and the Service for the conservation and improvement of the wildlife habitat values. The Grasslands WMA easement program manager upholds and protects these purchased rights for the benefit of all migratory birds and wildlife for the benefit of the American people. Most importantly, the easement manager maintains open and honest communication with the wide-ranging “Grasslands” community of landowners, managers and partners while maintaining friendly and agreeable relationships among most.

With 192 current easements to manage, the Grasslands WMA's conservation easement program is robust and growing. At the current time, easement management still involves easement acquisition and compliance monitoring, but has expanded to include restoration, partnership-building and technical assistance coordination with a multitude of other agencies and organizations, and integration and oversight of the co-located Partners for Fish and Wildlife (PFW) Program. The PFW program delivers technical assistance and financial assistance to private landowners interested in enhancing habitats for Federal trust species on privately owned lands, such as farms and ranches.

The responsibility of easement acquisitions for the Grasslands WMA begins by explaining the generalities and processes of the easement program to an interested landowner. Upon an initial commitment from the landowner, specific easement language is cooperatively developed through input from each party. The finalized language then is forwarded to the Service's Regional Realty Specialist, who administers the land acquisition; at this point the Grasslands WMA easement manager serves as a liaison between landowner and Realty staff.

After the acquisition process is completed, the easement manager again becomes the leading contact for issues pertaining to the easement lands. Compliance is maintained through annual site visits and/or aerial surveys. Observations are recorded through photographic and written documentation and then archived for future reference. In general, for the Grasslands WMA, a common interest in preserving, maintaining and improving prime waterfowl/waterbird habitat is shared by the Service and landowners alike. This cooperation has made most easement compliance visits in the Grasslands WMA non-confrontational and often genial; however, even with a positive constituency, challenges still exist for management of easement lands.

Although non-compliance issues seldom arise, in every case the Complex is committed to resolving disputes at the lowest level possible. Most issues have been resolved by explaining the intent of the easement language. Most often, potential conflicts are avoided through crafting creative and sometimes innovative solutions that satisfied both the landowner's and the Service's needs for the Grasslands WMA.

Gauging the success of the Grasslands WMA and the activities that occurred on easement lands is determined using various opportunistic surveys, field observations and photo records. Surveys include CDFW winter bird counts, neotropical migratory bird counts, water quality monitoring, winter food availability status, invasive plant surveys and water conservation and efficiency monitoring. Photo records are obtained during site visits, on aerial surveys and from commercially available aerial photographs. Results that indicate a need for habitat improvements are followed up with TA or habitat enhancement opportunities. As the program has grown, the monitoring requirement has grown, not in complexity but merely in quantity of acres to monitor.

Occasionally, easement lands can better benefit wildlife with some habitat restoration or enhancement, particularly in the areas of water delivery or distribution; increasing native vegetation for forage, cover, or to minimize disturbance; and noxious weed management.

Effecting, coordinating and acquiring funding for such projects constitutes a significant portion of the staff of the Grasslands WMA. Funding restoration projects in cooperation with our restoration partners—such as Natural Resource Conservation Service, CDFW, Ducks Unlimited, Central Valley Joint Venture (CVJV), California Waterfowl Association and many more, under a wide variety of programs such as Environmental Quality Incentives Program (EQUIP), California Landowner Incentive Program (LIP), North American Wetlands Conservation Act (NAWCA) grants and the like—takes time and concerted effort, but reaps huge benefits for wildlife.

Habitat restoration and enhancement efforts on easement lands of the Grasslands WMA are often integrated with those of the PFW because the goals and objectives of the program are very similar and compatible with those of the Conservation Easement Program.

Wildlife Management and Monitoring

Wildlife Monitoring

Wildlife monitoring is conducted by Complex biological staff, refuge managers and maintenance staff, visitor services staff and PFW program personnel, in addition to partnerships with other government agencies, universities and non-governmental organizations (NGO). The information garnered from these efforts is the cornerstone of management decisions and is critical in determining ecosystem function and resiliency. Wildlife monitoring varies in intensity based on funding, available personnel and time constraints. At the refuge level, studies include individual species surveys (threatened and endangered species, baseline inventories), long-term population level surveys (indices to track changes over time), wildlife response to habitat management (comparison of diversity and abundance under different management regimes) and controlled, replicated experiments (block designs to isolate treatment effectiveness). Complex staff also contribute to landscape, flyway, regional and national monitoring initiatives where the Complex is one of many participants working toward a common goal.

Monitoring programs focus on threatened and endangered species, migratory birds, Special Status species and groups that serve as indicators of ecosystem health. Numerous species-specific surveys are conducted, as funding and staff resources allow, to provide data on population levels that are lacking and answer more detailed management questions. All information gathered during monitoring activities is stored and tracked in Complex databases, analyzed using appropriate statistics and summarized in reports. When monitoring yields data with spatial components, Complex GIS layers are updated to reflect changes.

Migratory Bird Management

One of the Complex's primary purposes for establishment is to provide habitat for migratory birds, particularly wintering waterfowl. The habitat management described in the Habitat Section earlier in this chapter provides the mechanism in how that goal is met. The various Complex habitats support annual wintering populations of up to 1.3 million waterfowl, including one of the largest wintering populations of lesser sandhill cranes (*Grus canadensis*) in the Pacific Flyway; over 300,000 shorebirds during spring migration; neotropical migratory landbirds during the breeding and migration periods; an impressive number and diversity of migratory and resident raptors; and local breeding populations of wading and waterbirds. In addition to habitat management, Complex staff coordinate and/or directly participate in banding, migratory bird surveys, habitat use monitoring, research and management planning committees at the local, state, Pacific Flyway and national levels.

Waterfowl. Complex staff participate in flyway and national surveys by conducting ground counts to determine species and subspecies flock composition in state-wide dark and white goose surveys, the Midwinter Waterfowl Survey and other surveys. Staff conduct systematic surveys to monitor waterbird (including waterfowl) use of managed wetlands as well as nonsystematic observations to document use of restored wetlands. Nest boxes are installed and maintained by staff and volunteers to promote nesting by wood ducks and other cavity-nesting birds. Use is monitored, hen wood ducks (*Aix sponsa*) banded and nest production data forwarded to the California Waterfowl Association as part of the state-wide California Wood Duck Program. Staff coordinate and participate in on-refuge duck banding conducted each summer by technicians from the California Waterfowl Association. The Complex coordinates with and provides support for USGS researchers conducting northern pintail (*Anas acuta*), green-winged teal (*Anas crecca*) and other waterfowl research in the Grasslands.

Sandhill Cranes (*Grus canadensis*). The Complex conducts monthly surveys of sandhill crane use areas on- and off-refuge each winter from October to March to monitor populations and habitat use. Complex staff participate in flyway-wide greater sandhill crane (*G. c. tabida*) surveys in October.

Shorebirds. Staff conduct systematic surveys to monitor waterbird (including shorebirds) use of managed wetlands as well as nonsystematic observations to document shorebird use of restored wetlands. The Complex has participated in past surveys conducted by PRBO of shorebird populations in the Grasslands and Central Valley-wide surveys of long-billed curlews (*Numenius americanus*). A Complex staff member serves on the shorebird working group of the CVJV Technical Committee.

Great Egret. Photo: Paul Prado

Herons and Egrets. Counts are conducted each spring from February to June to determine the status and abundance of great blue herons (*Ardea herodias*) and great egrets (*Ardea alba*) on traditional rookery sites on the refuges and to track distribution of rookeries over time.

Neotropical Migratory Landbirds. The Complex, jointly with the PRBO, completed a 3-year study (1997–2000) of avian distribution, abundance and productivity in riparian habitat at San Luis NWR. A permanent Monitoring Avian Productivity and Survival (MAPS) station has been established in the riparian corridor of the San Joaquin River. Grassland bird monitoring transects have been established on San Luis NWR and Merced NWR and are surveyed by Complex staff to evaluate avian abundance, species composition and management impacts on the diversity and abundance of birds. A Complex staff member serves on the riparian bird working group of the CVJV Technical Committee.

Tricolored Blackbirds. Complex staff have been and are currently active participants in inter-agency efforts to maintain and restore populations of this state and Federal species of concern. This has included involvement with interagency working groups, species management planning, statewide surveys, on-refuge habitat management and population monitoring. Complex staff have worked closely each year with UC Davis researchers under Service contract since 1992. Farm field, irrigated pasture and other upland habitats at Merced NWR are managed specifically for tricolored blackbird (*Agelaius tricolor*) nesting colonies. Complex staff monitor on-refuge nesting colonies and population size on an annual basis and participate in statewide surveys conducted every 3 years.

Wildlife Disease Control

Because the refuges and wildlife management area are a concentration area for migratory birds and other wildlife, there is an elevated potential to have significant disease outbreaks and mortality events. With the exception of avian cholera, the northern San Joaquin Valley does not have a history of major disease outbreaks. No outbreaks of duck viral enteritis or Newcastle's Disease have ever occurred here. Avian botulism seldom occurs in the Grasslands, although avian cholera has been a chronic problem on the San Luis NWR Complex, with outbreaks of varying severity occurring throughout the years. Beginning in 2003, West Nile Disease has emerged as a wildlife and human health issue in the San Joaquin Valley. More recently, the potential for introduction of highly pathogenic avian influenza in North America through migration of birds from Asia or other sources has become a major human and wildlife health issue.

Complex staff conduct monitoring on an annual basis to detect and control any disease outbreaks. Disease management activities follow protocols established in the San Luis NWR Complex/Grasslands WMA Disease Contingency Plan (USFWS 2006) and the Aleutian Canada Goose Disease and Contaminant Hazard Contingency Plan (USFWS 1987).

Avian Cholera. Avian cholera occurs on an almost annual basis in the Grasslands. This is a highly contagious bacterial disease that typically begins in cold weather conditions between the months of December and March. The bacterium *Pasturella multocida* infects and directly attacks birds' internal organs and respiratory system. Most mortality occurs as chronic low-level losses that take place nearly every winter. However, acute outbreaks of avian cholera do occur periodically, predominantly on Merced NWR. Only one cholera outbreak (at the West Bear Creek unit in 1998) has occurred at the San Luis NWR since its establishment in 1967. Relatively few cases have been reported in the Grasslands WMA, local state wildlife areas or the nearby Los Banos Sewage Treatment Facility. Although losses average fewer than 200 birds per year on the refuges, die-offs of up to 12,000 birds have been recorded on the combined public and private lands. Approximately 75 percent of the birds dying of cholera on refuge lands are geese, followed by coots (*Fulica americana*) and dabbling ducks. Complex staff monitor roost ponds and other bird concentration areas regularly each winter for bird carcasses or birds displaying disease symptoms. Once an outbreak occurs, daily bird pick-up and disposal is initiated to limit the spread of pathogens to uninfected birds. All recovered birds are removed from the site and either buried or sent to the National Wildlife Health Research Center to confirm cause of death. Records of bird loss and disease control activities are maintained and summarized into annual reports.

Avian Botulism. The last reported case of avian botulism in the Grasslands occurred in the mid-1970s. Botulism normally occurs in the Central Valley during August and September when anaerobic conditions occur in shallow wetlands and mudflats. It evidently was more of a problem within the Grasslands in the early 1900s (prior to the Central Valley Project and other water diversion projects), when water was abundant and more areas were flooded in summer and early fall than was the practice during the late 1960s to mid-1990s. The potential for botulism outbreaks has increased in recent years due to greater water supplies and resumption of early season flood-up of local wetlands resulting from passage of the CVPIA in 1996. No botulism outbreaks have occurred within the Grasslands since then, possibly due to better drainage capabilities (constructed) within wetland basins and the practice of spilling a small amount of water over outlet structures to keep water in the wetlands fresh. However, avian botulism potentially could occur within the floodplains of the San Joaquin River and associated tributaries as floodwaters recede and water trapped in unmanaged basins begin to dry out.

West Nile Disease. West Nile virus has been recorded in mosquitoes off-refuge in Merced County, and cases of both humans and horses contracting the disease have been documented. Although sampling of migratory birds for this pathogen from the San Luis NWR Complex has been limited, the disease is considered widespread in the Central Valley and the long-term consequences for the wildlife community are not yet known.

Avian Influenza. In January 2022, highly pathogenic avian influenza was first detected in wild birds in the United States and the disease has since been detected in all four North American flyways. Because of the virulent nature of the disease and the potential for human health issues, a major disease monitoring program was initiated throughout the United States and Canada, with an emphasis on western North America prior to the recent detections. Staff at San Luis NWR Complex are participating in this monitoring effort. Bird species of greatest concern in this monitoring effort (due to their breeding grounds' proximity to Asian bird populations) include northern pintail (*Anas acuta*), Aleutian cackling geese (*Branta hutchinsii leucopareia*) and Wrangel Island population snow geese (*Chen caerulescens*). Complex staff will continue to monitor roost ponds and other bird concentration areas regularly each winter for bird carcasses or birds displaying disease symptoms. Carcasses will be sent to the National Wildlife Health Lab for testing.

Chronic Wasting Disease. Chronic wasting disease (CWD) occurs in deer and elk populations in numerous states but has not been documented in California. However, both state and Federal agencies are concerned about the potential for introduction of the disease into the state. CWD is addressed in the Complex's disease contingency plan due to the presence of a managed tule elk (*Cervus elaphus nannodes*) herd at San Luis NWR and the re-introduction of black-tailed deer (*Odocoileus hemionus*) into the area. A cooperative CWD Contingency Plan was developed and signed by the Service and CDFW in 2005.

Rabbit Hemorrhagic Disease Virus 2 (RHDV2). Rabbit Hemorrhagic Disease Virus 2 (RHDV2) is a highly infectious virus that is fatal to lagomorphs. Symptoms of RHDV2 in rabbits may include loss of appetite, lethargy, high fever, seizures, bleeding from the nose, mouth or rectum and sudden death. RHDV2 is a strain of RHDV that originated in France in 2010 and was first detected in North America in 2018. In California, RHDV2 was first detected in wild rabbits in 2020, and as of 2022, has spread to 19 counties including Stanislaus, Alameda and Fresno.

The virus was detected on San Joaquin River NWR in May 2022 in wild riparian brush rabbit and desert cottontail carcasses. Although the virus has not yet been detected on San Luis NWR or Merced NWR, refuge staff are looking for signs of rabbit die-offs and collecting any suspicious carcasses for testing. Any translocated riparian brush rabbits introduced to San Luis NWR will be vaccinated against the virus.

Threatened and Endangered Species Management

San Luis NWR, Merced NWR and the Grasslands WMA provide habitat for more than 20 Federal- and state-listed threatened and endangered species (Appendix E). Management activities implemented for these species and their habitats include vegetation manipulation (i.e., wetlands management, habitat restoration, grazing, burning, etc.), inventories on newly acquired lands, population monitoring and research. The habitat management actions generally are not conducted specifically for any one listed species, but rather to produce habitat conditions—such as short-cropped grasslands, native grasslands, vernal pool, or riparian forest—that benefit a suite of listed and non-listed species dependent on specific habitat types.

However, certain management and restoration activities that benefit some species or habitats may negatively impact others. Any special species requirements and potential adverse impacts of such an activity are documented through preparation of an Endangered Species Act (ESA) Section 7 Intra-Service biological evaluation. Avoidance measures or best management practices (BMP) to minimize impacts to listed species are identified for incorporation into that activity or project. If, in the opinion of the Complex, those avoidance measures or BMPs do not adequately protect those listed species, the project is dropped or modified, or the Complex enters formal consultation with the USFWS Ecological Services office.

In addition to conducting habitat management and monitoring to benefit listed species and ensuring that other activities do not adversely impact those species, the Complex directly participates in species recovery programs. Complex staff serve as members in species recovery teams or working groups to help formulate recovery plans and implement recovery action both on- and off-refuge. Past and current participation in recovery teams or working groups includes those for the Aleutian cackling goose (*Branta hutchinsii leucopareia,* delisted 2001), California tiger salamander (*Ambystoma californiense*), San Joaquin Valley kit fox (*Vulpes macrotis mutica*), giant garter snake (*Thamnophis couchi gigas,* San Joaquin population), riparian brush rabbit and other species. Habitat surveys for the possible reintroduction of riparian brush rabbit began in 2022 and are planned to continue. Currently, outside of habitat surveys, no management of the riparian brush rabbit occurs on the San Luis NWR, Merced NWR, or Grasslands WMA. More details about the habitat surveys can be found in Section 3.7.2.3 Management Concerns and Opportunities: Threatened and Endangered Species.

Ungulate Management

Historically, it is estimated that California's Central Valley was occupied by large numbers—up to 500,000 tule elk (*Cervus elaphus nannodes*) and "untold thousands" of pronghorn antelope (*Antilocapra americana*) and Columbian black-tailed deer (*Odocoileus hemionus columbianus*) (Bakker 1965).

Black-tailed deer were present in the northern San Joaquin Valley and in the vicinity of the San Luis NWR into the 1970s (USFWS 2003). With the construction of the Delta Mendota Canal in the 1950s, the historic short distance migration route of these deer between the coastal range foothills to the west of the Valley and the Valley floor was truncated and the deer suffered accelerated mortality thereafter, eventually resulting in their total extirpation from refuge lands. In 2003, a Cooperative Management Plan (CMP) was signed with the CDFW, the California Department of Parks and Recreation (State Parks) and the Stevinson Corporation for the purpose of the establishment and management of a deer herd in the GEA encompassing the San Luis NWR.

Thus far, 56 deer (50 adults and six fawns or yearlings) have been released on the San Luis NWR and the Great Valley Grassland State Park (CDFG 2007). Despite high mortality due to capture myopathy, collisions with vehicles, poaching and drowning, some 20 percent of these deer have remained in the study area following reintroduction (CDFG 2007). Since reintroduction, released deer have successfully fawned and raised twin and triplet fawns to the yearling stage, and fawns born on the refuge have in turn reached maturity, bred and fawned. The population of black-tailed deer on the refuge continues to expand and thrive today.

Tule Elk. Photo: Paul Prado

Tule Elk. Photo: Paul Prado

Tule elk, the largest animal on the Complex, were driven to the brink of extinction and extirpated from most of their range, including what is now the San Luis NWR in the 19th century (McCullough 1969). In 1973, the Service commenced construction of a 5.2-mile (760-acre) circumference tule elk (*Cervus elaphus nannodes*) enclosure on the San Luis unit of the refuge; this enclosure was built by force account and was finished in the autumn of 1974 (USFWS 1974A). In February 1974, a cooperative agreement was signed with the CDFW to provide for the reintroduction of tule elk (*Cervus elaphus nannodes*) to San Luis NWR (USFWS 1974B).

On December 6, 1974, 18 tule elk (*Cervus elaphus nannodes*)—11 bulls and 7 cows—were released into the enclosure and an additional 9 animals were subsequently added to the herd (USFWS 1974A, 1987, 1989). Tule elk have thrived at San Luis NWR—so much so that over 300 elk have been captured from the San Luis NWR herd and translocated to other habitats within the tule elks' native range in California during the last 30 years (USFWS 1978, 1979, 1985, 1987, 1995, 1998, 2001, 2005). These translocations were performed to keep the elk population at the refuge within the estimated carrying capacity of the elk enclosure habitat—estimated to be some 50–80 animals.

In 2006, the refuge initiated a study in cooperation with CDFW, the Rocky Mountain Elk Foundation and UC Davis to explore the feasibility of a free release or reintroducing tule elk

(*Cervus elaphus nannodes*) to the Grasslands WMA—including the San Luis NWR. The first year of this feasibility study documented the quantity and quality of existing habitat potentially available to tule elk in the Grasslands WMA. Potential issues, movement barriers and corridors for elk in this area were examined. The second year of this feasibility study examined potential alternatives for expanding the habitat available to tule elk in the Grasslands WMA and proposed strategies for addressing issues related to a possible free release or habitat expansion for this species. The Service partnered with CDFW, The Rocky Mountain Elk Foundation and the University of California-Davis to conduct a 3-year study[3] to determine the feasibility of establishing a free-ranging elk herd within the GEA.

The results of the study indicated that "…portions of the San Luis and East Bear Creek Units, as well as the Kesterson Unit, could provide tule elk introduced to the GEA with high quality habitat. Both of these areas have adequate cover and forage in proximity to each other, a diversity of habitat types (although it is greater in the San Luis and East Bear Creek zone due to riparian forests near the San Joaquin River), and are largely free from detrimental human impacts. The combined areas of these zones could provide enough habitat to support a relatively large herd of elk. Thus, it is recommended that any introduction sites be located within one or more of these high quality habitat zones. If elk are subsequently introduced to these areas, we expect the elk population to quickly increase in this landscape. A somewhat similar environment at Grizzly Island supports a thriving herd in an area substantially smaller than the GEA" (Huber et al. 2011).

However, the study also notes, "the locations of these habitat zones suggest several potentially hazardous areas for tule elk in the GEA, including (1) private duck clubs; (2) the San Luis Drain; (3) California Highway 165; and, (4) agricultural fields. The Kesterson habitat zone is directly adjacent to a number of private duck clubs located to the southwest of this unit. Disturbances could be detrimental to elk in this area (at least for a portion of the year). The San Luis Drain, a concrete-lined canal carrying agricultural runoff through the middle of the Kesterson zone, could prove lethal to elk. Another potentially lethal landscape feature is Highway 165, running north-south through the middle of the GEA. Roads are a well-known hazard for elk and other species, and collisions could further result in human injury or death. Adequate measures to mitigate for these hazards (e.g., funnel fencing techniques or road crossing structures) should be implemented as part of any reintroduction program, and will be especially important if elk movement between high quality habitat on opposite sides of the highway proves vital for population viability. Finally, the entire GEA is surrounded by agricultural fields. If elk move into these fields, farmers could suffer crop loss and fence damage (Rosatte et al. 2007). Programs to erect elk-proof fencing or implement hazing techniques in high risk areas could help alleviate these potential problems (Huber et al. 2011).

[3] Tule Elk Habitat Assessment 126 California Fish and Game Vol. 97, No. 3

CDFW and the Service will continue to collaborate and evaluate future management strategies of the captive tule elk herd. This does not exclude ruling out the possibility of herd expansion.

Little documentation exists concerning the occurrence or status of the pronghorn antelope (*Antilocapra americana*) in the northern San Joaquin Valley. However, this ungulate was likely, along with the black-tailed deer (*Odocoileus hemionus*) and tule elk (*Cervus elaphus nannodes*), an important component of the native mammal community in the valley and adjacent coastal ranges until it was extirpated. The restoration of native species is a goal consistent with the implementation of the Refuge Improvement Act. If and when possible, a feasibility study concerning the reintroduction or range expansion of the pronghorn antelope in the Grasslands WMA will be initiated, similar to what has already been achieved with the tule elk at the San Luis NWR.

Other Species Management

Most other management activities for wildlife consist of correcting nuisance situations. Beavers are controlled in specific circumstances by Complex staff because of their ability to disrupt the water infrastructure of refuge wetlands. Effort is required to remove beaver dams and lodges from delivery/drain canals and water control structures. In some cases, a beaver-proof water control structure can be installed to alleviate the need for beaver control. Management of beavers consist of preventing dams and lodges from being constructed and removing specific beavers from specific locations.

Nutria trapping and removal also are performed by refuge staff; see Section Management Concerns and Opportunities (Nutria Management) for a more detailed description. Another occasional vertebrate pest species includes the California ground squirrel (*Spermophilus beecheyi*). The local levee district at both the San Luis and Merced NWRs periodically trap ground squirrels to maintain their flood control levees.

Issues concerning mosquitoes and their associated problems (i.e., nuisance biting and vector-borne diseases) are encountered with aquatic habitats such as refuge wetlands, particularly when they are in proximity to human habitations. Aquatic habitats and wetlands, as well as irrigated pasture, provide conditions for breeding mosquitoes on the San Luis NWR Complex, which is situated within one mosquito control agency (Merced Mosquito Abatement District). This district is active and conducts mosquito monitoring programs (both larvae and adults), as well as disease monitoring programs (i.e., encephalitis, malaria and West Nile Fever) at the Grasslands. The district also conducts larviciding and adulticiding programs in Merced County; however, both the San Luis NWR and the Merced NWR are considered too distant from population centers that the district has not requested approval for any control program on refuge lands. Any mosquito abatement program using pesticides on refuge lands will require that the programs do not negatively impact natural resources and address legitimate mosquito nuisance and disease issues in neighboring communities.

Research Studies

The San Luis and Merced NWRs and Grassland WMA support research partnerships with other government agencies, universities and NGOs. Researchers investigate a wide range of biological and physical phenomena. These include topics on wildlife biology (diversity, distribution/abundance, reproductive success, impacts of contaminants), vegetative analysis (taxonomic descriptions, species composition/structure, exotic species impacts, landscape level vegetation classification/mapping) and physical analysis (water quality/quantity, contaminant levels, soils, hydrological modeling). Study proposals are evaluated by Complex staff to assure that the research is compatible with the Complex and that the results will contribute to wildlife and habitat management. A special use permit is issued to each researcher, which identifies and describes each project, provides contact information, identifies where research activities will take place and describes special conditions to ensure the safety of researchers and health of the environment. Because of the number of research projects occurring at any given time, coordination among the projects with normal Complex operations is essential. The Complex is provided with copies of all data, GIS products and reports that result from any research activities. The information provided is used in the adaptive management of the refuge and easement lands.

Management Concerns and Opportunities

Introduction

This chapter summarizes the challenges, needs and opportunities on the San Luis NWR Complex that can augment, enhance, diminish or facilitate the management of natural resources. To meet management goals and planning requirements, challenges, opportunities, restrictions and needs must be identified. The following list contains attributes and characteristics of the San Luis NWR, Merced NWR and Grasslands WMA that present opportunities, needs and/or challenges to their management and need to be considered for this planning process. These issues and topics were gathered from staff of the Complex and are based on past and present observations and discussions with numerous individuals, groups, partners and agencies, as well as from the public during various scoping activities for this CCP.

Biological Resources

Migratory Birds

The major management emphasis at the San Luis NWR Complex has been for the perpetuation and benefit of migratory birds, particularly waterbirds. The Merced NWR, San Luis NWR and Grasslands WMA together provide one of the largest contiguous remnants of wetland habitats remaining in California and support more than a million waterfowl and hundreds of thousands of other migratory waterbirds. These refuges and WMA were established primarily for the management and protection of migratory birds. Over 60 percent of Pacific Flyway waterfowl winter in the Central Valley and over 200 bird species have been documented in the vicinity. The primary management goal for these three refuge units has been and will continue to focus on maintaining and enhancing migratory bird populations. In recognition of how critical the area is to the protection of wildlife, especially migratory waterfowl and other waterbirds, the area has received national and international designations, including Wetland of International Importance by the Ramsar Convention, Western Hemispheric Shorebird Reserve Network International Shorebird Reserve and Audubon Important Bird Area.

The Pacific Flyway, one of four routes used by migratory birds in North America, is managed by the Pacific Flyway Council, composed of representatives from public wildlife agencies in each state and province in the western United States, Canada and Mexico (Pacific Flyway Council 2008). Migratory birds of the Pacific Flyway are managed primarily by the Service using management plans that identify common goals, prioritize actions and coordinate biological research.

Waterfowl and Waterbirds

Although waterfowl and waterbirds fall under the preceding category on migratory birds, the large seasonal concentrations of these two groups of birds were the primary rationale for creating these refuges and WMA. Providing habitat for wintering waterfowl and other wetlands-associated migratory birds has remained a cornerstone of management of those refuges since their establishment. The added responsibilities under the Endangered Species Act and increased emphasis on conservation of natural plant and wildlife communities may have impacted some earlier management practices, but in general are compatible with current waterfowl and waterbird habitat management.

Although no refuge-specific population goals are mandated, waterfowl and waterbird populations on the refuges are managed under the context of contributing to broad national and regional goals established through the North American Waterfowl Management Plan, CVJV, Southern Pacific Shorebird Conservation Plan and other conservation plans. Most of these plans emphasize habitat protection and management of those habitats, in order to provide optimal foraging, nesting and roosting habitat conditions.

Because of their location in the Flyway, the greatest contribution that Merced NWR, San Luis NWR and Grasslands WMA can make toward supporting these larger scale goals is to manage refuge lands so that they provide optimal foraging and roosting habitat for migrating and wintering waterfowl, cranes, shorebirds and other waterbirds. However, the provision of habitats during the summer months to meet the nesting and foraging needs of resident marsh birds and locally nesting ducks is also important and contributes to those larger scale goals. The greatest challenge the refuges face in providing for the year-round needs of waterfowl and other waterbirds is having sufficient water supplies for optimal habitat management. Given the effects of recurring droughts, the ever-increasing demands on the statewide water supply and impacts of global warming, the refuges in some years receive water allotments insufficient to meet resource needs. When this occurs, Complex staff will be forced to choose between decreasing irrigations for moist soil food production for wintering birds, providing less summer water for year-round residents and duck production, or deferring flood-up of some wetlands to stretch available water supplies. This would result in decreased quantity, quality and diversity of the habitats necessary to maintain migratory bird populations.

Other challenges to optimal habitat management for migratory birds revolve around the mechanical aspects of habitat manipulation and issues associated with water quality. With a large landbase, limited staff size and increased resource responsibilities, it is difficult to conduct the disking, mowing and other site disturbance of individual wetland units at the frequency necessary to ensure optimal site productivity; maintain and replace wetland infrastructure to provide efficient water deliveries; and control invasive species that degrade desired plant communities. In past years, use of contaminated water supplies adversely impacted both health of migratory birds and productivity of the marsh. As water supplies become more limited, Complex staff must remain vigilant to ensure that any potential relaxation of water quality standards do not adversely impact migratory birds or their habitat. In addition, BMPs imposed by other agencies to improve river water quality, have the potential to degrade wetland habitat by constraining the timing of unit drawdown, irrigations and other management activities.

Historically, numbers of rookeries and breeding pairs of waterbird species at the Complex have been consistent. As an indicator of riparian ecosystem health, if numbers of breeding pairs of the species monitored are poor, this would be a cue to investigate why numbers are declining and to trigger management action. Specifically, closing auto tour routes may reduce disturbance of rookeries. There is uncertainty about how this may benefit colonial nesting waterbirds. When this management action is implemented, Complex staff will track subsequent changes in colonial nesting waterbird breeding pair numbers.

Threatened and Endangered Species

Management of threatened and endangered species is a priority for the Service’s National Wildlife Refuge System. A total of 17 Federally listed endangered or threatened species currently or potentially occur on the San Luis NWR, Merced NWR and Grasslands WMA. Programs on these refuges are implemented in a manner that protects or contributes to the recovery of these listed species. In some instances, management activities for threatened and endangered species also can set limits on other activities on the refuges. Of the listed species currently or potentially present, those addressed in the following sections represent the species that will present the greatest resource challenges to management of the refuges, or to those which the refuges can make significant contributions toward recovery.

San Joaquin Kit Fox. Complex staff actively participate in the San Joaquin Kit Fox Recovery Team and the associated working group. Use of the refuges by San Joaquin kit fox has declined over time in conjunction with lowered kit fox populations within the northern San Joaquin Valley. No kit fox has been recorded on the refuges since 2000, despite subsequent spotlight and scat detection surveys from 2005–2008. Grazing and other management programs on Complex uplands are compatible with kit fox. These actions, along with land acquisitions since the 1990s, now provide habitat conditions on large blocks of acreage suitable for kit fox. However, other factors, such as high coyote populations or contaminants, may be limiting. Investigations need to be initiated through the San Joaquin kit fox recovery program to assess limiting factors and the feasibility of reestablishing kit fox populations on refuge lands. While much of the Complex is within the historical range of the species, the most recent Species Status Assessment (SSA) report identifies the "Kesterson NWR" as a "satellite" recovery unit and analysis region having "very low" population persistence and overall condition for San Joaquin kit fox (USFWS 2020).

Fresno Kangaroo Rat. The Grasslands area east of the San Joaquin River is within the historic range of this listed subspecies of San Joaquin kangaroo rat (*D. nitratoides*). The closely related short-nosed kangaroo rat (*D. n. breinaurus*) has been documented on private lands in the South Grasslands and the Heermann's kangaroo rat (*D. heermani*) is common on suitable Complex lands. The Fresno kangaroo rat has not been documented in the Grasslands area. However, this may be due to a lack of adequate survey coverage rather than a lack of presence. ESRP conducted surveys for Fresno kangaroo rats in 2008 on the Arena Plains, Snobird, Kesterson, West Bear Creek and San Luis units of the Refuge Complex and did not detect any Fresno kangaroo rats during the survey period. The recent acquisitions of fee-title refuge lands and expansion of the Grasslands WMA east of the San Joaquin River provide an opportunity to conduct such surveys. Determining status of the Fresno kangaroo rat on Complex lands is necessary to ensure that grazing programs and other management activities, including habitat restoration, are conducted in a manner that benefits any populations present. In addition, such knowledge would help prioritize easement acquisitions and contribute to species recovery. The most recent 5-year review for the species reported that "there are currently no known, extant populations of Fresno kangaroo rat" and "the species has not been positively identified in the wild since 1992" (USFWS 2020).

Riparian Brush Rabbit. The Complex actively participates in the Riparian Brush Rabbit Recovery Program and the riparian mammals working group in association with recovery actions elsewhere on the Refuge Complex (San Joaquin River NWR). San Luis NWR is being considered as a potential site for establishment of a population as part of the species recovery program. Resource challenges associated with such a population establishment program would include levee maintenance/flood control activities by the Lower San Joaquin Levee District, narrowness of the existing riparian corridors, and future activities associated with the SJRRP.

Recently, in conjunction with a statistician, the Complex began using camera trap surveys to examine the population of riparian brush rabbits at San Joaquin River NWR. Estimated population size and population density have been calculated and variations throughout the annual cycle have been determined. The riparian brush rabbit reintroduction program is the driving factor behind the collection and analysis of these data. The information gathered from San Joaquin River NWR, including characteristics of preferred habitat, estimated rabbit abundance and density targets, will be important for translocation of riparian brush rabbits to San Luis NWR and Merced NWR and are important for partners who are restoring riparian brush rabbit habitat.

To analyze the quality of riparian ecosystems from the Sacramento/San Joaquin Delta southward through the Grasslands and specifically at the Complex, in 2022 the FWS funded a habitat mapping project by the Endangered Species Recovery Program of California State University, Stanislaus to evaluate criteria for the habitat suitability and connectivity for riparian brush rabbits in the northern San Joaquin Valley. However, there is some subjectivity in the site criteria used to identify suitable habitat. Because data to analyze the indicators are collected at the Complex, staff will explore how to use data to best characterize habitat suitability. These indicators will be reexamined and possibly modified in the future.

Riparian brush rabbits currently are monitored at San Joaquin River NWR through analysis of camera trap data. A radio telemetry project could provide more informative data to analyze home range sizes of riparian brush rabbits at the Complex, which may be important information for translocation of rabbits to San Luis NWR and Merced NWR.

Periods of extended flooding at the Complex force riparian brush rabbits to higher ground and can lead to higher estimates of mortality when analyzing distribution data. Refuge staff would like to better understand the contraction and expansion of rabbit movement across the landscape as a result of environmental changes, including extensive flooding.

Some invasive species at the Complex have known detrimental effects on the riparian brush rabbit. More information about the impact of invasive plant species on riparian brush rabbits will allow refuge staff to better target their management of invasive plants in riparian areas and maximize suitable brush rabbit habitat.

The most recent Species Status Assessment (SSA) report identifies a “Refuge” population of riparian brush rabbit that occurs on the San Joaquin River NWR and is given a current condition of “high” (USFWS 2020).

Least Bell’s Vireo. Least Bell’s vireo once was a common nesting bird in riparian habitat throughout the Central Valley. Nesting by least Bell’s vireo had not been documented in the Central Valley for over 60 years. However, nesting was documented in 2005 and 2006 in a riparian restoration project site at the San Joaquin River NWR (45 miles north of San Luis NWR). Although no least Bell’s vireos have nested recently on Merced NWR, there have been recent sightings and nesting at San Luis NWR. Ongoing restoration and management are resulting in expansions of Complex riparian habitat that could potentially support least Bell's vireo populations and contribute to species recovery.

Refuge staff would like to investigate the preferred habitat characteristics of passerines to maximize suitable riparian habitat at the Complex. Ideally with the aid of a vireo expert, the Complex would intensify the least Bell's vireo monitoring effort to better understand habitat suitability and encourage breeding at the Complex.

Passerine bird species are currently monitored as an addition to the least Bell's vireo survey. Monitoring effort of passerines varies annually. In the future, refuge staff may consider conducting a separate survey to specifically measure passerine use as an indicator of riparian ecosystem health. Additionally, the data that are collected are rarely analyzed. In the future, staff would like to explore using online platforms such as eBird and Avian Knowledge Network to record data and potentially produce maps to visualize passerine use.

The most recent 5-year review for the species made a recommendation to "downlist to threatened status" due to implementation of section 7 consultation and habitat conservation plans (USFWS 2006).

Giant Garter Snake. San Luis NWR, Merced NWR and Grasslands WMA are within the historic range of the giant garter snake. There are historic records of giant garter snakes present on the San Luis unit of San Luis NWR and the Grasslands WMA. Widespread surveys by Complex staff, other agency personnel and contractors on public and private lands in Merced County have been ongoing since the early 1990s. Other than one e-DNA detection in the San Luis Canal in 2017, no giant garter snakes have been documented on San Luis NWR or Merced NWR in recent years (USFWS 2020). However, localized populations have been found on the Volta State Wildlife Area and private lands along the Los Banos Creek drainage within the Grasslands WMA. Because of the connectivity of wetlands in the Grasslands WMA, giant garter snakes probably move throughout the easement lands and the part of the Kesterson unit (San Luis NWR) associated with Los Banos Creek.

The most recent 5-year review for the species identifies the "San Joaquin Basin Recovery Unit" as overlapping the Complex lands and conservation easements (USFWS 2020).

Blunt-Nosed Leopard Lizard. The Grasslands area is within the historic range of blunt-nosed leopard lizard, but the species has apparently been extirpated from this part of the San Joaquin Valley. Based on descriptions by the former landowner of "large striped lizards," blunt-nosed leopard lizards may have been present at the Arena Plains unit of Merced NWR in the 1970s. However, surveys conducted shortly after acquisition in 1993 and the subsequent presence of Complex staff since that time have failed to document presence of the species. ESRP conducted a survey for blunt-nosed leopard lizards in 2008 along the Eastside Bypass of Merced NWR and Bear Creek on San Luis NWR and did not detect the presence of any blunt-nosed leopard lizards.The on-refuge grazing program has continued to maintain much of the Arena Plains unit in short-grass sandy habitat. However, investigations should be initiated to better assess the status of the species at the Arena Plains unit, any limiting factors and feasibility of reestablishing populations as part of the species recovery program. While the Complex is within the historical range of the blunt-nosed leopard lizard, the most recent Species Status Assessment (SSA) report does not reference any detections at the Complex since before 1999 (USFWS 2020).

California Tiger Salamander. Many of the vernal pools on the fee-title refuge lands have been inventoried for the presence of vernal pool fauna and the results incorporated into a refuge vernal pool database. These surveys have been performed on an intermittent basis. Based on those surveys, California tiger salamanders are thought to be abundant and widespread in the deeper pools throughout the refuges. California tiger salamanders have been documented on the Kesterson, Freitas, West Bear Creek and San Luis units of San Luis NWR, and the Snobird, Arena Plains and Merced units of Merced NWR. Grazing and other uplands management actions are conducted on the refuges in part to maintain short grass habitat and native vernal pool communities. However, periodic monitoring of tiger salamander populations is needed to ensure that Complex management actions continue to benefit the species. In addition, inventories of any new lands will need to be conducted to ensure that any planned restoration, such as leveling of berms and filling of ditches, does not adversely impact California tiger salamanders.

Anadromous Fish. Chinook salmon, steelhead trout, Sacramento splittail and other anadromous fish have not been a major management focus for refuges in the Grasslands area. Dam construction and water diversions upstream of the refuges, beginning in the 1950s, eliminated the historic runs of chinook salmon and Central Valley steelhead trout. These fish still occur in the San Joaquin River downstream of the confluence of the Merced River, but a CDFW-operated fish barrier at the confluence is used to divert salmon away from the San Joaquin River into the Merced River, where suitable habitat still exists. The few salmon that do get past the barrier end up stranded in Salt Slough and Mud Slough, where they ultimately die before reaching any spawning habitat. Sacramento splittail normally occur downstream of the refuges but can be temporarily present in the river corridor at San Luis NWR during flood events.

In 2006, a court settlement of a lawsuit involving the Natural Resource Defense Council, Friant Water Users Authority and the DOI was reached that mandated restoration of the San Joaquin River and salmon populations. The SJRRP was established by legislation and the USBR tasked with the job of implementing this restoration. As a result of this, Complex staff became more active in salmon recovery and management on refuge lands in Merced County. Fish screens will be installed on the lift pumps along the San Joaquin River, Salt Slough and Bear Creek to ensure that juvenile fish are not negatively impacted by pump operation. Floodplain wetlands have the potential to benefit salmon, steelhead and splittail populations by providing high quality rearing habitat. The design for any levee breeching and floodplain restoration of refuge lands, as well as subsequent management of the floodplain, needs to be closely coordinated with fisheries biologists to avoid creating conditions that promote fish entrapment, and to optimize anadromous fish-rearing habitat.

Valley Elderberry Longhorn Beetle. The refuges are within the historic range of the Valley elderberry longhorn beetle. This species is dependent on elderberry (*Sambucus mexicanus*) for its existence. Elderberry shrubs are an important component of riparian vegetation ecosystems in California and are present as scattered individuals throughout the refuges in the grassland area. However, the amount of elderberry habitat on the refuges and easement lands is limited, and presence of the beetle has not been documented. Elderberry plants have been incorporated into the mix of native shrubs planted as part of riparian restoration in recent years, and Valley longhorn beetle populations may become established in the future as that habitat matures and expands. The most recent recovery plan for the species includes the San Luis, Merced and San Joaquin River NWRs in the San Joaquin River Management Unit for Valley elderberry longhorn beetle (USFWS 2019). Future levee management at the Complex should consider possible effects to riparian vegetation and elderberry shrubs.

Vernal Pool Invertebrates. Most of the vernal pools on the fee-title refuge lands have been inventoried for the presence of vernal pool fauna and the results incorporated into a refuge vernal pool database. These survey efforts have been conducted on an intermittent basis. Based on those surveys, three Federally listed species of fairy shrimp (longhorn fairy shrimp, Conservancy fairy shrimp, vernal pool fairy shrimp) and the vernal pool tadpole shrimp are present in vernal pools throughout the Complex. Grazing and other uplands management actions are conducted on the refuges in part to maintain short-grass habitat and maintain native vernal pool communities. However, periodic monitoring of vernal pool invertebrates is needed to ensure that Complex management actions continue to benefit the species. In addition, inventories of any new lands will need to be conducted to ensure that any planned restoration, such as leveling of berms and filling of ditches, does not adversely impact listed fairy shrimp. The most recent recovery plan for these species includes the Complex in the San Joaquin Valley Vernal Pool Region (USFWS 2019).

Colusa Grass. Colusa grass has been documented within two vernal pool basins on the Arena Plains Unit of Merced NWR. Plant surveys elsewhere on San Luis NWR and Merced NWR have failed to find any other populations. At present, only a single population within one of those pools at Arena Plains occurs. That site was adversely impacted by an illegal spill from a turkey waste fertilizer processing facility on the adjacent property in 1995. Subsequently, only a few plants have been present each year, depending on the amount of rainfall during the wet season. The site needs to be monitored on an annual basis to determine if the Colusa grass population at the Arena Plains unit persists over time. Refuge staff should also monitor the pool for invasive plant species that may affect the success of the Colusa grass population over time. In addition, any lands with similar soil types in the East Grasslands proposed for fee or easement acquisition need to be surveyed to prioritize acquisition and protect any newly discovered populations. The most recent recovery plan for the species includes the Complex in the San Joaquin Valley Vernal Pool Region (USFWS 2005).


Sandhill Cranes. Photo: Rick Lewis

State of California Listed Species. Swainson's hawks and Delta button celery are relatively common on refuge and easement lands. Ongoing riparian restoration will increase both nesting and roosting habitat for Swainson's hawks. Delta button celery occur on heavy clay soils within the floodways between the levees at San Luis NWR, Merced NWR and Grasslands WMA, and in the floodplain on the Kesterson unit of San Luis NWR. Populations vary by year, with thousands of plants being present during summers following flood events. Management of floodway and floodplain habitats will need to include grazing and periodic flooding to maintain delta button celery populations. Other state-listed species are present in limited numbers. The needs of the few greater sandhill cranes present at Merced NWR can be accommodated through Complex management for the more abundant lesser sandhill crane populations. Yellow-billed cuckoos, willow flycatchers and bank swallows have been observed in the past as rare migrants/transients during spring through fall but are not local nesters. However, ongoing riparian restoration will increase nesting and foraging habitat for yellow-billed cuckoos and willow flycatchers.

San Joaquin Valley Endemic Species

Aside from conserving and enhancing migratory bird populations, the Complex provides habitat for a large suite of other non-migratory wildlife and plants. Many of these species are endemic to the San Joaquin Valley or to California. Due to these species' limited distribution ranges and the limited wildland habitat remaining in the San Joaquin Valley, the Complex serves a vital role in supporting these unique species and will need to continue to monitor and provide habitat for the conservation of these endemics. Endemic species in the San Joaquin Valley found, or with the potential to be found, on the Complex cross all taxonomic categories. By taxonomic group, both fish and plants at the Complex have the largest component of endemic species. Of particular interest for the Complex is the role it plays or could play for tule elk, San Joaquin kit fox, riparian brush rabbit, several kangaroo rat species, tricolored blackbird, blunt-nosed leopard lizard, giant garter snake, western pond turtle, California tiger salamander, native freshwater fish species, vernal pool invertebrate communities and vernal pool plant communities.

Ungulate Species

The reintroduction and establishment of native species and species assemblages is a high priority for the Refuge System (Refuge Improvement Act; Schroeder, Holler, and Taylor 2004). Thus, considering ungulate reintroduction of the full guild of hoofed mammals, including black-tailed deer, tule elk and pronghorn antelope (until the 19th century all relatively abundant in the GEA), is consistent with promoting resource conservation objectives defined by the Service. The last free-ranging ungulate native to the GEA, the black-tailed deer, was extirpated in the 1960s. Tule elk and pronghorn antelope were extirpated some 70–80 years earlier (Bakker 1965). This localized defaunation of the GEA is consistent with the severe decrease in distribution and abundance that occurred for deer, elk, pronghorn antelope and bison throughout the United States (Trefethen 1975). An ecological case also may be made for ungulate reintroduction to the GEA based on the important role that native ungulates provide in increasing habitat diversity, facilitating the herbivory of other species (Krebs 1978), fueling nutrient and critical element cycling (Crawley 1983) and providing a prey base for keystone predators. The considerable aesthetic contribution that large mammalian species, such as ungulates, make to promoting the conservation of wildlands is also worthy of consideration (DOI 2000).

An examination of the feasibility of restoring sustainable, free-ranging populations of native ungulate species to the Grasslands must consider the common anthropogenic obstacles faced by elk, deer and pronghorn antelope. Physical and environmental constraints include habitat loss, conversion, degradation and fragmentation due to urbanization; an expanding agricultural frontier; and invasive species colonization. More localized impediments to ungulate restoration include roads (mortality and injury due to ungulate-vehicle collisions), cement-lined canals and drains that trap and drown ungulates and crop fields that serve as a high-quality food resource for ungulates yet may lead to ungulate-human conflict due to crop depredation. Human food security and human health may be threatened by zoonotic diseases of ungulates, such as highly pathogenic *E. coli*, that have been isolated from at least one ungulate species native to the GEA. Additional threats include poaching and the relatively high levels of environmental contaminants, such as agricultural toxins, that occur in and around the GEA. Some studies have shown that these contaminants may suppress the immune systems of mule deer, weakening disease resistance (Ferguson 2006).

Black-tailed Deer Buck. Photo: Karl Stromayer

Just as each ungulate species has unique behavioral ecology and life history requirements, each species will face unique constraints and opportunities and will respond to the resources and challenges posed by the human footprint in the Grasslands ecosystem in a different way. Therefore, the habitat suitability for each species, the types of issues requiring consideration in conducting a feasibility study prior to reintroduction and the likely persistence and population viability of the species following reintroduction may differ. For example, black-tailed deer and tule elk may be confined or diverted from designated areas by the erection of eight-foot panels of woven wire fence, but four-foot panels of woven wire fence are sufficient to confine or divert pronghorn antelope (CDFG 1982). Possible dietary overlap and competition between reintroduced ungulate populations and domesticated ungulates, employed in current refuge grazing programs, also will have to be investigated. For example, competition for forage resources is a greater concern between domesticated sheep and pronghorn antelope than it is between pronghorn antelope and cattle due to differential overlap in forage preferences (Bleich et al. 2005).

Reintroduction efforts for tule elk, black-tailed deer and pronghorn antelope to the GEA are currently at different stages. Initiated in 2003, the reintroduction of black-tailed deer is ongoing; a feasibility study to examine the possibility of establishing a free-ranging herd of elk to the

GEA has been published; and the reintroduction of pronghorn antelope is in the conceptual stage. The next sections of this review will summarize key points that need to be considered as the Complex moves forward with possible feasibility investigations and reintroduction efforts concerning each of the three historically occurring native ungulate species.

Black-tailed Deer. In marked contrast to the feasibility study of the reintroduction of free-ranging tule elk to the GEA and the conceptual plan to initiate a similar feasibility investigation for pronghorn antelope, the reintroduction of black-tailed deer to the GEA is framed by a Memorandum of Understanding (MOU) and a CMP and is informed by 7 years of experience. The review of the lessons learned by this effort are presented first, followed by the treatment of challenges and issues that should be reviewed and, if appropriately addressed, to ensure that all necessary steps are taken to achieve the objective of a self-sustaining black-tailed deer population in the GEA.

In 2003, an MOU between the Service, the CDFW, the California Department of Parks and Recreation and the Stevinson Corporation was signed with the purpose of reintroducing and reestablishing a resident Columbian black-tailed deer population to portions of Federal, state and private (Federal conservation easement) lands within the GEA. This MOU is effective until terminated by any party upon 6 months' notice in writing to the other parties of the intention to do so. Under the MOU, the Service agreed to: (1) allow for the reintroduction of the appropriate subspecies of deer; (2) provide access to the CDFW to monitor reintroduced deer; (3) maintain habitat suitable for a deer population; (4) consider the needs of the deer as a component of the natural wildlife community "without compromising endangered species, migratory bird, or other Federal trust resources at the San Luis NWR"; and (5) "evaluate compatible deer management alternatives at the San Luis NWR if or before deer impact trust resources, their management, other refuge programs, or adjacent lands. Public hunting will be one of the alternatives considered."

A CMP was developed by the signatories to guide the implementation of the deer reintroduction effort. This document defined the Pacheco deer herd as the deer herd in Merced and Stanislaus Counties west of Highway 99, identified a "primary" 25,000-acre area for the reintroduction effort and noted there were about 45,000 acres of land immediately to the south of this area, where "the presence of deer is considered compatible with current land management." The CMP defined the primary goal of the effort as the establishment of a "self-sustaining deer population" and noted that, "if the deer population becomes established, the goal will be to maintain a population size where reproduction is self-sustaining, public use is diversified and depredation issues are minimized." The CMP set a population goal of a deer herd size between 100 and 420 animals (with a "target" number of 150–250 animals) and estimated that the population might increase to its maximum desired level within 10–25 years.

The CDFW, supported by the Service, released 59 deer into the GEA. As of 2007, the population was between 10 and 25 deer (CDFG 2007). Overall mortality of released collared deer was high—56 percent overall with 57 percent outside the study area (only 22 percent of released deer remained within the study area following release [CDFG 2007]). Causal factors contributing to the 33 known mortalities were: roadkill (26 percent); drowning (19 percent); capture myopathy or recapture-related (16 percent); and poaching (13 percent), with all other factors including the unknown category contributing 26 percent. Fawn production and survival was excellent in 2004, with four does producing twin fawns. No fawns were observed during 2005. In 2006, five does were found with six fawns. Does and twin fawns were observed on the San Luis NWR in both 2007 and 2008. The following observations from 2007 include other interesting results: 1) no deer have established home ranges on the Freitas unit of the San Luis NWR or the Great Valley Grassland State Park in the 4 years following reintroduction; 2) deer have established home ranges on the San Luis unit of the San Luis NWR; and 3) the onset of the waterfowl hunting season and the flooding of the San Joaquin River led to shifts in home ranges of radio-collared deer (CDFG 2007).

Black-tailed Deer. Photo: Lee Eastman

While mortality has been high among reintroduced deer in the first years following reintroduction, this result is consistent with the literature on ungulate reintroduction efforts (Rosatte et al. 2007). Known black-tailed deer predators that occur in the reintroduction area include dogs, coyotes and humans. While one of 33 known mortalities of introduced deer was attributed to the domesticated dog, humans accounted for 39 percent of known mortality (roadkill [26 percent] and poaching [13 percent]).

Successful fawning has been documented among reintroduced does and fawns that were born to reintroduced does. This result suggests that the first precursor to establishing a self-sustaining population was met within the first few years of reintroduction. Research conducted by CDFW and USFWS to assess the population of deer following reintroduction found that the population grew from 11 to approximately 175 individuals between 2006–2015 (166 percent). The reintroduced population has shown and is currently considered to be established at the refuge. Black-tailed deer have since been documented in almost every unit of San Luis and Merced NWRs, achieving the goal of creating a self-sustaining population in the GEA.

As the population of black-tailed deer increases throughout the GEA, the number of deer entrapped in the cement-lined San Luis Drain also continues to rise. Deer entrapment in the San Luis Drain was documented within two years of reintroduction and continues to be a problem and a source of mortality for deer on the refuge today. Refuge records from 2015–2022 have documented 75 deer observed in the drain, including 16 mortalities and 59 rescues (USFWS 2022). Rescuing deer from the drain also poses significant risks of injuries to refuge and CDFW staff while handling the deer. CDFW and the refuge have experimented with wooden ladders installed on the sides of the drain; however, the current designs have failed to solve the problem and deer are still becoming entrapped in the drain. The refuge will continue to solicit input from the USBR for a solution to the issue, until it is resolved.

The black-tailed deer is a subspecies of the mule deer, named for its large ears and robust body (Bauer and Bauer 1995). Does, weighing from 100 to 150 pounds at maturity, are much smaller than bucks, weighing 150 to 200 pounds, on average. Mule deer have the ability to change their foraging habits to eat leaves, needles, succulent stems, fruits, nuts, shrubs, forbs, agricultural crops and grasses, in a variety of states from living to decaying (Bauer and Bauer 1995). Hiding cover and thermal cover are crucial aspects of mule deer habitat, the former for predator avoidance, and the latter for moderating body temperature in heat and cold. Natural predators are mountain lions, wolves, coyotes, black bears, grizzly bears, lynx, bobcats and golden eagles. The habitat suitability of the GEA for deer was not assessed as part of this study. The movement of deer between the coastal range mountains immediately to the west of the GEA and the high mortality that these migratory deer suffered when the Delta Mendota Canal and California Aqueduct were constructed is well documented (USFWS 2003). However, the extent of local (i.e., non-migratory populations) of black-tailed deer that occupied the GEA prior to the extirpation of this deer subspecies is not known. Logic dictates that deer will remain within the GEA as long as their needs for suitable habitat, space, food and water are met, and births and possible immigration exceed mortality and possible emigration. However, it remains to be demonstrated whether, in the absence of a migratory route to the nearby Coastal Range Mountains, the GEA serves the ecological function of a year-round versus seasonal habitat for this subspecies, or if, indeed, the habitat was in historic times a sink or possibly a source habitat for this subspecies. The reintroduced population of black-tailed deer are currently found in the GEA year-round.

Further research regarding the long-term viability of this newly established deer population might focus on the possibility that the habitat served as a sink or (largely unavailable) habitat during flood years yet might have served as a refuge during drought years. Under current water management regimes in the State of California and the GEA (even with possible floodplain enhancement/river restoration proposals under consideration), it is unlikely that extreme flood events less than 100-year return flows of the San Joaquin River would drastically reduce available habitat for this species. The assessment of the degree of success of this reintroduction effort will remain inconclusive without research into the population dynamics and herd health and/or nutritional ecology of this reintroduced deer population.

At the present time, observation of individual deer and ocular assessment of their body condition (including antler development in males and the presence or absence of one or multiple fawns with mature does post parturition) will provide a minimal index to the continuation of this reintroduction effort and a crude measure of habitat suitability for this (small) potential founder population. The black-tailed deer is classified as a generalist herbivore, so the riparian and upland vegetation of the GEA (including the many non-native plant species that are variously palatable to native and domesticated livestock) would seem to provide ample cover and forage resources for this species. In summer, the added food resource of the fertile seasonal wetland basins that support a high biomass of succulent grasses and herbs and heavy carbohydrate-rich seed crops also would suggest a most suitable forage resource. Extensive upland, wetland and riparian habitats and relatively large tracts of habitat free of roads and fences also would seem to provide adequate resources and space for this species.

Black-tailed deer may browse agricultural crops, thereby creating costs for farmers (Ferguson 2006), but this is not currently an issue within the GEA. Deer-vehicle collisions may cause human fatalities and result in deer mortality as well (McShea, Underwood, and Rappole 1997). Deer have been killed on State Highway 165 and the Service has initiated contact with California Department of Transportation (Cal Trans) to post deer warning signs along the road to alert motorists to the presence of this species. Mule deer are affected by waterfowl hunting, moving their home ranges away from hunt areas during the hunting season and returning after the season closes (Ferguson 2006), so the hunting of waterfowl on the Grasslands WMA may affect deer habitat use. However, the plentiful availability of closed zone areas (greater than or equal to 50 percent of all available fee-title land) suggests that this variable will not be a significant impediment to black-tailed deer survival. Similarly, flooding of the San Joaquin River causes deer to relocate their home ranges, moving away during flood events and returning when the flood recedes; this issue will be exacerbated if plans to restore the San Joaquin River proceed. Yet, flooding events have been so attenuated that this factor is largely mitigated under current management of most GEA lands.

Differences in deer and cattle habitat use have mitigated concerns over anaplasmosis, a disease that may threaten livestock, but there is still a need for monitoring (Ferguson 2006). The documented presence of highly pathogenic *E. coli* in the fecal samples of three of 85 tule elk surveyed in coastal California (*Modesto Bee* 2009) also dictates a need for monitoring; while only three animals tested positive, this disease is expected to infect black-tailed deer and might move between sympatric wild and domesticated ungulates. Monitoring of the reintroduced black-tailed deer population to document recruitment, numbers and survival would be desirable. Food habits studies based on microhistological analysis of fecal samples and available forage (Braun 2005) and fecal DNA sampling would be feasible indirect methods of assessing food habits and criteria of population size and sex ratio, respectively. At some point in the future, herd health and plant community monitoring would be desirable to inform possible population management actions.

Tule Elk. Currently, tule elk are managed as a semi-captive herd in a 760-acre fenced enclosure at the San Luis NWR. The elk are managed in cooperation with the CDFW under a MOU (USFWS 1974). This MOU stipulates that the Service "build and maintain an elk proof enclosure" and provide ample habitat and security for the elk while not negatively impacting waterfowl management responsibilities. It requires that the Department will provide elk to populate the enclosure, remove any elk judged to be in excess of the carrying capacity of the enclosure and provide TA if necessary in managing the population. The MOU is effective until terminated by either party by providing six months' notice in writing.

This model has provided 48 years' (1974–2022) experience with tule elk ecology within the GEA and provides strong evidence that the current GEA habitat, of which the elk enclosure is thought to be representative, is suitable for sustaining relatively high densities of tule elk in the long term. This is a significant finding. The productivity of this elk herd is also notable, with over 300 elk captured from the San Luis NWR herd and translocated to other habitats, despite considerable effort to reduce recruitment to the population via contraception (USFWS 1978, 1979, 1985, 1987, 1995, 1998, 2001, 2004, 2005, 2013, 2014, 2019, 2022).

The establishment of a fenced population of elk in the GEA has contributed significantly to the recovery of this elk subspecies and has provided high priority public use and pedagogic value to the American public by highlighting the role and legacy of the tule elk in the Central Valley of California and the GEA specifically. Regardless of the ultimate decision to move forward (or not) with experimental free ranging tule elk reintroduction to the GEA, it is anticipated that the maintenance of elk (and possibly other endangered or endemic species) in the tule elk enclosure will continue to provide highly valuable public outreach and scientific research opportunities. The carrying capacity of the enclosure is reached when the population exceeds 50 animals and approaches 80 animals (Bureau of Reclamation). When the carrying capacity is reached, the elk are managed through live capture and a translocation process that is resource-intense and expensive. Historically, this recurrent cost of maintaining the population has been borne by the Service and CDFW and it is anticipated that it will become increasingly difficult to justify this expense as the demand for founder stock to reintroduce tule elk to available habitat (not yet restocked with elk) decreases.

In partnership with CDFW and UC Davis, and with support from the Rocky Mountain elk foundation, the Service has initiated a feasibility study to examine the reintroduction of free-ranging tule elk to the GEA. This study was designed in two phases. The objectives of year one (completed in February 2009), were to 1) document, via a GIS and habitat suitability model, the quantity and quality of existing habitat in the GEA for tule elk and 2) examine potential conflicts with man, movement barriers and corridors for elk in this area. The second year of the feasibility study will develop a model, incorporating spatial and population modeling components, to examine the potential results (in terms of elk numbers and habitat occupancy) and to identify conflicts/issues that may arise should an experimental release of elk be conducted. This model will estimate a theoretical elk population growth curve at 2, 5, 10 and 15 years, post-release, and will identify sites in the GEA where elk-human conflicts are likely to occur under such a scenario. Finally, this study will propose actions that will need to be taken if an experimental release ever occurs. These studies were initiated to examine the feasibility of a free-ranging tule elk herd in the GEA, or portions of, as well as to document concerns and impacts of such an action. These studies are not a plan of action for a free-ranging elk herd in the GEA but an examination of the possibility and the identification of impacts from such an activity.

The GEA tule elk feasibility study produced a GIS map describing the type and quantity of different land cover features potentially available to tule elk in a 225,000-acre area of the GEA. The study then conducted a habitat suitability analysis for tule elk in the GEA using the GIS that modeled cover and forage presence, habitat diversity and human impacts. Densities of occurrence of these features were measured within a 2.711 km radius to produce a habitat suitability value for each such 2.711 km radius polygon in the GEA. This polygon size was based on the average home range size for tule elk in the Cache Creek herd, a free-ranging population in the Coastal Range Mountains bordering the Sacramento Valley, which is the most ecologically analogous tule elk population for which detailed movement data are available. Based on this analysis of the 225,000 acres of the GEA, it was estimated that 28,790 acres of potential tule elk habitat existed within the GEA. Of this habitat, 11,460 acres were considered “very high quality” habitat. These areas are characterized by public land ownership; a mosaic of grasslands, freshwater wetlands and riparian forest; and isolation from public roads.

The study concluded that the 11,460 acres of “very high quality” habitat could conservatively support between 180 and 320 elk, based on the mean number of acres occupied by elk in the Cache Creek herd. The study acknowledged that this estimate was probably an underestimate, as forage resources in the GEA were much superior to those occurring in the Cache Creek area and perhaps similar to conditions at Grizzly Island in the California Bay Delta Region, where tule elk occur in densities far higher than at Cache Creek. It is notable that the 760-acre tule elk enclosure at San Luis NWR has maintained a tule elk population of close to 50 animals (range 18–90) over 48 years, while maintaining excellent herd health among the elk and no documented long-term degradation of the habitat within the enclosure. The elk enclosure at San Luis NWR was sited expressly to incorporate what was then perceived to be high-quality habitat with a mixture of grassland, freshwater emergent wetland and riparian components, much as quantified in the Habitat Suitability Index (HSI) model developed by the tule elk feasibility investigation. If the elk number (50 or so) typically supported by the tule elk enclosure is extrapolated to the 11,460 acres of very high-quality habitat identified by the HSI model, a figure of 754 elk is calculated, nearly twice the range of elk numbers predicted by the HSI model. It must also be considered that, if reintroduced, elk reasonably might expect to expand their range into habitat of lesser suitability, thereby increasing the total number of tule elk that the GEA might be expected to support.

Tule Elk. Photo: Lee Eastman

The potential for elk vehicle collisions and human fatalities that might result from such collisions is a major concern. If elk are reintroduced, this hazard is expected to be particularly severe along State Highway 165, a two-lane highway that receives heavy commercial truck and commuter traffic and bisects the GEA from North to South. This highway is notable for receiving a high number of vehicle collisions, often with fatalities each year. Efforts to mitigate elk-vehicle collisions would eventually be needed along State Highway 165 and along State Highway 140, Henry Miller Avenue and State Highway 152. The threat elk might pose to human industry by virtue of crop depredation is also an issue that needs to be examined and planned for. Alfalfa, irrigated pasture, corn and other field and orchard crops are grown in properties adjacent to refuge lands and all of these crops might be subject to depredation. Additional threats that elk might pose may include their capacity to serve as vectors for diseases of livestock (such as anaplasmosis and Johnnies disease) and zoonotic diseases such as *E. coli*. The latter threat has led to the destruction of large numbers of black-tailed deer and feral pigs in the nearby Salinas Valley over concern that fecal contamination of lettuce and spinach crops may pose a biohazard and bring severe economic consequences to farmers and the food technology industry. The feasibility study focused on ecological carrying capacity issues, but of equal or greater interest might be the cultural carrying capacity of the GEA for elk. Future research may focus on the extent the public residing within or immediately around the GEA would support elk reintroduction and the accompanying potential threats this may pose (however real or remote they may be on a case-by-case basis) to human safety, health and agricultural and livestock-producing livelihoods.

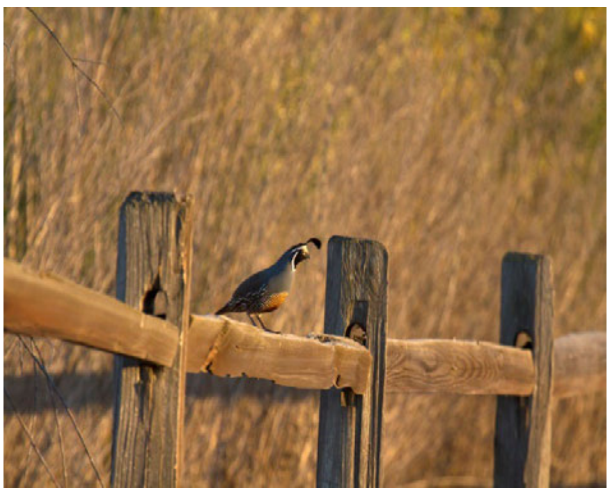
The second year of the feasibility study will model elk numbers and occupancy, including conflicts with humans, as (a theoretical) reintroduced elk population nucleus expands its numbers from a designated release site and occupies a larger and larger range within the GEA. This modeling process should identify key features of the landscape that will need to be mitigated prior to or during an elk reintroduction effort to minimize elk threats to humans and/or human infrastructure and property and to minimize mortality factors for elk. Scenarios that might arise from this modeling effort may include the identification of lands that will need to be fenced to avoid crop depredation, roadways where elk-vehicle collisions will need to be mitigated and canals and drains that will need to be secured from elk entry or modified to permit elk egress. If factors that currently pose a risk or prohibit a potential elk reintroduction can be identified and then mitigated, an experimental release of radio-collared tule elk at a single release site might be warranted. Protocols would be developed with CDFW to make clear the trigger point and response that would be elicited by the movement of elk into certain areas where elk are not wanted. If such a free release becomes possible, an opportunity to compare the behavior and ecology of a free-ranging and a confined elk population inhabiting similar habitat will become available.

Pronghorn Antelope. In California, historic accounts indicate that pronghorn antelope inhabited much of the grasslands, oak woodlands and sagebrush steppe vegetation communities of the state. Pronghorn antelope density in the San Joaquin Valley of Central California (where the GEA is located) was reported to be greater than in any area west of the Mississippi River (CDFG 2004). Today, the range of the pronghorn is much restricted in California with some 4,160 animals (CDFG 2008) found chiefly in northeast California (CDFG 1982) and some small populations also found in Kern, Los Angeles, San Luis Obispo, Santa Clara, Alameda, Colusa, San Benito and Monterey counties (CDFG 2008). The goal of pronghorn antelope management in California is to “encourage the conservation, restoration, maintenance and utilization of the State’s pronghorn antelope populations” (CDFG 2004).

Pronghorn antelope were probably the most abundant ungulate in the Central Valley of California (Caton 1876), outnumbering tule elk and black-tailed deer in what is now the GEA. An evaluation of the feasibility of restoring this species to the GEA would be a logical first step in any consideration of a reintroduction effort. A feasibility investigation would be informed and facilitated by the experience the Service and partners (particularly CDFW) have already gained with the black-tailed deer restoration program and the tule elk feasibility investigation. Preliminary opportunities, rather than challenges, lie in conducting a feasibility investigation into the possible reintroduction of the species to the GEA, given CDFW’s clear goal of restoration of the species and the likelihood that the subspecies of pronghorn that inhabited the Central Valley was *Antilocapra americana americana*, by far the most numerous pronghorn subspecies (O’Gara 1978).

While the tule elk feasibility investigation has created something of a groundwork for a possible pronghorn antelope feasibility investigation, important differences between the ecology and behavior of these species will need to be evaluated in any pronghorn antelope investigation. For example, while the extensive fencing characteristic of private conservation easement lands within the GEA is not an obstacle to black-tailed deer and tule elk movements within the GEA, fencing is generally considered detrimental to pronghorn movements, although desirable if containment is a goal (CDFW). Food habits studies of pronghorn indicate that they eat a large variety of plants with forbs and shrubs as the mainstays of the diet in many locales (O'Gara 1978). However, as is the case with the black-tailed deer, the ability of the GEA to sustain a population of non-migratory pronghorn is unknown and requires further investigation. In conclusion, the restoration of pronghorn to the GEA is an intriguing possibility that bears further investigation.

Invasive Species



California Quail. Photo: Rick Lewis

On a global scale, invasive species are considered a severe threat to biological diversity because they are difficult to manage and often create ecosystem-level changes, some of which are irreversible. California, with its varied climate and topography, is a biologically diverse state with many endemic species. However, the warm climate, a growing human population and easy access from other states and countries have created a haven for invasive species in California, many of which have become established and spread throughout the state. Some of the most damaging invasive species occur in the Complex, including yellow starthistle (*Centaurea solstitialis*), perennial pepperweed (*Lepidium latifolium*), giant reed (*Arundo donax*) and water hyacinth (*Eichhornia crassipes*).

It is the responsibility of the Service to conserve native wildlife populations and the ecological processes on which they depend. Invasive species have the potential to impact wildlife populations by degrading or changing native habitats, competing with native wildlife for resources, disrupting ecosystem functions and relationships and reducing the diversity of the ecosystem, thereby making it susceptible to further invasion and disturbances such as diseases and natural disasters. Federally listed threatened and endangered species often are more susceptible to the ecological impacts of invasive species. The impact of invasive plants and animals on refuge lands redirects valuable resources away from native habitat enhancement and wildlife conservation towards prevention, detection, monitoring and control of invasive species.

On the Refuge Complex, invasive species are managed by the Service, under the authority of several legislative acts including the FWSM, Federal legislation and Presidential executive orders. Under the regulatory force and effect of Title 600, regarding Land Use and Management, the Service is prohibited by executive order, law and policy from authorizing, funding, or carrying out actions that are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere. Biological integrity, diversity and environmental health policy provides refuge managers with an evaluation process to analyze their refuge conditions and recommend the BMPs to prevent further degradation of environmental conditions and, where appropriate, restore lost or severely degraded components. The Service also supports the reintroduction of extirpated native species within their historical ranges and habitats (unless naturally extirpated) and may also allow for the introduction of non-native species for control of invasive species as prescribed by an integrated pest management program.

Series 601 of the FWS Manual also states that the Service will prevent the introduction of invasive species; detect and control populations of invasive species; provide for restoration of native species and habitat conditions in invaded ecosystems; and develop integrated pest management strategies that incorporate the most effective combination of mechanical, chemical, biological and cultural controls while considering their effects on environmental health. In addition, no action to reduce or eradicate self-sustaining populations of non-native, non-invasive species (e.g., ring-necked pheasants, *Phasianus colchicus*) will be taken unless those species interfere with the refuge purposes and mission. However, populations of such species will not be encouraged unless such habitat management aids in accomplishing refuge goals.

The National Invasive Species Council, consisting of 13 departments and agencies and established by the signing of Executive Order 13112 by President Clinton in 1999, mandates Federal agencies to control and minimize the economic, ecological and human health impacts of invasive species. The Lacey Act (Title 18 USC 42), regulated by the Secretary of the Interior, prohibits the importation and interstate transport of animal species determined to be injurious to human beings, to the interests of agriculture, horticulture, forestry, or to wildlife or the wildlife resources of the United States. The Endangered Species Act of 1973 (16 USC §1531) gives some protection to local endangered species by allowing the eradication of non-native species that threaten endangered species. NEPA Public Law 91-190 (January 1, 1970) requires Federal government agencies to consider the environmental effects of their actions on the human environment in their planning and decision-making processes.

Although multiple statutes provide the Service with the authority to control and manage invasive species, no legislation provides funding specifically for this purpose. Without dedicated funding, controlling the spread and impact of invasive species will a challenge.

Nutria Management

General Description

The nutria (or coypu) is a large, light- to (typically) dark-brown, fur-bearing aquatic rodent. Nutria resemble beavers, but with arched backs and long, round, sparsely-haired tails, rather than wide and flattened like the beaver. Adults typically reach a body length of 2 feet, weigh 15–20 pounds and have tails 1–1.5 feet long. Nutria tracks can reach up to 6 inches long, have five toes per foot and have webbing on the hindfeet that is often visible in tracks. An adult nutria is about one-third the size of an adult beaver, and over five times the size of a muskrat, which has a thin, laterally flattened (side to side), nearly triangular tail. Nutria are distinguished from beavers and muskrats by their long, white whiskers and rounded tails; beavers and muskrats have black whiskers and flattened tails. Once introduced, nutria populations increase rapidly; nutria reach sexual maturity as early as 4 to 6 months of age and can produce their first litter by 8 months of age. They breed year-round, producing up to three litters per year, with two to 13 young per litter.

Current Distribution

Nutria were originally introduced to the U.S. (Elizabeth Lake, California) for the fur-trade in 1899, but failed to reproduce. Subsequent introductions were successful, as records indicate nutria were present in the Central Valley and South Coast of California in the 1940s and 1950s but were eradicated from the state by the 1970s. There are established populations of nutria on every continent except Antarctica and Australia. In the U.S., nutria have been found in 30 states, and are currently established in as many as 18, including Washington and Oregon. In 2017, a reproducing population of nutria was discovered in California's San Joaquin Valley. As of May 2019, nutria have been confirmed in San Joaquin, Stanislaus, Merced, Fresno, Mariposa and Tuolumne counties.

Habitat Preference

Nutria are found near permanent water sources, such as rivers, streams, lakes, ponds and wetlands. Though common in freshwater, nutria also inhabit brackish coastal water areas. Native to South America, nutria thrive in warmer climates, and their reproductive success is reduced by severe winter conditions.

Pathways

During the 1930s, introductions to several states for development of "nutria ranches" were successful. When the fur market collapsed in the early 1940s, many nutria were released. Throughout the 1940s, agencies and entrepreneurs also promoted and released nutria to control aquatic vegetation. Subsequent ecological impacts led many states to implement eradication efforts. Nutria are restricted in California and cannot be imported, transported or possessed without a permit.

Impacts


Nutria. Photo: Rick Lewis

Nutria cause environmental damage through burrowing, intense herbivory and carrying pathogens and parasites. Nutria do not construct dens. Nutria burrow and frequently cause water-retention or flood control levees to breach, weakening structural foundations and eroding banks. They can consume up to 25 percent of their body weight in above- and below-ground vegetation each day, but they waste and destroy up to 10 times as much, causing extensive damage to the native plant community and soil structure, as well as significant losses to nearby agricultural crops. The loss of plant cover and soil organic matter (roots, rhizomes, tubers) results in severe erosion of soils, in some cases destroying marshlands and leaving behind open water. The destructive feeding habits of nutria threaten populations of rare, threatened, or endangered species that rely on critical wetland habitats. Nutria are hosts for tuberculosis and septicemia, which are threats to humans, livestock and pets. Nutria carry tapeworms, a nematode that causes a rash known as “nutria itch” and blood and liver flukes, which can contaminate swimming areas and drinking water supplies.

Control Techniques

Nutria eradication in California is a collaborative effort by many agencies and organizations and is led by the California Department of Fish and Wildlife. CDFW developed the current program based on the successful eradication techniques used in the Chesapeake Bay Nutria Eradication Program. Following this model, counties in California were divided into 40-acre grid cells, which are used as the management units for nutria monitoring. Cells are prioritized by the presence of potential nutria habitat (permanent or semi-permanent water) and assessed on a cell-by-cell basis. Cells with suitable habitat for nutria are monitored via baited game camera stations, as well as thoroughly searched on foot or by boat for the presence of nutria signs such as scat, tracks or vegetation damage. If nutria are detected in a cell, live traps are set and monitored daily. Any nutria caught in live traps are dispatched by refuge staff, and non-target captures are released. The goal of the refuge nutria management program is the total eradication of nutria from refuge lands, and the goal of the CDFW is total eradication of nutria from California.

Invasive Species Descriptions & Management Options. The list of the most problematic invasive species currently occurring on Grasslands WMA lands includes 19 terrestrial plant species and 15 animal species.

Yellow Starthistle. The Complex has significant infestations of the highly competitive plant yellow starthistle (*Centaurea solstitialis*), a serious pest of grassland, uplands, meadows, fields and roadsides. Starthistle is a deeply rooted, winter annual that produces many spiny, yellow flower heads during the spring, summer and fall. With its ability to alter water tables, starthistle displaces native plants and animals and threatens ecosystems by encroaching on riparian areas and wetlands (Ditomoso and Healy 2007). Starthistle also seriously degrades the quality of forage available to native ungulates, such as tule elk. Areas heavily infested with starthistle are aesthetically unappealing and difficult to walk through, a condition that leads to decreased public visitation. Two species of seed head weevils have been used as biological controls at the Complex to manage starthistle. Current major control programs for this species include prescribed burning, mechanical cutting and chemical controls.

Giant Reed. A tall, perennial grass, giant reed (*Arundo donax*) grows in multi-stem, cane-like clumps, ranging from 9 to 30 feet tall. Giant reed out-competes and affects many native riparian species in disturbed riparian and wetland areas by forming massive stands that shade out other plants; destabilizing stream and river banks with its shallow root system, which is easily undercut and eroded; monopolizing the water supply; and creating less desirable habitat for endangered species such as the least Bell's vireo (*Vireo bellii pusillus*). At the Complex, current control methods include chemical methods and mechanical removal by hand weeding.

Herbicide Application. Photo: USFWS

Perennial Pepperweed. Perennial pepperweed (*Lepidium latifolium*), a fast-spreading, multi-stem, perennial herb in the mustard family, is a major problem at the Complex. Reaching 3 to 8 feet in height, with a woody crown and spreading underground root system, pepperweed is found in seasonally wet areas and can quickly form monocultures under optimal conditions. It is a difficult plant to control as it spreads through both seeds and rhizomes, making it an aggressive invader that can out-compete native and desirable plants (Wilson et al. 2015).

Poison Hemlock. Large populations of poison hemlock (*Conium maculatum*) occur at the Complex, particularly in shaded riparian areas. A biennial member of the carrot family, it can grow from two to 10 feet tall, has small, white flowers in umbrella-shaped clusters and is found in dense patches along streams, roads and fields. Once established, poison hemlock is highly competitive and can prevent establishment of native plants. It also can establish in upland fields and may interfere with crops. Due to its known toxicity to livestock, wildlife and humans, its presence in the elk enclosure is of great concern.

Five-Hook Bassia. Although common at the Complex, five-hook bassia (*Bassia hyssopifolia*) is creating problems in dominance in select locations. A common weed in California, this grayish annual with inconspicuous flowers that grow one to three feet in height resembles Russian thistle, does well in basic or saline soils and is often found in abandoned agricultural fields. While bassia may displace native species, it does not appear to alter ecosystem processes. Bassia is toxic to sheep and can be a threat to livestock (James et al. 1976), which is a concern near the elk enclosure.

Russian Thistle. Russian thistle (*Salsola tragus*), a bushy multi-branched annual that grows up to three feet tall and has short leaves tipped with a stiff spine, is a common weed in agricultural settings in the Central Valley (Orloff et al. 2008). Often called "tumbleweed," it is well adapted to dry conditions and disturbed landscapes; at maturity, the seeds are scattered by the tumbling action of the plant when the stem breaks off at ground level. Russian thistle is well adapted to dry conditions and disturbed landscapes. It is a common weed in agricultural settings in the Central Valley (Orloff et al. 2008).

Black Mustard, Field Mustard and Wild Radish. Mustards (*Brassica* spp.) are annual or biennial herbs that may reach up to 6 feet tall and grow in dense stands, often in disturbed areas (Whitson et al. 1996). While beneficial to some wildlife species by providing food and cover, they may crowd out native plant species and are reported to produce allelopathic chemicals that inhibit the germination of other plant species (Tawaha and Turk 2003) Wild radish (*Raphanus sativus*), an annual or biennial herb growing to 6 feet tall, may be poisonous to livestock.

Russian Knapweed. Russian knapweed (*Centaurea repens*), a bushy rhizomatous perennial that grows up to 3 feet tall, has flowers that are pink to purplish. Known to produce allelopathic chemicals, it invades open, disturbed land and suppresses growth of surrounding plants. This plant is a poor seed producer and does not colonize new sites efficiently, but once established in open areas, it is highly competitive and spreads aggressively, often forming dense, single-species stands that can persist indefinitely (DiTomaso 2007). Russian knapweed is considered a crop and roadside pest and is often found in agricultural settings (Watson 1980).

Bull Thistle. Bull thistle (*Cirsium vulgare*) is a biennial thistle that reaches 2 to 6 feet tall when mature, with first-year plants forming a rosette that may grow to over 3 feet in diameter (Bossard et al. 2000). Native to Europe and Asia, bull thistle is widespread in California and is most common in coastal grasslands, along edges of fresh and brackish wetlands and in meadows and forest openings in the mountains below 7,000 feet. A ready colonizer of recently or repeatedly disturbed areas such as pastures, overgrazed rangelands and along roads, ditches and fences, bull thistle competes with and displaces native species, including forage species favored by native ungulates such as deer and elk.

Milk Thistle and Musk Thistle. Invasive thistles native to Europe, milk and musk thistle (*Silybum marianum* and *Carduus nutans*) are biennial or winter annuals that grow up to 6 feet in height. Both species tend to invade pastures, rangelands, forestlands, waterways, meadows, waste areas and grain fields (Whitson et al. 1996) and may rapidly form dense stands from seed, with up to 20,000 seeds per plant and 90 percent viability being common (Whitson et al. 1996). These plants can form dense stands that will crowd out native species by competing for light and resources, but the seeds are attractive to many songbirds and may provide an important food source for the birds and pollinators that are attracted to the flowers (Desrochers et al. 1988).

Prickly Lettuce. Prickly lettuce (*Lactuca serriola*), a winter annual weed often found in no-till soybeans, winter wheat, or along field edges, is sometimes referred to as wild lettuce because it is closely related to cultivated lettuce (Whitson et al. 1996). A native of Europe and naturalized throughout most of the United States, prickly lettuce is a serious invader in disturbed soils, including orchards and croplands. It may hybridize with cultivated lettuce and is spread by seeds along roadsides, railways and watercourses.

Italian Thistle. Italian thistle (*Carduus pycnocephalus*), a winter annual that varies in height from 8 inches to 6 feet, infests areas below 3,000 feet throughout most of California, except the Great Basin and northern Mojave Desert (Whitson et al. 1996). Italian thistle occurs in meadows, pastures and ranges, on roadsides and in disturbed wildland areas. Partial to warm, dry Mediterranean climate areas, basalt soils, soils of naturally high fertility or soils with a relatively high pH > 6.5, this plant commonly colonizes disturbed habitats with less intense interspecific competition (Bossard et al. 2000). Italian thistle dominates sites and excludes native species, crowding out forage plants in meadows and pastures. The blanketing effect of its overwintering rosettes can severely reduce the establishment of other plants, as the leaves of the rosette can become erect in dense stands. Its dense spines discourage grazing on this plant and on neighboring forage species.

Johnson Grass. A tall, coarse grass with stout rhizomes, Johnson grass (*Sorghum halepense*) usually grows in dense clumps or nearly solid stands and can reach 8 feet in height. Leaves are smooth, are 6 to 20 inches long and have a white midvein (Bossard et al. 2000). A Mediterranean native, this grass now occurs in all warm-temperate regions of the world and is common in the Central Valley. Johnson grass occurs in crop fields, pastures, abandoned fields, rights-of-way and forest edges, as well as along stream banks (CDFA) and thrives in open, disturbed, rich, bottom ground, particularly in cultivated fields. It invades riverbank communities and disturbed sites, particularly fallow fields and forest edges, where it crowds out native species and slows succession. Quickly dominating the herbaceous flora, it reduces plant diversity, degraded wildlife habitat and is aesthetically unappealing (CDFA).

Stinkweed/Stinkwort. Native to South Africa, stinkwort (*Dittrichia graveolens*) was first discovered in California in 1984. This fall-flowering, sticky, aromatic annual appears to be rapidly expanding its range in California, including the Central Valley (CalIPC 2008). This plant has a strong, pungent odor when touched and is covered with glands that secrete a sticky resin containing terpenes, capable of coating clothing or animal fur and thought to cause allergic dermatitis in some people. The barbed seedhead can become imbedded in the intestines of sheep, causing enteritis, an inflammation of the small intestine that may lead to death.

European Annual Grasses. The list of invasive grass species includes any introduced grass species common to California grasslands, including ripgut brome (*Bromus diandrus*), wild oats (*Avena fatua*) and cheat grass (*Bromus tectorum*). These species are widespread and dominate the grasslands at the Complex. These exotic species in total are more common and widespread at the Complex than native grass species. No effective or inexpensive method has been employed/found to restore on a large-scale the restoration of these exotic-dominated grasslands to native grasses and other flora.

Water Hyacinth. This floating aquatic plant with bright green, waxy leaves and attractive, violet flowers (Whitson et al. 1996) originated in the Amazon River basin of tropical South America. Water hyacinth (*Eichhornia crassipes*) has now spread to all tropical and subtropical countries and is universally regarded as one of the most serious of the world's weeds (Parsons 1992). In California, water hyacinth can quickly dominate a waterway or aquatic system due to its rapid leaf production, fragmentation of daughter plants and copious seed production and germination. It degrades habitat for waterfowl by reducing areas of open water used for resting and when decomposing it makes water unfit for drinking. It displaces native aquatic plants used for food or shelter by other wildlife species, obstructs navigable waterways, impedes drainage, fouls hydroelectric generators and water pumps and blocks irrigation channels (Parsons 1992).

Parrotfeather. Parrotfeather, a Class B noxious weed, is a submerged aquatic plant that grows aggressively in lakes, ponds, ditches and other freshwater habitats. Spikes of feathery leaves, with whorls of 4–6 leaves, grow up to a foot above the water and resemble miniature pine trees. You can identify this plant underwater by its stiff, bright-green upper stems. It grows from late May to October and reproduces via stem and rhizome fragments.

Although parrotfeather is a native of the Amazon River in South America, it has naturalized throughout the world. In California, it has become entrenched in multiple drainage systems and even small infestations are highly challenging to control. Although it doesn't grow in deep water, parrotfeather can completely cover and fill in shallow water. The dense growth causes problems for hunting, fishing or other water recreation. It encourages mosquito growth and can increase flooding. In rivers, it can impact salmon habitat, especially in side channels where juvenile salmon rear.

San Joaquin River Restoration Program. The San Joaquin River bisects the San Luis NWR and the river's tributaries cross and are adjacent to all units of the Complex. Management and restoration of the river and its tributaries both on and off the Complex impacts the wildlife resources. The Complex seeks to join with others in restoring the health and natural processes of the San Joaquin River.

Complex staff have been involved with river issues and river restoration since initial establishment of the two refuges and the WMA. The Service was forced to accept alteration of Mariposa Creek and its floodplain, and construction of a flood control levee along the western side of Merced NWR in the 1960s. During the 1980s, virtually all the woody riparian vegetation was removed from within the Eastside Bypass by the Lower San Joaquin River Levee District on what are now USFWS easement lands. However, the Service was successful in stopping similar plans for clearing the riparian vegetation along the mainstem of the San Joaquin River within San Luis NWR. In the late 1980s and early 1990s, Complex staff participated in development of the interagency San Joaquin River Management Plan and later provided input for the USACE's Sacramento and San Joaquin Rivers Comprehensive Study.

On a more local level, Complex staff implemented direct riparian restoration on both fee-title and easement lands. As lands were acquired on both sides of the San Joaquin River, fences were erected to exclude cattle from the river corridor and allow development of midstory and understory riparian vegetation. Private lands staff have provided technical assistance and helped secure program funds to fence off riparian corridors on USFWS easement lands within the Grasslands WMA. Over the years, thousands of native trees and shrubs have been planted on fee-title and easement refuge lands. However, virtually no trees have been planted within the floodway corridors of the San Joaquin River or Mariposa Creek due to flood control and levee/floodway maintenance mandates. In 1998, the Complex issued a contract to determine the feasibility of breaching the flood control levee on the West Bear Creek Unit of San Luis NWR to restore floodplain functions across refuge lands. The resulting floodplain restoration proposal was selected as a priority project under the Sacramento and San Joaquin Rivers Comprehensive Study but was not funded.

Savannah Sparrow. Photo: Paul Prado

The 2006 court settlement of a lawsuit involving the Natural Resource Defense Council, Friant Water Users Authority and the DOI that mandates restoration of the San Joaquin River and salmon populations will affect refuge and easement lands. As the USBR-led SJRRP progresses, Complex staff will become more active in salmon recovery and management on refuge lands in Merced County. Fish screens will need to be installed on the lift pumps to ensure that juvenile fish are not negatively impacted by pump operation. Any levee breeching and floodplain restoration design of refuge lands, as well as subsequent management of the floodplain, would need to avoid creating conditions that promote fish entrapment, and create conditions that optimize anadromous fish-rearing habitat. Despite overall gains in natural habitat diversity, there may be impacts to the wetlands management program.

Mosquito Abatement

Issues concerning mosquitoes and their associated problems (i.e., nuisance biting and vector-borne diseases) are frequently encountered with aquatic habitats, particularly when they are in proximity to human habitations. Aquatic habitats and wetlands, as well as irrigated pasture, provide conditions for breeding mosquitoes on the Complex. Both the San Luis and Merced NWRs are situated within the Merced Mosquito Abatement District. This is an active district that conducts mosquito monitoring programs (both larvae and adults), as well as disease monitoring programs (i.e., encephalitis, malaria and West Nile Fever) in the County. However, both the San Luis and Merced NWRs are considered too distant from population centers in Merced County for the abatement district to conduct active monitoring or control programs at the Complex. Mosquito abatement on Complex lands, if requested, will require that these mosquito programs do not negatively impact natural resources and addresses legitimate mosquito nuisance and disease issues in neighboring communities and follow USFWS national policy on mosquito programs.

Land Acquisition

Potential land acquisitions for the Complex are based on a combination of factors including identified natural resource need, connectivity to existing refuge lands, and willing sellers of land parcels. Both the San Luis and Merced NWRs have been established for more than 50 years and land acquisition has occurred throughout these decades, increasing the size of each of these refuge units. Land acquisition for these two fee-title refuges is limited and there are no near-term plans for additional land acquisition. However, both refuge units should be examined to ascertain if there are any remaining suitable land parcels from willing sellers that would provide benefits to the wildlife resource.

The Grasslands WMA, which consists of easements on private lands, was initiated in the 1970s. This WMA has an acquisition boundary that was most recently modified in 2005 to allow for the purchase of easements on private lands from willing sellers in areas around the Merced and San Luis NWRs. The majority of these easement lands are either wetlands (private waterfowl hunt clubs or hunt areas) or grasslands (private ranch lands). Because funding for land acquisition is limited, only one to three easements (depending on overall size and cost) can be purchased per year. Potential easement acquisitions are prioritized by wildlife and natural resource values that can be difficult to quantify and gauge. Generally, criteria for potential easement acquisitions are scored by wildlife values to migratory birds and threatened and endangered species use, current land use, connectivity to other habitats and size (both individually and when included with surrounding protected lands).

Easements

Conservation easements are cost-effective tools through which a landowner agrees with a government or non-profit land trust to restrictions on land use rights to preserve natural, agricultural or scenic values, typically in perpetuity (Byers & Ponte, 2005). These legal agreements can keep working agricultural lands in production while delivering conservation benefits to the affected habitat and wildlife.

The Grasslands WMA consists of 192 conservation easements on over 80,000 acres of private lands. Most of these easements are in Merced County surrounding the San Luis and Merced NWRs. In addition, the Service has purchased easements on properties within San Joaquin River NWR in Stanislaus County. The Service has been implementing the Conservation Easement Program in California's San Joaquin Valley by purchasing easements from willing landowners within the acquisition boundary of the Grasslands WMA since 1979.

A conservation easement is a legal contract in which the Federal government purchases certain rights on privately owned land from a willing landowner. The landowner retains ownership and most rights to their land, but transfers farming and development rights, with wildlife-friendly agricultural practices and other wildlife-friendly activities continuing, depending on the agreement. Rights retained by the landowner include water rights, grazing rights, habitat management rights, mineral rights, trespass rights, the right to hunt and/or operate a hunting club and the ability to pursue other types of undeveloped recreation (e.g., fishing, hiking). These conservation easements last "in perpetuity."

The management of easement lands for the benefit of wildlife is specific to and specified in each easement document. The intent is for the habitat provided by these lands to continue in the same or better condition for wildlife in perpetuity. For example: a wetland will be managed to remain a wetland; native pasture or vernal pools will be managed to remain as such. The Service secures limited rights to manage the easement habitat if the landowner is unable to do so (i.e., flood wetlands or graze pastures for the benefit of wildlife).

A critical management action for the conservation easement program of the Grasslands WMA is to routinely monitor the land use/management of easement lands to ensure they are in compliance with the terms of the agreements. Annual monitoring of these lands and maintaining accurate land records is key to documenting compliance with conservation easements. Interacting with landowners who own lands encumbered by conservation easement lands is also critical for providing guidance on easement language and being proactive on meeting easement requirements. Easement compliance for the Grasslands WMA historically has been high. The Service provides technical assistance at the request of easement owners, who also may choose to participate in programs for habitat restoration, enhancement, and management.

Water Resources

Water Quantity

The Merced and San Luis NWRs and the Grassland Wildlife Management Area operate with a serious water deficit despite their key role in providing fall and wintering habitat for over one million waterfowl. This statement may be substantiated by calculating the average number of acre-feet of water needed to optimally manage each acre of managed wetland in the GEA and dividing this figure by the average number of acre-feet of high-quality delivered water that is available to wetland managers (on average) per annum in the GEA. Given the severe loss of wetlands in the Central Valley, it is notable that all informed additions to the water supply or increases to the acreage under management generates a reduction in the habitat deficit as compared to historic conditions, when wetland habitat was much more abundant in the Central Valley.

The source, quality, location, availability (time of year when water can be sourced or accessed), cost and opportunity cost of accessing available water quantities are all factors that determine the costs and benefits of using possible water sources for habitat management purposes. An example of how these factors inter-relate is provided by the following example: The San Luis NWR has a License for Diversion and Use of Water (State of California SWRCB 2006) for up to 19,890 acre-feet per annum of water from Salt Slough, yet use of this water source was suspended from 1985 to 1989 due to selenium contamination of the water. This water source is now used by the Service only when mixed with higher quality (less laden with soluble salts) water delivered by the Henry Miller Reclamation District. This water often is not available during the midwinter, when it is most needed by the refuge. The cost of pumping this water, per acre-foot, exceeds the wheeling or conveyance cost that the refuge pays to the water district for delivered water that is used on the same wetlands. When using this water source, the costs of staff time and operation and maintenance expenses involved in utilizing lift pumps to move riparian water into distribution canals also must be considered.

Ideally, each unit of the GEA would be supplied with optimal quantities of high-quality delivered water, where and when these supplies are needed, to fully achieve wetland management objectives. In the current situation, high-quality quantities of delivered water are available at some times and places within the GEA and inadequate quantities of less than high-quality water are available at other times. At some locations and times of year, adequate quantities of low-quality water are available if funds and water quality management concerns permit their utilization.

The greatest single factor affecting the total volume of water available for wetland management in the GEA is the variation in implementation of the CVPIA Water Supply Program (Table 2-5). This program mandates certain quantities of delivered water to certain areas including the San Luis NWR Complex. In years of relative water abundance, Level 2 supplies are delivered, and

Level 4 water allocations may or may not be delivered. Conceptually, Level 2 supplies are secure and substantial (if not adequate or optimal) supplies for wetland management, whereas Level 4 supplies may not be secure from year to year, while being more representative of optimal quantities for management. In years of water scarcity, Level 2 supplies may be reduced by 25 percent and Level 4 supplies may be suspended entirely. In practice, the San Luis NWR receives Level 2 supplies but does not receive Level 4 water supplies; Merced NWR receives Level 2 and occasionally Level 4 supplies annually, whereas the Grassland Wildlife Management Area, comprising private landholdings under Federal Conservation Easement and other private lands, receives Level 2 and Level 4 supplies in most years.

Riparian water rights held by San Luis NWR (20.2 and 40.9 CFS to Salt Slough) and Merced NWR (9 CFS to Deadman Creek, 3 CFS to Duck Slough and 31 CFS to Deep Slough/Bravel Creek) are used on an as-needed and if-available basis and are an important asset to the Refuge System. The licenses for use of these waters are maintained by the State Water Resources Control Board (SWRCB) and are maintained locally by the Merced County Recorder. Although the Merced NWR is not supplied by CVP water supplies, nor through the infrastructure of the CVP, in drought years its water supply is equivalently reduced by an identical amount as that of the other CVPIA-supplied refuges. Groundwater use on Federal lands is exempt from regulation by the State of California's Sustainable Groundwater Management Act. However, the rate of change via depletion and recharge and extent of groundwater resources in the GEA currently is not well understood and warrants further investigation.

In cooperation with the Service Regional Office for the Pacific Southwest Region, the San Luis NWR Complex has completed exercises aimed at estimating the additional quantities of high-quality delivered water that would be desirable to achieve optimal management of the existing wetland acreage on the San Luis and Merced NWRs. Similar exercises have been conducted by the Grassland Water District, which supplies delivered water to landowners in approximately 95 percent of the Grasslands WMA. These exercises (Table 2-5) have revealed that the San Luis NWR receives 50,380 acre-feet of delivered water per annum yet would receive ideally 65,380 acre-feet of delivered water per annum. The Merced NWR receives 16,000 acre-feet of delivered water per annum yet would receive ideally 35,000 acre-feet of delivered water per annum. Finally, the Grassland Resource Conservation District, which is within the GEA, currently receives approximately 180,000 acre-feet of delivered water per annum yet would receive ideally even greater supplies of delivered water per annum to achieve optimal wetland management for wildlife species of concern.

Generally, the Service favors the use of delivered water over well and riparian water to meet wetland habitat management needs. The use of delivered water generally optimizes water quality concerns and does not deplete groundwater and naturally occurring surface water supplies as does the use of wells and riparian water rights. Exceptions to this generalization do occur. For example, at the Merced NWR, most water requirements after September are supplied by pumping of groundwater from wells. Fortunately, the quality of well water at the Merced NWR (and other locations in the GEA East of the San Joaquin River) is relatively high. West of the San Joaquin River, groundwater quality generally improves with distance from the river channel; however, this water is variable and generally of suboptimal quality (Quinn 2007). At the San Luis NWR and most private easement lands, groundwater is used only sparingly and during times when delivered water supplies are inadequate to achieve management objectives. This is due to two principal factors: the high cost of operating deep wells that are powered either by electric or diesel motors and concerns over the quality of well water, which often exceeds the salinity threshold desired by resource agencies (State of California Agriculture and Quality of Life Standard of 0.7 microsiemens per milliliter of salt).

The source and quality of water quantities used are linked factors. Delivered water and water subject to water rights regulations are limited resources and use at one time of year may exclude their availability at another time of year. The period of the year when a given water quantity is available is a factor that poses constraints. For example, delivered water is unavailable to the Merced NWR during the months of October through March, when it is critically needed for management purposes. The quality of water differs greatly between delivered supplies, wells and riparian sources. The location where a given quantity of water is available at a certain time also produces challenges for the refuges. For example, all wetland units on the San Luis and West Bear Creek units of the San Luis NWR are primarily flooded and maintained by the Island C canal. This canal, at 11 miles long, has difficulties moving water to the far end of the distribution system. When the canal is down for maintenance, there are no comparable alternatives to efficiently move water to the large number of wetland basins served by Canal C. Future work should continue to build redundant and alternate water conveyance systems that may be used when such primary facilities become temporarily unavailable.

Generally, both the real cost and opportunity cost of handling delivered water is the most cost-effective option for the Service because delivered water is generally gravity-fed. While the Service does pay a “wheeling” or handling fee to water tenders, the cost of the water itself generally is paid for or subsidized by Acts of Congress. Lifting water from riparian water rights and/or recycled water that flows through wetlands and is recaptured generally is the second-most cost-effective method of accessing water quantities. The cost of pumping water from wells using electric or diesel-powered motors generally is the most expensive method due to the great distance and decreased volume of water that may be accessed due to constraints posed by the depth and diameter of wells. The cost to the environment of securing riparian rights for the flooding of wetlands also must be weighed against the need to conserve riparian waters for downstream ecosystems, much as the need to avoid depletion of groundwater aquifers must be considered in a context encompassing the entire GEA.

Table 2-5. CVPIA Water Allocations (USBR) and Optimal or Desired Delivered Water Quantities for the Six Units of the San Luis NWR, the Four Units of the Merced NWR and the Grasslands WMA

Refuge and Refuge Unit	Acres of Managed Wetlands	Level 2 Water Supplies	Level 4 Water Supplies	Desired Delivered Water Quantity for Ideal Management
San Luis NWR East of Highway 165 (San Luis and West Bear Creek Units)	2,778	26,207	3,603	36,207
San Luis NWR East Bear Creek Unit	1,000*	8,863	4,432	10,863
San Luis NWR West of Highway 165 Kesterson, Freitas and Blue Goose Units	1,637	15,310	As and if available	18,310
Merced NWR Merced Unit	1,281	13,500	2,500	20,000
Merced NWR Lonetree Unit	129	0	0	5,000
Merced NWR Arena Plains Unit	497	0	0	5,000
Merced NWR Snobird Unit	165	0	0	5,000
Grassland Wildlife Management Area (Grassland Resource Conservation District figures) †		125,000*	55,000*	

† Water management on easement lands is conducted by easement partners rather that the FWS.


Wetland Habitat Management. Photo: USFWS


Wetland Habitat Management. Photo: USFWS

The Complex will continue to seek secure, delivered water supplies of high quality while also seeking to minimize the use of groundwater supplies and riparian water supplies that generally are contaminated by agricultural drainwater and often exceed state- and Federally recognized thresholds/guidelines for salinity and certain contaminants, including selenium, mercury, methylmercury, nitrites and nitrates. The Complex will work to realize the implementation of river restoration programs, such as the SJRRP, which will recreate largely lost ecosystem services and a more normal hydrologic cycle in the GEA. Further, the Complex will continue to develop water conservation measures, including recycling of delivered water and optimal management of the water conveyance system to derive maximal resource benefit from existing water quantities. Expanding urbanization, global climate change and concomitant increased demand for water from multiple user groups will continue to pose a challenge to acquiring and maintaining adequate water quantity for conservation purposes in the GEA into the future.

Water Quality

Water quality is a continuing concern for the management of fish and wildlife resources at the Complex. Several sections in this plan comment on the issues associated with water quality for the San Luis Complex. Most of these water quality concerns are generated at a landscape-valley level that impacts the water at the Complex. The main water quality issues for the Complex involve delivered water, groundwater, the water quality of the San Joaquin River and its tributaries and water discharging from the USBR's San Luis Drain.

Most of the water used for wetland management at the Complex is delivered through local water districts. The Complex is dependent on delivered water for its wetlands and aquatic habitats because of the historic changes in the natural hydrology of the San Joaquin Valley due to past and current land use practices of urbanization and modern agricultural practices. Delivered water for wetlands at the Complex is through CVPIA, which is a water program managed by the USBR, the agency responsible for the quality of the delivered water to the Complex. The quality of water delivered to the Complex varies greatly. The main concerns with water quality of delivered water are salinity, selenium, boron, mercury and agricultural pesticides and nutrients. Local delivery canals throughout the San Joaquin Valley can serve as both water delivery canals as well as water drains, resulting in a blend of water and uneven water quality of delivered supplies depending on water district, location within the district, season and source water employed. It is imperative that the water suppliers monitor the quality of the water being delivered and coordinate review of water quality data with USFWS.

In a similar manner, the San Joaquin River and its tributaries are impacted by surrounding land uses, both urban and agricultural, that impact its water quality. The San Joaquin River is designated as an impaired waterway by the U.S. EPA. The Complex needs to focus with partners and work with larger landscape-level initiatives/coalitions to identify water quality concerns of these "natural" waterways and identify and implement techniques to improve water quality.

A separate issue is the USBR's San Luis Drain. This artificial waterway carries agricultural drainwater from lands to the south of the GEA and empties into Mud Slough on the San Luis NWR, which then leaves the refuge and eventually enters the San Joaquin River. This is a long-standing issue and originally received attention due to a selenium contaminant identified in the 1970s/1980s that caused wildlife die-offs. To address this issue, the USBR and its partners developed the Grassland Bypass Program, which has been in effect for two decades. The purpose of this program is to reduce the amount of drainwater and select contaminant loads that impact the Grassland Ecological Area. The program and modifications to it are ongoing by the USBR to provide a long-term solution to this problem.

Habitats

Wetlands

Wetlands are the most actively managed of all the habitat types occurring at the Complex. Although there is potential for expanding the amount of managed wetland habitats at both the San Luis and Merced NWRs, any increase would require new water supplies either from delivered water or from groundwater, which would require obtaining either additional funding for purchase or operating expenses. Any expansion of wetland management at the Complex will be limited by the ability to obtain adequate water supplies.

Aquatic Habitats

Water quantity and quality in aquatic habitats is largely determined by off-Complex factors both natural and man-made. Likewise, sediment and nutrient loads of these habitats are impacted by off-Complex land uses. To protect these habitats on the Complex, vegetation corridors are maintained and protected from physical disturbances and/or vegetative restoration activities conducted on an as-needed basis.

Grasslands

Grassland ecosystems of North America have declined by 80 percent since the mid-1800s (Knopf 1994). In California, grasslands are currently one of the State's most threatened ecosystems (Noss, LaRoe, and Scott 1995), with approximately 90 percent of species listed in the *Inventory of Rare and Endangered Species in California* occurring in grassland ecosystems (Skinner and Pavlik 1994). The grasslands of the Central Valley of California, which developed under a natural system of year-round grazing by mule deer (*Odocoileus hemionus*), pronghorn antelope (*Antilocarpa americana*), elk (including tule elk, *Cervus elaphus nannodes*) and abundant small mammals, were originally as close to a climax type of grassland as were the prairies of the Midwest (Beetle 1947). California grasslands have been altered by drought, agriculture, heavy sheep- and cattle-grazing, fire exclusion, competition from introduced species and urban development, to the point where there are no undisturbed fragments remaining.

Grassland restoration requires an understanding of plant population dynamics and community interactions, including native and non-native seed dispersal, fecundity, competitive ability and response to disturbance (Heady 1988). This is especially true in valley grasslands, where the ability of annual grasses to germinate and compete for resources is subject to fluctuations in precipitation, temperature and competition with other plants for soil moisture in the summer. A science-based, adaptive management approach to restoring Complex grasslands that is informed by existing research and new studies is necessary to determine the effectiveness of current management strategies. Science-based management utilizes the analysis, interpretation and writing of collected data. Data is then stored in accessible and useable formats available for refuge management, the scientific community and the general public (Parris et al. 2004). Grazing, prescribed fire, supplemental seeding, herbicide applications and mechanical treatments, when used alone, have all been unsuccessful in suppressing non-native species in valley grasslands (Corbin, Dyer, and Seabloom 2007). Research must address specific questions to allow for the identification of the management strategy or mix of strategies that would be most likely to increase native perennial species and reduce non-native annual species while addressing wildlife needs (Corbin and D'Antonio 2004).

Biological monitoring to determine changes in species diversity following the use of management techniques is critical to assessing the effectiveness of these techniques in meeting management goals and increasing overall biodiversity (Griggs 2006). Monitoring techniques in arid California grasslands must consider a watershed level of grazing effects, including weather, geography and history of the site, in addition to plant-herbivore dynamics (Jackson and Bartolome 2007). This approach to assessing the impacts of grazing is necessitated by the influence of weather conditions on the species composition of California grassland vegetation.

However, constraints on time, money and workforce resources make it difficult to monitor and account for all species present within an ecosystem. Managers and biologists are forced to focus on select taxa when evaluating restoration and management practices and establishing conservation objectives.

Vernal Pool Habitats

Remaining vernal pool habitat throughout California continue to be threatened by continuing urban and industrial development and conversion to agriculture. Even protected vernal pools are threatened with invasion by exotic species. An estimated 90 percent of vernal pools in the central valley have been destroyed by conversion to pastureland, agriculture, draining and water diversion.

Croplands

One of the challenges to the farming program is that it is expensive and time-consuming. The farming program would not be possible with current levels of refuge funding if not for the CAA program. Share-in-kind accounts generated under the CAA vary from year to year depending on climatic conditions (i.e., precipitation), grazing acres available and market factors. This means that, for example, if drought conditions are present and/or farming costs increase due to a raise in fuel or corn prices, the refuge would have a difficult time meeting its farming objectives. To buffer the farming program from negative fluctuations that would prevent the refuge from being able to provide crop-dependent foraging opportunities for wildlife, additional funding sources need to be identified and pursued. Availability of water of adequate quality provides another challenge to the refuge's farming program. As previously mentioned in this chapter, water issues are already a contentious, growing concern and will continue to become more so as urban and agricultural demand increases with the subsequent decrease in water quality and the potential effects of climate change materialize. Additional water supplies/rights, as well as improved conveyance infrastructure, is needed and could be secured through Federal legislation or other mechanisms.

Riparian Woodlands

The extent and connectivity of riparian habitat has been assessed at San Joaquin River NWR as part of a habitat suitability and connectivity study for riparian brush rabbits (Phillips et al. 2013). A similar analysis of riparian habitat extent and connectivity is being carried out for San Luis NWR and Merced NWR. Additional understanding of these habitat characteristics would help inform future translocation of riparian brush.

Invasive plants pose a significant threat to the riparian ecosystems at the Complex. Although chemical spraying has been an important strategy used to combat invasive plants, emerging biological control methods may reduce the environmental relative to chemical control. If implemented, refuge staff will track the success of biological control methods on invasive plants in riparian communities.

Another major need for the Complex is to restore in suitable areas as much riparian woodlands as feasible, including seeking to establish these habitats in areas currently excluded from having woody vegetation.

More details on the riparian habitat present on the Complex and the management objectives/strategies addressing management concerns can be found in the Refuges Adaptive Management Project[4] for the San Luis NWR Complex.

Ecological Processes

The San Luis NWR, Merced NWR and Grassland WMA as a total form a relatively large and contiguous block of protected habitats. One of the greatest challenges these protected areas face is the human-induced alteration and, in some cases, complete truncation of natural ecological processes such as flooding, fire, intact food webs and biogeochemical cycling. The maintenance, management and restoration of these ecological processes is a high priority for the Complex to meet resource conservation goals and maximize the efficiency and cost-effectiveness of management interventions for the benefit of wildlife.

In striving to restore the historic conditions (Schroeder, Holler, and Taylor 2004) that once characterized the northern San Joaquin Valley and GEA, the Complex faces a dual challenge: restoring and amplifying some phenomena while seeking to decrease or attenuate others. The Complex needs to foster and restore some ecological processes by increasing the number, frequency, extent, or duration of those phenomena (i.e., flooding, fire, native species), and control and reduce other processes (i.e., salinization, bioaccumulation of selenium and methylmercury, accumulation of pesticide and herbicide residues and the colonization of invasive species). The review of key ecological processes of importance to the management of the Complex over the next 15 years aims to examine the challenges and opportunities the Complex will face in seeking to restore a more natural hydrologic cycle and to reverse a history that has left the Complex with a legacy of reservoirs of selenium, salts and methylmercury in wetland soils that challenge management objectives.

The flux or passage and sequestration of the chemical elements and contaminants known to challenge ecosystem function in the GEA have been of great concern since the 1960s.
The deleterious effects of selenium, salts and methylmercury contaminants have been the most well documented. Efforts should continue to monitor and wherever possible, reduce the quantities of these agents entering the GEA.

[4] https://ecos.fws.gov/ServCat/Reference/Profile/131617

The Selenium Cycle

The flooding and irrigation of managed wetlands with delivered water either composed entirely of subsurface agricultural drainage water or mixed with such water has resulted in selenium contamination of wetland habitats in the GEA (Paveglio et al. 2007); boron and salts also have accumulated at the refuge and have been of serious if lesser concern.

Selenium contamination resulted in large-scale morbidity and mortality of waterbirds at the Kesterson NWR in 1983–1985 after storage of agricultural drainage started at the refuge in 1978 (Pavaglio et al. 2007). Although the storage of agricultural drainage water no longer occurs on refuge lands due to the implementation of the Kesterson Mitigation Plan, refuge lands continue to receive agricultural drainwater mixed in with delivered water, and selenium concentrations in aquatic birds remain above background levels, indicating that there is a reservoir of selenium remaining in the GEA that needs to be depleted to restore historic conditions (Pavaglio et al. 2007). To achieve a net loss of selenium in the Grasslands, the Refuge Complex needs to continue to strive toward securing the best-quality delivered water supplies that will help meet the selenium water quality objective—a monthly mean of $\leq$ 2 parts per billion) as established under Section 303d of the Clean Water Act (Pavaglio et al. 2007).

Salt Flux/Salinization

Soils throughout the San Joaquin River basin are naturally high in salts because impermeable clay layers accumulated salts as the valley was geologically formed from an inland sea (Presser and Ohlendorf 1987). Salinity levels in the soils are exacerbated by agricultural flood irrigation where 50–70 percent of the water applied is evaporated, causing a two- or threefold concentration of the dissolved salts (Dunne and Leopold 1978). Soil salinity and concomitant salt concentrations in waters of the Grassland Wildlife Management Area are of great importance to the Complex because salt concentrations exceeding certain thresholds have deleterious impacts on plant and animal life (Cassel 2005). Of particular concern is a scenario in which soil salinity in managed wetlands exceeds known plant tolerances and key waterfowl food plants might be adversely affected, thereby compromising the Refuge Complex capability to meet mandated responsibilities for the management of migratory birds.

Water quality monitoring with an emphasis on salt flux onto and off managed wetlands (measured as electrical conductivity) has been undertaken with intensity on refuge land and private lands and by the Grassland Water District and the San Luis Canal Company/Henry Miller Reclamation District. Generally, water leaving refuge lands is higher in electrical conductivity than water being delivered to refuge lands (Beckon and Milar 2003); however, evidence suggests that this phenomenon may stem from the buildup of a reservoir of soil salinity due to a history in the GEA of the use of salt-rich irrigation drainwater to flood and irrigate managed wetlands.

Song Sparrow. Photo: Paul Prado

A significant project to reduce salinity (and selenium and boron) influx into the Grasslands WMA was undertaken in 1996 with the establishment of the Grassland Bypass Project, which consolidates subsurface drainage flows on a regional basis and utilizes a portion of the Federal San Luis Drain to convey the flows around managed wetlands (USFWS 2004). Prior to the bypass project, the same water delivery canals used to flood managed wetlands were used to convey drainage water to the San Joaquin River via the wetlands. The benefits of the project to managed wetlands in the Grasslands WMA are well-documented; however, the project has increased agricultural drainwater and contaminant loads in the 6 miles of Mud Slough that receives the rerouted drainage water. The results of the project indicate success in conserving managed wetland basins (USFWS 2004). In water year 2003, drainage volume was reduced 48 percent, selenium load was reduced 60 percent, salt load was reduced 39 percent and boron load was reduced 48 percent, all from pre-project conditions in 1996. In 1996, prior to the project, the mean annual selenium concentration in Salt Slough at Highway 165 was 16 parts per billion (ppb). Since 1996, the 2 ppb monthly mean water quality objective for Salt Slough has been met in all months—except one in which it was 4 ppb; in that month, uncontrollable flood flows were mixed with subsurface drainage water and could not be contained within the project (USFWS 2004).

Soil and Water Salinity

Unpublished refuge water quality data indicates some broad themes—that salinity generally increases from east to west in the GEA, and both surface and groundwater supplies used for management purposes on the Grasslands WMA may exceed water quality objectives for agriculture or State of California receiving waters. As with selenium, the soil salinity reservoir may need to be assessed before an accurate model of salt flux on and off Grasslands WMA/refuge lands can be realized. Further research into soil salinity mapping on the Refuge Complex would be valuable, as limited research thus far (Quinn et al. 2005) suggests that a great deal of variability exists in salt concentrations across the study area. As of early 2009, research into the flux of salt through the Complex-managed wetlands is well underway while little is known of the status of soil salinity on the Complex. With the benefit of future research into soil and water salinity, the Refuge Complex will continue to strive to secure high-quality delivered water to reduce salinization.

Methylmercury

Methylmercury is a potent neurotoxin that accumulates in biota, which may be exposed to the compound after it enters water bodies from mercury-rich soils such as those that exist south and west of the Grasslands WMA. Unlike other contaminants, mercury influx into the Grasslands WMA is considered a relic of past mining practices that contaminate surface and groundwater supplies entering the region. Current concentrations of methylmercury in managed wetland water and invertebrate and vertebrate species, as well as the role that managed wetlands play in sequestering, amplifying or reducing loads of mercury and methylmercury also have been or currently are the subjects of research by the U.S. Geological Service / Biological Resources Division and the State of California Regional Water Quality Control Board. Preliminary results from both partners suggest that, given the Refuge Complex objectives, bioaccumulation of methylmercury is a serious threat to trust resources and human health in the Grasslands WMA and bears prioritization for mitigating action when and as possible.

Fire Management

Fire, as an ecosystem process, has played a major role in the structure, composition and function of California’s dominant native vegetation (Sugihara et al. 2018). For millennia, humans also have played a role in ecosystem changes through suppression of wildfires and the utilization of fire as a tool to manipulate their environment. Today, the variable nature of the state’s climate, topography, vegetation, and large, rapidly growing population have combined to create unique challenges for fire managers.

While coastal regions of California experience a temperate climate and the onshore/offshore exchange of air, the inland valleys are characterized by high temperatures and limited horizontal air movement (Ahuja 2006). The Complex is in the San Joaquin Valley Air Basin (SJVAB), a continuous valley approximately 250 miles long and 80 miles wide, bordered by the Coast Mountain Range with peaks reaching 5,020 feet to the west, the Sierra Nevada Range with peaks reaching past 14,000 feet to the east and the Tehachapi Mountains with peaks extending above 6,000 feet to the south (Cox et al. 2008). The mountains surrounding the SJVAB prevent the dispersion of air from within the basin, inhibiting the removal of air pollutants.

This air basin has an inland Mediterranean-type climate of hot, dry summers and cool, rainy winters, primarily controlled by the Pacific High, a semi-permanent subtropical high-pressure belt located off the west coast of North America that migrates north and south (Cox et al. 2008). The air of this high-pressure belt descends almost continuously, which raises its temperature and lowers relative humidity. During the summer months, when this high-pressure belt is dominant, precipitation is extremely low; in winter, the belt creates intermittent periods of storms alternating with periods of no precipitation. The dispersion of pollutants is further inhibited by these high summer temperatures as well as frequent temperature inversions (Ahuja 2006).

Pollution levels, in particular ozone levels, also rise during the summer when westerly winds carry pollutants through low coastal gaps from San Francisco Bay Area commuters to the valley. The increase of California's population from 22.1 million in 1975 to 34.5 million in 2000 and the corresponding increase of vehicle miles traveled each day (from 359 million miles per day in 1975 to 797 million miles per day in 2000) have combined to make automobile sources the largest cause of ozone problems in the basin (Ahuja 2006). With more than one-third of its area in non-attainment status for PM10 and ozone national ambient air quality standards, the State of California is aggressively enforcing the Clean Air Act to reduce the health, environmental and economic impacts of air pollution.

Prescribed burning is monitored in the SJVAB due to its creation of smoke, a complex mixture of carbon dioxide, water vapor, carbon monoxide, particulate matter, hydrocarbons and other organic chemicals, nitrogen oxides and trace minerals (SJVAPCD 2018). The composition of smoke is dependent upon fuel type, moisture content, fire temperature and wind conditions. Pollutants of concern in smoke include particulate matter, a mixture of solid particles and liquid droplets suspended in the air, and carbon dioxide, a colorless, odorless gas. Smoke particles tend to be fine particles, labeled PM2.5, with diameters of 2.5 micrometers or smaller, which can be inhaled deep into the lungs, affecting the lungs and heart. The respiratory irritants, acrolein and formaldehyde, and the carcinogen benzene also are present in smoke, but at much lower concentrations than particulate matter and carbon monoxide.

Prescribed burns conducted on the Complex are regulated by the San Joaquin Valley Air Pollution Control District (SJVAPCD), a public health agency mandated with improving the health and quality of life of valley residents through its air quality-management strategies. The SJVAPCD operates under the authority of the California Air Resources Board (CARB) the administrator of the Clean Air Act of 1988 in California. The CARB and SJVAPCD design and execute a State Implementation Plan to meet and maintain ambient air quality standards as issued by the U.S. EPA.

Air quality standards "establish the concentration above which the pollutant is known to cause adverse health effects to sensitive groups within the population such as children and the elderly. Both the California and Federal governments have adopted health-based standards for the criteria pollutants, which include but are not limited to ozone, PM_{10}, $PM_{2.5}$, and CO" (Cox et al. 2008).

Before conducting a burn, a burn manager must register the burn with the air district, obtain a permit and submit a smoke management plan containing burner name and contact information, location and size of the burn, burn method and fuel type, expected air emissions, nearby population centers, smoke travel projections (including maps), planned burn time, duration, acceptable burn ignition conditions, smoke minimization techniques, contingency planning, burn monitoring procedures and public notification procedures (SJVAPCD 2007).

The air district does not automatically give permission to burn to the Service when requested. Instead, the district uses computer modeling to determine the amounts of acceptable pollutants that can be released into the atmosphere and then gives approval to the parties interested in burning that are within the emissions threshold. It is common for prescribed burns to be put on hold until the district feels that the airshed can handle the emissions released into the atmosphere from the burn.

In the future it is possible that the allowable emissions that can be released into the atmosphere will be reduced. This reduction will limit the number of allowable burn days and the size of the projects that can be conducted. This reduction in prescribed fire will reduce the number of hazard fuels projects completed in the wildland-urban interface. This could cause larger and more destructive wildfires to the Service and the local community.

Prescribed burning is a long-term and ongoing strategy for managing the wetland, upland, and riparian ecosystems at the Complex. Burning can be used to set back the successional stage of specific areas to provide habitat for species that rely on early successional (ruderal) plant communities. It would be helpful to understand the quantity and quality of successional stages throughout riparian, wetland and upland ecosystems to better determine the prescribed burning schedule. It may be helpful to visually observe experimental burning plots in the riparian and wetland ecosystems to better determine desirable frequency and extent of burning. Mechanical and chemical treatments also are used to reduce hazardous fuels and can sometimes be used in place of prescribed burning to reduce emissions.

Challenges:

- Smoke and air quality permits.
- Prescribed fire often is considered discretionary and unnecessary
- Control of invasive plants
- Restoring native plant communities
- Competition with agriculture for burn permits

Climate Change

Global temperature is expected to reach or exceed 1.5 º C of warming between 2030 and 2052 if it continues to increase at the current rate (reported with "high confidence," IPCC 2018). Temperature increases and changes in precipitation levels and timing are expected to affect ecological processes and the distribution and abundance of many species (Hannah et al. 2002). In California's Central Valley, regional changes in climate are similar to global trends, resulting in increasing temperatures, decreasing precipitation, reduced snowpack and earlier snow melt (Medellin-Azuara et al. 2008; Luers et al. 2006; Scott et al. 2008).

The mandate of the Complex is to conserve, manage, restore and enhance habitats and associated plant and wildlife species, with an emphasis on supporting an abundance and natural diversity of wintering and migrating waterfowl, shorebirds, birds of prey and songbirds. This mandate, currently challenged by the state's large and growing population, agricultural encroachment and water and energy issues, may be further challenged by climate change. Impacts of climate change may include difficulty in accessing an adequate and reliable water supply, rising water costs, erosion, increased demands for electricity, changes in land use, shifts in species distributions, effects on species' reproductive capabilities, changes in arrival and departure times of migratory birds, decreased air quality, an increase in wildfires and the spread of non-native species and pathogens. It will be difficult to predict how climate change will impact existing issues and how those impacts will affect the plant and wildlife species of the refuge.

In the Central Valley, where 85 percent of precipitation occurs during the winter, but peak usage occurs during the summer, water users rely heavily upon storage of water in the snowpack of surrounding mountains. Temperature increases will cause less precipitation to fall as snow, resulting in a reduced snowpack (average snowpack in the Sierra Nevada is predicted to decrease by 12 to 47 percent by 2050), higher winter runoff and reduced runoff in the late spring and summer in California rivers and streams (King et al. 1989). In the summer, this would decrease the amount and reliability of water available in Central Valley reservoirs, which would lead to increased demands and rising water costs and thereby increase competition between a growing urban population, the agriculture industry and wildlife needs. Higher winter runoff may increase the need for storage in late winter, reducing the availability of reservoir space for spring flood protection. The need to use surface and groundwater supplies during the same time period is also expected to increase water costs while decreasing its availability (Medellin-Azuara et al. 2008). Predicted lower freshwater streams in hotter and drier summers may result in increased refuge reliance on lower quality agricultural runoff water.

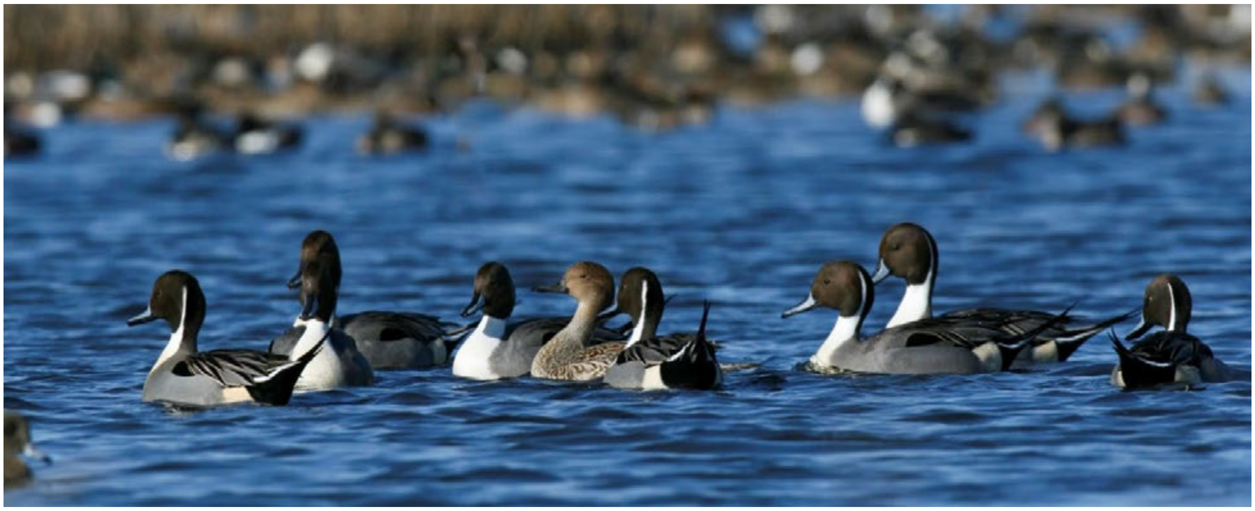
With precipitation and increasing temperatures, rising demands for electricity to power air conditioning units and other societal needs coupled with a decreasing ability to provide hydropower (due to decreased snow melt) may impact the ability of the Complex and private landholders maintaining conservation easements to use electrically powered wells for the flooding of wetland habitat (Luers et al. 2006) as well as the ability to conduct summer irrigations to seasonal wetland habitats essential for the moist soil management necessary for the production of waterbird food sources or to conduct wildlife-friendly agricultural and restoration activities. Additionally, limited sources of high-quality water could negatively influence the willingness of private landowners, who may have otherwise enrolled their lands into conservation easements, to consider other options that could eventually result in the conversion of habitat valuable to wildlife into housing and commercial developments, which provide no value to wildlife.

Changes in temperature and precipitation levels, atmospheric CO_2 composition and nitrogen deposition may affect plant community composition and ecosystem functioning (Zavaleta et al. 2003). Wetland plants and animals will be affected by changes in air, soil and water temperatures (Kusler 2006). In many cases, climate change favors non-native species over native species because non-native species tend to be highly adaptable with the ability to spread quickly. Yellow starthistle, *Centaurea solstitialis*, a noxious, deeply rooted winter annual plant that displaces native plants and animals, currently presents a serious problem on the San Luis and Merced Refuges. Increasing temperatures and precipitation may favor yellow starthistle because the density of this plant is determined partially by the timing and intensity of rainfall and temperatures above the plant's thermal threshold (Gutierrez et al. 2008; Bradley, Oppenheimer, and Wilcove 2009).

Wildlife species may be affected by changes in prey abundance, changes in reproductive capabilities and the potential return of their natural predators. The distribution and abundance of birds, in general, is subject to vegetation structure and composition, food availability and predators, all factors susceptible to moderation via climate change (Seavy, Dybala, and Snyder 2008).

For example, wading bird populations may be impacted by the recovery of the bald eagle, *Haliaeetus leucocephalus*, a significant predator of wading birds that declined during the widespread use of pesticides in the 1960s (Butler and Vennesland 2000).

Plant and animal dispersal patterns also may shift with species dispersing to more northern latitudes, filling vacated niches or interacting with existing species, while species with limited dispersal abilities, especially threatened and endangered species, may not be able to shift their ranges (Scott et al. 2008). Increased winter rainfall and higher winter temperatures may result in longer, warmer flooding of vernal pools; however, the future of vernal pool species is determined as much by habitat loss as by climate change (Pyke 2005).



Northern Pintal. Photo: Mike Peters

Migratory waterfowl that overwinter in the Central Valley are affected by climate change at their summer breeding grounds in the Arctic ecosystems of Alaska and Canada, where the impact of climatic warming is expected to be greater (Kaplan and New 2006). Arctic regions have been subject to rapid warming—between 1954 and 2003, temperatures in Alaska increased 3.6 to 5.4 degrees (Arctic Climate Impact Assessment 2004) —creating impacts on the habitat and food supply, reproductive timing and migratory habits of waterfowl. Melting permafrost has resulted in the drainage of some lakes and ponds into underground aquifers and the creation of new wetlands in other areas (Riordan et al. 2006). In small wetlands in Yukon Flats NWR in northeast Alaska, common duck foods including amphipods and other invertebrates have been replaced by algae and other non-duck foods (Corcoran 2005). Warmer temperatures have also coincided with earlier hatching (LaRoe and Rusch 1995). Unpredictable weather may cause breeding delays, an important factor for Arctic geese if they are required to deplete their energy reserves prior to breeding. It is difficult to predict how continued climate change will impact migratory waterfowl species because they are able to cover large distances in search of suitable habitat; however, during warm years, migrating waterfowl may choose to winter farther north or migrate to California later in the year.

Warmer temperatures and earlier snowmelt are contributing to increased flammability of vegetation and an increase in wildfires throughout California. In Northern California, Fried, Torn, and Mills (2004) reported that grass- and brush-dominated ecosystems experienced the largest increases in fire spread rates and area burned. The recovery time and composition of plant and animal communities affected by fire also may be negatively influenced.

Climate warming is expected to expand the range of pathogens, disease-causing organisms and their vectors, increase the rate of pathogen development and increase pathogen survival rates (Harvell et al. 2002). Waterfowl are at greater risk of exposure to pathogens due to their migratory nature and may act as vectors between ecosystems. Changes in hydrology (reduced water levels) and hydroperiod (the period of time during which a wetland is covered by water) and higher water temperatures, may facilitate the spread of disease or pathogens (Scott et al. 2008).

A workshop for the U.S. Climate Change Science Program focusing on the Refuge System, held in 2007 to coordinate scientific research on climate change, produced a report reviewing management options for increasing the resilience and resistance of ecosystems to climate variability. The report recommended the following management actions: “plant vegetation in riparian areas to lower water temperature; translocation of plants and less mobile species to new locations; protect migratory corridors so that species can move pole-ward and to higher elevations; acquire land to secure needed habitat; identify and monitor climate sensitive species and phenologies; determine tradeoffs between existing habitats and potential habitats; identify structures that are effective in adaptation; recognize maladaptive practices (e.g., mowing wetland grasses); detection, containment and eradication of invasive species; decide whether to abandon vulnerable populations or focus on them; consider managing for open space or ecosystem services rather than for species; and develop an interagency council (interdepartmental) on climate change” (Scott et al. 2008).

Partnerships and Coordination

Coordination is necessary for effective and efficient natural resource management on Complex lands. Migratory birds and other wildlife move across the landscape and require that actions and activities be jointly planned by land managers and others to obtain the greatest impact for natural resources. The Complex routinely coordinates many of its management actions with neighboring land managers regarding water management, wetland management, avian disease management, invasive species management, wildlife monitoring, research, wildlife reintroduction programs, fire management, law enforcement activities and visitor services.

Partnerships allow the completion of projects that are not possible with limited refuge staff and funds while expanding public outreach and bringing the input and support of stakeholders, including community members, into the management process. Refuge partnerships have allowed the refuges to provide natural resource management on a landscape scale; resulted in land acquisitions; and enhanced programs for endangered/threatened species, natural resource monitoring and habitat restoration activities, among other projects.

The San Luis National Wildlife Refuge Complex is an active participant in many multi-partner partnerships, some of which are listed below. The Complex manages lands to support native fish and wildlife populations and the habitats they depend on and to provide the public with wildlife-dependent recreational opportunities. Only with public support can the Service succeed in its mission; thus, strong support of communities and partners is crucial to achieving the goals of the National refuge System. Involving citizen groups in resource and management issues and the decision-making process helps refuge managers understand public concerns. Partners provide support for refuge activities and programs; raise funds for projects; are activists on behalf of wildlife, habitat and the Refuge System; and provide support for important wildlife and natural resource issues.

A variety of people including, but not limited to, researchers, birdwatchers, hunters, anglers, farmers, ranchers, outdoor enthusiasts and students are keenly interested in the management of the Refuge Complex and associated ecological issues. This interest is demonstrated by the number of visitors and volunteers the refuges receive and the partnerships that have already developed. Current Complex partners include a wealth of organizations; civic groups; Tribes; Federal, state, county and local government agencies; schools; and private landowners (see Table 2-6 for a list of current partners).

The Service has entered unique partnerships with private landowners through the development of conservation easements and Partners for Fish and Wildlife habitat restoration or enhancement projects on privately owned land. Since 1979, approximately 170 conservation easement agreements have been formalized with private landowners in the Grasslands WMA, protecting approximately 77,240 acres of wetland and associated habitats. The easement lands become part of the Refuge System and are protected in perpetuity. Since the inception of the Partners for Fish and Wildlife restoration and enhancement program in 1981, approximately 300 projects have restored or enhanced roughly 50,000 acres of wetland habitat for the benefit of migratory birds and other wetland-dependent species. In both the Easement and Partners Programs the landowners manage and maintain the projects. When requested, the Private Lands staff provide technical assistance on habitat management, enhancement and restoration as needed. To date, many positive, long-lasting partnerships have been fostered through these private lands programs.

Some, but not all of our partners, include:

Table 2-6. List of San Luis National Wildlife Refuge Complex Partners in 2022

Federal Government

U.S. Army Corps of Engineers
U.S. Department of Agriculture
U.S. Department of the Interior
U.S. Bureau of Reclamation
U.S. Geological Survey
U.S. Environmental Protection Agency
U.S. National Marine Fisheries Service
Natural Resources Conservation Service
Lawrence Berkeley National Laboratory
Federal Highway Administration

State Government

- California Department of Conservation
- California Department of Fish and Wildlife
- Wildlife Conservation Board
- California Department of Food and Agriculture
- California Department of Parks and Recreation
- California Department of Transportation
- California Department of Water Resources
- California Resources Agency
- California State Clearing House
- California State Parks
- Office of Historic Preservation
- California State Water Resources Control Board

County and Local Government

- Merced County
- Department of Public Health
- Department of Public Works
- Mosquito Abatement District
- Merced Resource Conservation District
- East Stanislaus Resource Conservation District
- City of Atwater
- City of Los Banos
- City of Gustine
- City of Merced
- Grasslands Water District
- Merced Irrigation District
- Central California Irrigation District
- Lower San Joaquin Levee District
- San Luis Canal Company
- Friant Water Authority
- Lone Tree Mutual Water Company
- San Luis & Delta-Mendota Water Authority
- San Joaquin Valley Air Pollution Control District

Organizations

- American Farmland Trust
- California Trout, Inc.
- Central Valley Joint Venture
- California Native American Heritage Commission

- National Wildlife Refuge Association
- Defenders of Wildlife
- Ducks Unlimited
- Los Banos Sportsmen's Association
- MBK Engineers
- Moose Legion
- Motus Wildlife Tracking System
- National Wildlife Federation
- Point Blue Conservation Science
- River Partners
- Rocky Mountain Elk Foundation
- Los Banos Rotary
- San Joaquin River Partnership
- San Joaquin River Parkway and Conservation Trust
- Sierra Club (Delta/Sierra Group, Tehipite Chapter, Yokuts Group)
- Sustain Environmental Inc.
- The Nature Conservancy
- Trust for Public Land
- Tuolumne River Preservation Trust
- Xerxes Society
- California Waterfowl Association
- California Deer Association

<u>Academic Research and Education</u>

- California State University—Stanislaus
- Endangered Species Recovery Program
- Los Banos High School
- Modesto Junior College
- Orestimba High School
- University of California, Berkeley
- University of California, Davis
- University of California, Merced

<u>Tribes</u>

- Miwok Nation (Central Sierra Miwok, Ione Band of Miwok, Southern Sierra Miwok)
- Tachi-Yokut Tribe

<u>Audubon Organizations</u>

- Audubon Society
- Central Sierra Audubon Society

- Fresno Audubon Society
- Golden Gate Audubon Society
- Mt. Diablo Audubon Society
- Napa–Solano Audubon Society
- San Joaquin Audubon Society
- Stanislaus Audubon Society
- Yolo Audubon Society
- Yosemite Audubon Society

The Tricolored Blackbird Working Group (TBWG)—Audubon California, UC Davis.

Tricolored blackbirds (*Agelaius tricolor*) are managed according to a cooperative conservation plan[5] involving state and Federal agencies, nongovernmental organizations, universities, agricultural associations and public interest groups of the TBWG (a complete list is provided in the plan) (TBWG 2007). The plan was developed in response to the steady decline of this species over the past century from its historic population size, estimated in the millions, to current population estimates of 300,000 birds globally (Meese 2007). The objectives of the plan are habitat conservation, research and monitoring and outreach and education programs (TBWG 2007). Complex personnel have worked with the Department of Environmental Science and Policy at UC Davis to collect data used to track population trends, spatial and temporal movements, social structure and reproduction of tricolored blackbirds. From 2006 to 2008, known breeding colonies and dairies were surveyed and monitored, and breeding birds were color-banded to track spatial and temporal movements and site fidelity. In addition, in late April 2008, volunteers, Audubon California and the Service participated in a statewide survey of colony locations and size and abundance of breeding tricolored blackbird on the refuges and adjacent dairies to provide data to prioritize colonies for conservation activities and to estimate fecundity. Further research is needed to determine if the tricolored blackbird's preference for dairy silage fields is based on nesting substrate rather than food availability; determine the factors involved in habitat selection, including substrate, foraging needs and social structure; and identify whether small colonies are beneficial to conservation of the species or are population sinks. Opportunities to improve communication between USFWS staff, researchers and the private sector would result in increased colony identification and conservation.

Motus Wildlife Tracking System (MOTUS)

MOTUS is an international collaborative research network that uses coordinate automated radio telemetry to facilitate research and education on the ecology and conservation of migratory

[5] TBWG 2007 Plan available online at: https://tricolor.ice.ucdavis.edu/sites/g/files/dgvnsk3096/files/inline-files/Conservation%20Plan%20MOA%202009%202.0%20update.pdf

animals (Birds Canada 2022). There is a MOTUS tracking station at Merced NWR. The Complex issues a special use permit for their monitoring structure on the Merced Shop. The monitoring structure tracks migratory bird patterns as they move through.

International Crane Foundation.

Merced NWR and adjacent private lands provide wintering habitat for the largest number of lesser sandhill cranes within the Pacific Flyway. Two subspecies of sandhill cranes occur on the San Luis NWR: lesser sandhill crane (*Grus canadensis canadensis*) and greater sandhill crane (*Grus canadensis tabida*), with lesser sandhill cranes composing 95 percent of the cranes using the Refuge Complex. In 2007, Complex staff coordinated with the International Crane Foundation in a valley-wide study of lesser sandhill crane populations. Additional research is needed to determine crane forage preferences in irrigated pasture, native uplands and winter wheat as well as grazed, burned and ungrazed sites; use of foraging and roosting areas off the Complex; additional forage and roosting needs on the refuge; and the effects of disturbance on wintering needs due to management and public use.

Red-winged Blackbirds. Photo: USFWS

Deer Herd Management Implementation Program— California Department of Fish & Game.

The Deer Herd Management Plan Implementation Program, a cooperative effort between the Service and the CDFW, was created to reestablish black-tailed deer (*Odocoileus hemionus columbianus*) in Merced County, along the San Joaquin River. At the San Luis National Refuge Complex, reintroduction of this native species, a keystone ungulate, into the GEA also was intended to help restore natural ecosystem function that had been altered by the removal of key species and the introduction of invasive species. In 2003, with the cooperation of California State

Parks and private landowners, the Deer Herd Management Plan Implementation Program reintroduced 20 to 35 deer to the San Luis NWR, conservation easement lands and state park lands. The project involved health assessments pre-capture, capture and relocation and post-release monitoring.

Rocky Mountain Elk Foundation.

In 1974, an MOU between the Service and the CDFW provided for the reintroduction of 18 tule elk (*Cervus elaphus nannodes*) into a 760-acre enclosure on the San Luis NWR. The memorandum incorporated a cooperative management agreement with three objectives: the development of a display herd for public viewing, the provision of transplant stock for establishing and augmenting free-ranging elk herds in other Central California locations and the availability of a location for on-site elk research.

The elk herd provides a major visitor attraction for the San Luis Refuge and management of the San Luis herd has contributed to the successful reintroduction of tule elk in 21 locations in the San Joaquin Valley and Coast Range. The Service partnered with CDFW, The Rocky Mountain Elk Foundation and the University of California-Davis to conduct a three-year study[6] to determine the feasibility of establishing a free-ranging elk herd within the GEA.

The results of the study indicated, "…portions of the San Luis and East Bear Creek Units, as well as the Kesterson Unit, could provide tule elk introduced to the GEA with high-quality habitat. Both of these areas have adequate cover and forage in proximity to each other, a diversity of habitat types (although it is greater in the San Luis and East Bear Creek zone due to riparian forests near the San Joaquin River), and are largely free from detrimental human impacts. The combined areas of these zones could provide enough habitat to support a relatively large herd of elk. Thus, it is recommended that any introduction sites be located within one or more of these high-quality habitat zones. If elk are subsequently introduced to these areas, we expect the elk population to quickly increase in this landscape. A somewhat similar environment at Grizzly Island supports a thriving herd in an area substantially smaller than the GEA" (Huber et al. 2011).

However, the study also notes, "the locations of these habitat zones suggest several potentially hazardous areas for tule elk in the GEA, including (1) private duck clubs; (2) the San Luis Drain; (3) California Highway 165; and (4) agricultural fields. The Kesterson habitat zone is directly adjacent to a number of private duck clubs located to the southwest of this unit. Disturbances could be detrimental to elk in this area (at least for a portion of the year). The San Luis Drain, a concrete-lined canal carrying agricultural runoff through the middle of the Kesterson zone, could prove lethal to elk. Another potentially lethal landscape feature is Highway 165, running north-

[6] Tule Elk Habitat Assessment 126 California Fish and Game Vol. 97, No. 3

south through the middle of the GEA. Roads are a well-known hazard for elk and other species, and collisions could further result in human injury or death. Adequate measures to mitigate for these hazards (e.g., funnel fencing techniques or road crossing structures) should be implemented as part of any reintroduction program, and will be especially important if elk movement between high quality habitat on opposite sides of the highway proves vital for population viability. Finally, the entire GEA is surrounded by agricultural fields. If elk move into these fields, farmers could suffer crop loss and fence damage (Rosatte et al. 2007). Programs to erect elk-proof fencing or implement hazing techniques in high risk areas could help alleviate these potential problems (Huber et al. 2011).

California Partners in Flight.

In 1994, California Partners in Flight initiated the RHJV project, a Cooperative Agreement between 18 Federal, state and private organizations to protect and enhance habitats for native landbirds throughout California. Riparian songbird populations on the refuges have been heavily impacted by the loss of riparian nesting habitat due to the redirection of water from the San Joaquin River since the building of the Friant Dam in 1942 to meet demands for irrigation needs. As a Flagship Project of the RHJV, protection and restoration efforts along the river throughout the refuges have resulted in the conservation of song sparrows (*Melospiza melodia*), blue grosbeaks (*Guiraca caerulea*), black-headed grosbeaks (*Pheucticus melanocephalus*) and Swainson's hawks (*Buteo swainsoni*). Multi-year surveys and studies have facilitated long-term monitoring of riparian songbird populations, utilizing mist netting stations and transects (RHJV 2004). The resulting data are used to determine the distribution, diversity and relative abundance of riparian songbirds.

Tour Group at Merced NWR. Photo: Jack Sparks

Grassland birds are managed according to the Grassland Bird Conservation Plan developed by California Partners in Flight. This species group has been greatly impacted by the loss of habitat and fragmentation associated with the conversion of grassland to agriculture and the resulting replacement of native perennial and annual grasses and forbs by exotics (due to their competitive advantage) during periods of overgrazing and droughts. In 2006 and 2007, in support of the Grassland Bird Conservation Plan, Complex staff assisted with surveys to determine the abundance, diversity and habitat use of grassland birds using point count transects.

Pacific Flyway Council.

Mourning doves (*Zenaida macroura*) are not specifically managed on the refuges but they do benefit from wetlands, uplands and riparian management and restoration. Population surveys are not conducted for mourning doves on the refuges, but doves were banded from 2005 to 2021 in support of the National Dove Management Plan, conceived by the Service, and designed to provide guidelines for harvest and monitoring of mourning doves in California. Future banding and conservation of mourning doves is subject to funding and staffing availability.

Ducks Unlimited

Ducks Unlimited has been a major partner in securing project implementation funding and collaborating with the Complex to enhance wetland habitat. Ducks Unlimited has brought 3.5 million dollars of project implementation funding to the Complex since 2015, worked on all three refuges and enhanced over 2,000 acres of habitat. Projects completed since 2015 have included three phases of work on the East Bear Creek unit, two phases of work on the Blue Goose unit, four projects on the Kesterson unit and two projects on Merced NWR on the Lonetree and Main Merced units. From 1995 to 2015, significant projects included the Freitas and West Bear Creek units.

Partners for Fish and Wildlife Program.

Habitat restoration and enhancement efforts on easement lands of the Grasslands WMA often are integrated with those of the Partners of Fish and Wildlife (PFW), because the goals and objectives of these programs are very similar and compatible with those of the Conservation Easement Program. The PFW is a USFWS program designed to provide technical and financial assistance to landowners for habitat improvement projects on private lands for the benefit of migratory bird species, anadromous fish species of special concern to the Service, endangered, threatened, or candidate species, species proposed for listing and other declining or imperiled species (USFWS 2003). In addition to habitat improvement projects, the program is designed to provide conservation leadership, promote partnerships, encourage public understanding and participation and work with the USDA on conservation efforts.

Public Use Issues

The Refuge System, in accordance with the Refuge Improvement Act, supports six wildlife-dependent public uses: hunting, fishing, wildlife observation, photography, environmental education and interpretation. Public use of the Complex includes all six activities, though permitted activities vary from one refuge unit to another. Public use activities at the Complex require a management balance between protection and enhancement of wildlife populations and their habitats and providing a quality wildlife-dependent recreational activity to visitors.

Virginia Rail. Photo: Rick Lewis

The primary purpose of NWRs is to protect and manage wildlife; therefore, the impacts of public use activities must be assessed and considered. Assessment of public use impacts to wildlife and habitat should take into account the type and number of visits to the refuge; the activities; and the degree of interaction between visitors, wildlife and habitat (Pomerantz et al. 1988). Disturbances to wildlife caused by public use activities may result in changes in wildlife physiology, behavior, reproduction, population levels and species composition and diversity (Hammitt and Cole 1987). Public use activities such as hunting, fishing, wildlife observation, photography and mere human presence can impact wildlife, producing stressful conditions even if unintentional (Hammitt and Cole 1987). Public use on the refuges could also impact soils and vegetation, which may in turn affect wildlife.

National Surveys of Fishing, Hunting, and Wildlife-Associated Recreation have been conducted by the Service every 5 years since 1955. The Survey collects information on people 16 years of age and older who participate in wildlife-associated recreation (fishing, hunting and wildlife-watching) on a national and state-by-state basis. For the Survey, wildlife-watching is defined as observation, photography and feeding of fish or wildlife and is categorized by away-from-home—where people travel at least one mile for the primary purpose of watching wildlife—or around-the-home—where people remain within one mile of home (DOI 2016). Nationally, the 2016 survey showed a 16-percent increase overall in the number of people participating in wildlife-associated recreation compared to the 2011 survey (DOI 2016).

In California, from 2006 to 2011, participation by state residents in wildlife-associated recreation showed fishing decreased 32 percent, hunting remained statistically unchanged, away-from-home wildlife-watching remained unchanged and around-the-home wildlife-watching increased by 22 percent. For the period 1996 to 2006, state residents participating in fishing decreased 38 percent, hunting decreased 45 percent and both away-from-home and around-the-home wildlife-watching remained statistically unchanged. Despite the decreasing or unchanged status of participation in wildlife-associated recreation from 1996 to 2006, the survey indicated that only 26 percent of Californians six years of age and older participated in wildlife-associated recreation in 2006 (DOI 2011).

Lack of Local Awareness

While the San Luis and Merced refuges are well known to neighboring major urban areas in California (San Francisco Bay Area/San Jose, Sacramento, Fresno), feedback from local communities has consistently indicated a lack of awareness among local residents about the refuges and public use opportunities. This issue is common for rural refuges. The refuge Complex has emphasized the environmental education program as an outreach tool for engaging local communities. The Complex has had some success securing soft funding for school field trip transportation, a major financial barrier for local schools. Local communities consist of large Spanish-speaking populations and the Complex has set a priority to hire visitor services interns fluent in spoken and written Spanish to better communicate and engage with local residents.

High Seasonal Use and Disregard for Refuge Rules

Visitation periods are seasonal at the San Luis and Merced refuges, with peak visitation during fall through spring, coinciding with wintering migratory waterbird use. Both refuges see a significant drop-off in visitation during the summer. During peak wintering periods, the Merced auto tour route can become especially crowded with visitors wanting to see the large flocks of sandhill cranes and geese. Visitors intentionally breaking the rules by walking on the tour route (which is prohibited) or walking/driving into closed areas is a chronic problem at the refuge, despite an abundance of regulatory and educational signage. These illegal activities by visitors disturb wildlife and negatively impact the experience for other visitors. Many of these violations likely occur because the refuge does not have sufficient personnel to patrol the auto tour route to maintain a presence and correct unlawful behavior as it occurs.

Chronic Vandalism, Theft and Other Illegal Activities

Decades ago, routine law enforcement issues were primarily related to hunting and fishing. During the past 40 years, the size of the Refuge Complex and the length of its boundary have increased, resulting in more isolated landscape in which undetected illegal activities can occur and greater opportunity for people to gain uncontrolled access to refuge lands. Complex law enforcement personnel now encounter more urbanized types of illegal activities such as drug trafficking, drug production (marijuana gardens) and dumping of hazardous waste from methamphetamine production labs. Additionally, refuge lands are targeted for trash-dumping, vandalism and general misuse, as well as infractions directly associated with public use such as vehicular and pedestrian trespass into closed areas. Another factor contributing to the amount of illegal activity on the Complex is the "low visibility" of personnel on site due to long-term staffing shortages. The San Luis and Merced Refuges are both plagued with chronic vandalism and theft, which primarily occur during summer months when wildlife-oriented visitation decreases. Graffiti and gang-style tagging on visitor kiosks, interpretive panels and pit toilet restrooms is common. Trash dumps and shenanigans such as tearing railings off observation decks and cars peeling out and spinning circles that tear up gravel parking lots commonly occur during summer. These activities result in time-consuming, expensive repairs that should be better spent on habitat work. Theft of refuge property also is a major drain on refuge resources and staff time.

Limited Visitor Services Staff to Provide Programming at Optimal Levels

Visitor services staffing at the refuge complex currently consists of a supervisory outdoor recreation planner and a park ranger, both permanent full-time positions. School field trips could be conducted more optimally with additional visitor services personal to facilitate activities, ideally by breaking up the typically large groups into more manageable units. Additional visitor services staff also would allow the Refuge Complex to institute regular recurring weekend nature walks and other similar programming for the public. A new 16,000-square-foot visitor center was completed in 2022. The visitor center provides opportunities to learn from interpretive panels and educational materials, and access to refuge staff and volunteers for questions.

Waterfowl Hunting and Sanctuaries

Waterfowl hunting has been a part of the management of both the San Luis and Merced NWRs since their establishment as refuges. As part of the hunt program, the Service has maintained sanctuaries on a portion of the landbase of both refuges. Section 2.8 of 605 FW 2 states, "If a refuge, or portion thereof, has been designated, acquired, reserved, or set apart as an inviolate sanctuary, we may only allow hunting of migratory game birds on no more than 40 percent of that refuge, or portion, at any one time unless we find that taking of any such species in more than 40 percent of such area would be beneficial to the species" (USFWS 605 FW 2). On Complex lands purchased with Migratory Bird Conservation Act (MBCA) funds before November 8, 1978, those lands are required be managed as an inviolate sanctuary. On November 8, 1978 Congress amended the MBCA to permit the Service to acquire land under the Act for "any other management purpose, for migratory birds." After that date, lands acquired under the MBCA are not acquired for inviolate sanctuary purposes unless explicitly stated in the Migratory Bird Conservation Commission proposal (16 U.S.C. 715-715d). In addition to the legal requirements, there has been a long-standing recognition within the wildlife management community of the importance of disturbance-free sanctuary as one of the components of habitat necessary to meet the needs of migratory birds and other wildlife (Heitmeyer, Connelly, and Pedersen 1989, Madsen 1998).

Ross's Geese. Photo: Rick Lewis

Western Kingbird. Photo: Paul Prado

Since refuge establishment, operation of the hunting areas and the unhunted sanctuaries has remained a contentious issue in the Grasslands area. Some participants of the public hunting on the refuges want maximum hunting opportunity, even at the expense of other public uses. Some members of local duck clubs and others have felt that too many waterfowl concentrate on the sanctuaries—especially at the San Luis NWR—which reduces hunter success on their lands. Over the years, their concerns have been voiced in meetings and letters to refuge managers, the Service's regional and Washington offices, CDFW, outdoor news columns and private waterfowl conservation organizations.

In response, the Service enacted numerous revisions to the hunt area boundaries and operation of the hunt programs during the 1950s through 1980s. These revisions included delaying flood-up in the sanctuaries, realigning sanctuary boundaries, allowing pheasant-hunting in the waterfowl closed zones and establishing a hunting unit in the middle of the sanctuary at San Luis NWR. Such activities lowered waterfowl concentrations in the sanctuary, but also resulted in increased use by ducks of a nearby reservoir and sewer ponds, decreased use of the Complex by sandhill cranes and arctic nesting geese and exclusion of other Complex visitors by closing designated tour routes on hunt days. These management practices were incrementally eliminated during the mid- to late 1980s.

During the 1990s, the ongoing controversy over closed zones in the Grasslands area, especially the San Luis NWR sanctuary, escalated as new state and Federal lands were being acquired and restored. It was widely claimed that excessive sanctuary in the Grasslands area was adversely impacting hunter success and providing a disincentive to manage privately owned wetlands or even to maintain those areas as duck clubs. Because most of the wetlands remaining in the Central Valley are under private ownership (mostly as intensively managed duck clubs), the Service has long recognized that maintaining reasonable harvest rates on private clubs is critical for keeping these lands as managed wetland habitat for waterfowl and other migratory birds. As such, the Service has never wanted the operations of San Luis NWR and Merced NWR to contribute to the demise of any of the more than 165 organized duck-hunting clubs in the Grasslands area and conversion of those managed wetland habitats to other land uses.

These concerns resulted in a number of actions being taken. In 1996, the Central Valley Habitat Joint Venture of the North American Waterfowl Management Plan prepared a technical report comparing Central Valley hunting success in the 1995–96 waterfowl season with that of previous years. That same year, the Service prepared a reference document detailing the history of the Complex hunting program in the Central and Imperial Valleys of California. The Joint Venture report documented that within the San Joaquin Valley portion (location of the Grasslands area) of the Central Valley, sanctuary areas in 1995 totaled 6.5 percent of the managed wetlands on the combined state, Federal and private landbase and had only increased by 1.2 percent in the last ten years. The report further indicated that increases in sanctuary acreage were not the primary influence of hunter success in the Grassland area in 1995–1996, and reported that overall duck harvest in Merced County, the location of San Luis and the Grassland duck clubs, had actually increased from 1988 through 1995–1996, and that the county consistently ranked first or second in annual duck harvest for the United States (Technical Committee of the Central Valley Habitat Joint Venture 1996). During 1996 through 1998, the Service—in partnership with the CDFW, Grassland Water District and Grassland Resource Conservation District—hosted annual workshops within the Grassland area for waterfowl hunters to inform and engage them in discussions about waterfowl harvest trends, annual population forecasts, Complex operations, management of non-waterfowl species and local issues.

Since that time, the Service and its local partners have formed a committee to address local issues, especially those regarding closed zones; coordinate ongoing management activities on public and private lands; and provide an outreach venue to disseminate information on local waterfowl and wetlands management via newsletters, public meetings and contacts with individual duck club members. As a result of committee discussions and recognition that state and private wetlands managers elsewhere in the Central Valley and other parts of the country maintain sanctuaries for the purpose of holding birds in the area to improve their local hunting success, a few of the larger duck clubs in the Grassland WMA established small sanctuaries on their lands to see if it would improve hunting success on their individual clubs. Within two years, most of these clubs began holding more ducks on their lands and having higher harvest rates. As word of increased hunter success spread, more clubs in the Grassland WMA area have started their own private sanctuaries.

Sanctuaries, whether public or private, do have the potential to affect local waterfowl distribution. As such, the Service carefully evaluates potential impacts to local waterfowl distribution in addition to meeting wildlife resource needs and other public use objectives when deciding how much and where to establish new sanctuary and hunting zones on San Luis NWR and Merced NWR as additional public lands are acquired and restored in the Grassland area.

Infrastructure Maintenance

The maintenance of the Complex's infrastructure and real property is key to achieving the station's wildlife conservation mission and desired visitor use experience. The Complex's large landbase and its intensive management activities require extensive infrastructure to operate.

Buildings

The buildings found on the San Luis NWR Complex can be classified into five general categories: administrative/public use buildings, living quarters, maintenance shops, barns/storage facilities and dilapidated structures. The administrative/public use buildings consist of a Complex administrative office and visitor center (completed in 2011) located on the San Luis NWR and four public comfort stations situated along the auto tour routes of both San Luis and Merced NWRs. Additionally, San Luis NWR and Merced NWR each maintain a small field office on site. Living quarters consist of a three-bedroom/two-bath single family dwelling on the Merced NWR and a 12-person occupancy bunkhouse on the San Luis NWR. A large maintenance shop is also located on each of the refuges along with numerous equipment storage facilities. Merced NWR also maintains one barn that was inherent to the properties upon their acquisitions. Collapsing infrastructure that is not feasible to maintain, notably on the Snobird unit, will be decommissioned and removed from the landscape when funding and time allow. Due to the high degree of traffic, use and visibility, all public facilities receive frequent cleaning, upkeep and landscape maintenance. All buildings must meet or exceed the standards and requirements set by the Occupational Safety and Health Administration (OSHA).

The final category of buildings found on the Complex are those structures too dilapidated or otherwise in disrepair to be safely utilized for refuge-related activities. These structures are normally inherited when new lands are acquired. Because funding typically is not available to demolish and remove these

American White Pelicans. Photo: Rick Lewis buildings immediately, the structures often sit for some time until resources do become available. This can become problematic, as these structures often present safety concerns to both people and wildlife and detract from the aesthetic experience of visitors.

Roads

Collectively, the San Luis and Merced NWRs maintain approximately 300 miles of gravel-surfaced roads and 600 miles of dirt road. Roughly 100 miles of gravel roads are open for public access in the form of auto tour routes and hunter access roads while the remainder of roads (i.e., refuge administrative roads) provide access for management activities. As a result of heavy use, animal burrowing, flooding/washouts and invasive plant species, roads require a tremendous amount of maintenance and upkeep. These activities most frequently include weed control, grading, resurfacing and reshaping. Due to the many miles of road and limited staff and equipment, maintenance work is prioritized to place the most emphasis on auto tour routes and hunting access roads, followed by graveled service roads and lastly dirt roads.

The road infrastructure also includes bridges and high water and low water crossings. Bridges undergo regularly scheduled inspections from the Service and the Federal Highways Commission. High water crossings take the form of earthen roads (graveled or un-graveled) crossing over either culverts or water control structures, while low water crossings pass through the water channel itself and are usually constructed with concrete or gravel.

The largest challenges to maintaining the road infrastructure are the limited number of trained equipment operators and lack of sufficient funds to effectively maintain the road system. Funding is extremely limited and materials, repairs and replacement equipment are expensive. Because of limited staff time and funding available to effectively maintain the service roads, many sections of road receive minimal attention are only seasonally available for use. Roads open to public use receive most of the annual maintenance work.

Water Conveyance

The ability to move water from source points to points of use for wetland and upland management is the single most important activity conducted by refuge staff and the private land managers of the Grasslands WMA. Water is of premium value in the Central Valley and is no longer delivered to wetlands via a naturally occurring process but is instead delivered through a heavily regulated procedure dependent on priority water rights and controlled delivery schedules. Water conveyance infrastructure is extensive and complex. Point sources of water originate from either surface water or groundwater. Surface water, from existing water rights or delivered water, is diverted into a conveyance system through the use of lift pumps and gravity-fed water control structures. Groundwater from deep wells is delivered directly into a wetland basin or to a conveyance system. The actual conveyance of water occurs through open, earthen or cement-lined delivery ditches or through pipelines.

Tule Elk. Photo: Paul Prado

Maintaining the water conveyance infrastructure is both time-consuming and expensive. Lift pumps and deep wells run continuously for long stretches. Many are greater than 20 years old, and experience fluctuations in water levels and surges in electricity loads that over time negatively affect their ability to operate efficiently and cause them to frequently break down and require costly repairs. Water conveyance ditches require the periodic removal of sediment and re-sloping, as well as annual vegetation control to ensure the efficient movement of water to wetland basins and other points of use. Cement-lined ditches need frequent patching or repair of cracks to prevent the loss of water. Pipelines require annual maintenance and periodic repairs due to leaks, sediment build-up and damage to diversion and inlet valves. Water control structures crack and leak over time as well and require replacement, and are frequently plugged up with free-floating debris or by beaver activity and must be routinely inspected and cleaned out.

The cost and time commitment will continue to be a challenge for the refuges and Grassland WMA. In addition, the increasing demand for water and the effects of climate change will present challenges, causing the refuge and water managers within the Grassland WMA to look for more effective ways to convey and conserve water. These strategies may include increasing the construction of pipelines, greater efforts towards vegetation control and maintenance of delivery ditches and an increased focus on pump and well efficiency.

Fencing

Fencing is utilized on the San Luis NWR Complex as a security measure and for management purposes. The San Luis NWR maintains approximately 60 linear miles of boundary and interior fencing while the Merced NWR retains approximately 45 linear miles of fence. Most of the fencing is five-strand barbed wire with some wooden split-rail fencing around public parking areas and trailheads. Both boundary and interior fencing require a considerable amount of upkeep and maintenance due to automobile accidents, fire damage, flooding and vandalism. Roughly 30 to 40 percent of fencing is in need of replacement due to age and disrepair, and another 10 percent of the existing fencing is no longer useful and needs to be removed completely. Furthermore, both San Luis and Merced NWRs require an additional 10 linear miles of fencing to close openings along the refuge boundaries and for management needs.

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Chapter 3: Refuge Resources

Environmental Settings

The Merced NWR, San Luis NWR and Grasslands WMA were initially established due to their importance to migratory birds, particularly waterfowl and shorebirds. These lands have the potential to provide habitat for all the avian species known to occur in the Central Valley, which includes over 250 species of birds. Close to 30 species of ducks, geese and swans make use of the refuge units, the most common being the Ross's goose (*Anser rossii*), snow goose (*Anser caerulescens*), greater white-fronted goose (*Anser albifrons*), green-winged teal (*Anas crecca*), northern shoveler (*Anas clypeata*), mallard (*Anas platyrhynchos*), northern pintail (*Anas acuta*), cinnamon teal (*Anas cyanoptera*), gadwall (*Anas strepera*), American wigeon (*Anas americana*), ring-necked duck (*Aythya collaris*) and ruddy duck (*Oxyura jamaicensis*). Other conspicuous waterbirds include the pied-billed grebe (*Podilymbus podiceps*), double-crested cormorant (*Phalacrocorax auritus*), white-faced ibis (*Plegadis chihi*), white pelican (*Pelecanus erythrorhyncos*), sandhill crane (*Grus canadensis*), American coot (*Fulica Americana*), common moorhen (*Gallinula chloropus*), killdeer (*Charadrius vociferous*), black-necked stilt (*Himantopus mexicanus*), American avocet (*Recurvirostra americana*), greater yellowlegs (*Tringa melanoleuca*), western sandpiper (*Calidris mauri*), least sandpiper (*Calidris minutilla*) and long- and short-billed dowitchers (*Limnodromus scolopaceus* and *L. griseus*). Colonial nesting waterbirds maintain colonies on these lands and include the great blue heron (*Ardea herodias*), great egret (*Ardea alba*) and double-crested cormorant (*Phalacrocorax auritus*).

The Merced NWR is located in Merced County approximately 15 miles southwest of the city of Merced, situated on the floodplain of Bear Creek and other tributaries of the San Joaquin River. The refuge encompasses over 10,200 acres of freshwater wetlands, native uplands, agricultural fields, vernal pools and riparian corridors. Although the refuge is an important area for migratory waterbirds and assemblages of other native wildlife, it plays a major role in supporting the large numbers of wintering Ross's geese (*Anser rossii*), snow geese (*Anser caerulescens*) and lesser sandhill cranes (*Grus canadensis*) along the Pacific Flyway. Each winter, as many as 50,000 white geese and 20,000 cranes will use this refuge. These and the large flocks of ducks and other waterbirds are highly visible from the 5-mile auto tour route.

The San Luis NWR is located in western Merced County approximately 8 miles northeast of the city of Los Banos and 20 miles southwest of the city of Merced. At over 26,800 acres, it is the largest contiguous NWR in the Central Valley. The San Joaquin River and several natural tributaries—Salt Slough, Mud Slough and Bear Creek—flow through the refuge and, historically, seasonally inundate much of the landscape. The refuge provides wintering habitat for more than a half million ducks and geese. In addition to being an important area for waterbirds in the Valley, the refuge supports two populations of large ungulates. A herd of tule elk (*Cervus elaphus nannodes*) —a subspecies unique to California—is managed in a 780-acre enclosure with a 5-mile auto tour route along the perimeter. In recent years, mule deer have been successfully released to freely roam in the refuge's well-suited habitat and are sometimes visible from the auto tour routes.

The Grasslands WMA includes the private lands in Merced County that have a Service conservation easement for the purpose of protecting or enhancing wildlife habitat. The Grasslands WMA completely consists of conservation easements on over 190 private properties (approximately 80,000 acres). These easement lands form the largest concentrated wildlife easement program in the State of California and provide habitat protection for hundreds of thousands of waterbirds. Typically, Service easement lands occur in proximity to the Merced and San Luis NWRs, providing enhanced protection for their natural resources as well as the private lands. Land use on these easement lands consists primarily of managing habitat for waterfowl hunting clubs, as well as wildlife-friendly agriculture and grazing practices.

Sandhill Crane Dance. Photo: Rick Lewis

Historical Environment

Historical Central Valley Environment

Historically, the Central Valley contained vast grasslands that graded up the sides of the foothills of the surrounding mountains. These grasslands provided rich forage for numerous grazers, including pronghorn antelope (*Antilocapra americana*), tule elk (*Cervus elaphus nannodes*), black-tailed deer (*Odocoileus hemionus*) and a complex suite of small grazers and seed predators (Barbour and Billings 1988). They also supported an array of grassland-dependent birds, including songbirds, birds of prey, and gamebirds. Woodlands meandered across these grasslands in belts that varied from half a mile to six miles wide along rivers. Oak woodlands, which had a park-like quality, became denser and more mixed with cottonwoods (*Populus* spp.), sycamores (*Plantanus* spp.), ash (*Fraxinus* spp.), and willow (*Salix* spp.) near the river edges and sloughs (Barbour and Billings 1988). Acorns produced by valley oaks (*Quercus lobata*) and other oaks (*Quercus* spp.) provided abundant forage for numerous wildlife species (Bonnicksen 2000; McShea and Healy 2002).

The riparian tracts and woodlands served as forested habitat for diverse breeding and migratory songbirds, provided nesting sites for birds of prey and colonial nesting waterbirds and acted as travel corridors for forest-dependent wildlife. Extensive marshes were a dominant feature along the water courses of the valley, some large enough to be almost impassable (Ornduff 1974). The marshes were dominated by monocots, particularly tules (*Scirpus* spp.), cattails (*Typha* spp.) and sedges (*Carex* spp. and *Cyperus* spp.). These wetlands hosted one of the largest concentrations of wintering waterfowl in the world. In the mid-1800s, early explorers reported vast numbers of waterfowl and other marsh and shorebirds in the Central Valley.

During the last 150 years, the natural resources of the Central Valley have been severely altered with the increase in cultivation, ranching, urban centers and industry. These changes significantly altered or reduced a majority of the valley's native habitats and ecological processes. The former native grasslands that once dominated portions of the valley are now composed of "weedy," non-native annual grasses, such as *Avena*, *Bromus*, *Lolium* and *Erodium* species, and many non-native forbs (Barbour and Billings 1988). Large herbivores are no longer dominant or even present on the landscape. The once-stately valley oak woodlands, which once supported the largest oak specimens in North America, have been decimated following land use change. Much of the riparian forest along stream and river corridors has also been eliminated (Bonnicksen 2000). Of the eight oak woodland types of the Pacific Coast, the valley oak woodland is now the second rarest by total acreage (McShea and Healy 2002). Wildfire suppression efforts and changing land use have reduced fire as a natural process within much of the Central Valley. Both water demands and flood control activities for urban centers and agriculture have drastically transformed the natural hydrology. As a result, these changes have destroyed or modified over 95 percent of the historic wetlands in California (Heitmeyer, Connelly, and Pedersen 1989).

Historical San Luis NWR Complex Environment

The lands composing the San Luis NWR Complex historically were a mosaic of riverine channels, broad riparian floodplains, wetlands and grassland savannas dominated by valley oaks (*Quercus lobata*). This area was bisected by the main stem of the San Joaquin River. Historically, the San Joaquin River and its tributaries would overtop natural levees and inundate the floodplain following winter rains and Sierra Nevada Mountains' snow melt. This system was dynamic, depositing rich alluvium, creating and cutting streambanks, creating and maintaining riparian forests, creating oxbow lakes and backwater sloughs by changing the courses of the river and its tributaries, clearing and depositing debris, scouring streambeds and exposing and depositing gravel and sand. The resulting floodplain corridor was vegetated by trees, such as button willow (*Cephalanthus occidentalis* var. *californicus*), black willow (*Salix goodingii*) and sandbar willow (*Salix exigua*) in the lower areas. The upper areas were dominated by box-elder (*Acer negundo* ssp. *californicum*), Fremont's cottonwood (*Populus fremontii* ssp. *fremontii*), Oregon ash (*Fraxinus latifolia*), arroyo willow (*Salix lasiolepis*) and valley oak (*Quercus lobata*). The most common mid- and ground-level shrubs included California rose (*Rosa californica*), California blackberry (*Rubus ursinus*), elderberry (*Sambucus mexicana*) and wild grape (*Vitis californica*). Dominant grasses and forbs included creeping wild rye (*Leymus triticoides*), basket sedge (*Carex barbarae*), mugwort (*Artemisia douglasiana*) and goldenrod (*Solidago californica*). The uplands adjacent to the floodplain were less frequently inundated by floods and were dotted with valley oaks (*Quercus lobata*) with an understory of perennial grasses and forbs, such as creeping wild rye (*Leymus triticoides*), saltgrass (*Distichlis spicata*), alkali sacaton (*Sporobolus airoides*), gum plant (*Grindelia camporum*) and spikeweed (*Hemizonia pungens*). Wetlands and vernal pools were abundant throughout the upland savannas. These habitats supported a wide array of migratory birds, salmonids and other fish, large herbivores and other wetland- and upland-associated wildlife.

American Indians lived in permanent villages on elevated locations above the floodplain. These native people, the Yokuts, made their homes along the San Joaquin River and its tributaries in part because of the abundance of natural resources in the area. When Lieutenant Gabriel Moraga led the Spanish cavalry into the San Joaquin Valley in 1805, the explorers were astonished by the abundance of wildlife. The Spaniards saw ducks, geese, cranes, herons, pelicans, curlews, pronghorn antelope, tule elk (*Cervus elaphus nannodes*) and grizzly bears, all in large numbers.

Conditions began to rapidly change by the 1850s, following European settlement and development. Pronghorn antelope were extirpated, tule elk (*Cervus elaphus nannodes*) were nearly made extinct and other wildlife were diminished by commercial hunting that was driven by the meat markets of San Francisco and mining camps of the California Gold Rush. Valley oaks (*Quercus lobata*) and riparian forests were cut down for lumber and firewood to fuel steamboat traffic on the rivers. By the late 1800s and early 1900s, wetlands were being drained, creeks channelized, and floodplains cleared of trees to create farmland.

During the 1940s and 1950s, Friant Dam and other water storage/flood control facilities were built on the San Joaquin River and its major tributaries, and water diversions were made for agricultural, industrial and metropolitan uses. Flood control levees were constructed along the river's course to contain and greatly narrow the floodplain. Nearly two centuries after Moraga's expedition, the San Joaquin Valley landscape is dominated by agriculture and is now one of the most intensively farmed regions in North America.

The lands composing the San Luis NWR Complex were drastically altered, but to a lesser extent than most of the lands along the San Joaquin River. Levees were built on both sides of the river. Many local drainages were channelized and much of the floodplain cleared for orchard and row crop agricultural development in the early 1900s. East of the river, much of the floodplain and adjacent uplands were cleared of trees and converted to grazing lands for cattle. Stock ponds were developed, and natural slough channels were used to provide water for cattle in some areas. Eventually, much of the eastern land was leveled, canals and pipelines were constructed for irrigation and native grass/forb plant communities were replaced by domestic pasture grasses.

Habitat alteration has continued into recent times. Valley oaks (*Quercus lobata*) and other trees in the river corridor were cut down in the 1960s and 1970s and much of the pastureland was converted to row crop agriculture in the 1980s and 1990s. Even with these recent developments, the area provides critically important habitat for a wide array of wildlife species. The river channels and associated oxbows serve as migration corridors and rearing habitat for salmonids and other fish species. The riparian forest and fallow fields provide migration and nesting habitat for neotropical birds and other riparian-associated species. The uplands provide foraging and roosting habitat for migratory birds, such as waterfowl, cranes and shorebirds.

Great Blue Heron in Rookery. Photo: Lee Eastman

Pacific Flyway Setting

The San Luis NWR, Merced NWR and Grasslands WMA lie within the Pacific Flyway, which extends from the crest of the Rocky Mountains westward to the Pacific Ocean within North America. The Pacific Flyway is used by millions of waterfowl and shorebirds for migration to and from wintering and breeding grounds (Figure 3-1).

On a more localized level, the refuges are within the San Joaquin Valley in the southern portion of the Central Valley of California. The Central Valley is the wintering area for approximately 60 percent of the waterfowl in the Pacific Flyway and provides critically important migration habitat for other ducks and geese continuing southward to wintering areas in Mexico and Central America (Gilmer et al. 1982). Approximately 8.5 million waterfowl were estimated in the Central Valley Joint Venture planning area in 2020, according to the Central Valley Midwinter Waterfowl Survey (USFWS and CVJV 2020). Common wintering species include the snow goose (*Chen caerulescens*), Ross's goose (*Chen rossii*), western Canada goose (*Branta canadensis moffitti*), Aleutian cackling goose (*Branta hutchinsii leucopareia*), mallard (*Anas platyrhynchos*), northern pintail (*Anas acuta*), green-winged teal (*Anas crecca*), northern shoveler (*Anas clypeata*), gadwall (*Anas strepera*), American wigeon (*Anas americana*), canvasback (*Aythya valisineria*) and ringed-necked duck (*Aythya collaris*) (Root 1988).

The Central Valley is also a key region for many other waterbirds and shorebirds. Species of waterbirds seen in abundance include sandhill cranes (*Grus canadensis*), great blue heron (*Ardea herodias*), great egret (*Ardea alba*), white-faced ibis, (*Plegadis chihi*) and American coot (*Fulica americana*). Millions of shorebirds, including greater yellowlegs (*Tringa melanoleuca*), long-billed curlew (*Numenius americanus*), western sandpiper (*Calidris mauri*), least sandpiper (*Calidris minutilla*), dunlin (*Calidris alpina*) and long-billed dowitchers (*Limnodromus scolopaceus*), either winter in or migrate through the Central Valley. Other shorebirds, such as killdeer (*Charadrius vociferus*), black-necked stilt (*Himantopus mexicanus*) and American avocet (*Recurvirostra americana*), stay and are present as local breeding birds (Root 1988; Shuford, Page, and Kjelmyr 1998).

Figure 3-1. Pacific Flyway

Physical Environment

This section describes the characteristics of the air, water and soil/geological resources of the lands composing the San Luis NWR Complex.

Climate

The climate of California's San Joaquin Valley is classified as Mediterranean, with cool, wet winters and hot, dry summers. The annual average precipitation is less than 5 inches in the south to 15 inches in the north. Heavy fog is common during the winter months, while thunderstorms, hail and snow are rare occurrences. The San Joaquin Valley has a frost-free growing season of 270 to 300 days and is responsible for the tremendous agricultural industry on the valley floor. The average temperature ranges from a low of 38 degrees F to a high of just over 100 degrees F; however, extreme temperatures, as low as 20 degrees F and as high as 115 degrees F, have been recorded. The general wind direction is out of the northwest, but some early autumn storms may have a south wind associated with them.

Air Quality

The refuges and WMA are located within the San Joaquin Valley Air Pollution Control District, which is made up of eight counties in California's Central Valley: San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare and the Valley portion of Kern. The entire district is classified as a "non-attainment area" because it does not meet ambient air quality standards for ozone or $PM_{2.5}$ (EPA 2022). Air pollution within the district comes from a variety of sources, including industrial facilities, agriculture, vehicles and consumer products. This pollution is exacerbated by the stagnant air masses that frequent the area. Efforts to reduce emissions from these sources are required by Federal and state mandates such as the Federal Clean Air Act Amendments and the California Clean Air Act.

The San Joaquin valley is the first air basin classified as "serious non-attainment" by the U.S. Environmental Protection Agency (U.S. EPA) to come into attainment of the particulate matter at the 10-micron level or smaller (PM_{10}) standards. PM_{10}s are generated by transportation, agriculture and industry. Though effective air pollution control programs are still needed, past efforts have brought about an overall improvement in air quality.

Soils, Geology and Topography

The soils of the Central Valley are mostly Entisols and Alfisols. Schoenherr (1992) provides a broad overview of the soils and geology of the Central Valley:

> "The Central Valley is a huge basin filled with sediments. The deepest parts of the gravels and sands are marine sediments that have accumulated since the late Jurassic—145 million years ago. The sea retreated from the Central Valley at about the same time that the southern Coast Ranges were uplifted, and during the long history of accumulation of marine sediments in the valley, the basement rock continued to subside. During most of the Pleistocene the area was occupied by shallow brackish and freshwater lakes. During the last 5 million years, sediments accumulated as alluvial deposits washed out of the mountains. These deposits are only a few thousand feet deep over most of the valley floor."

Physical conditions on refuge lands consist primarily of recent alluvial floodplains and basin lands. Soil types often are mixed alluvium mapped as soil associations. Basin soils are affected by high-water tables from river water seepage, as well as saturation of the land by deep penetration of rain and irrigation water. Most soils exhibit very poor drainage, with a high-water table at a depth of just 3 to 6 feet from December to April (Arkley 1964). The refuges are part of a fairly level, but undulating, ancient alluvial plain incised by the San Joaquin River, and several small creeks and sloughs. Elevations vary from 20 feet along the edge of the San Joaquin River to 40 feet in several locations to the east and west of the River. The landscape is bisected by the San Joaquin River and the Bear Creek and Mariposa Creek drainages, all of which have flood control levees on both banks. Much of the refuge land near these drainages has been laser-leveled and intensively farmed in the past for row crops and irrigated pasture. Each refuge also has natural areas that retain their historic topography. The riparian corridors inside the levees were not intensively developed for agriculture and retain their natural topography.

Water

Natural hydrology in the northern San Joaquin Valley has been severely altered with the settlement of the area. Natural flows and quality of the water have been impacted significantly. The vast majority of the water used on the San Luis NWR Complex is delivered by local water districts through delivery and/or drain canals or is from groundwater at the refuge units. The San Joaquin River, which is centrally located through the San Luis NWR Complex, has little natural flow in this area and immediately upstream is typically dry most of the year.

Water quality in the San Joaquin River is degraded by irrigation drainwater and urban runoff during summer and by flushing of accumulated pollutants in urban stormwater and other runoff in the winter. The California State Water Resources Control Board (SWRCB) designated 100 miles of the San Joaquin River, including the reach in Merced County, as an impaired water body in 1990 (SWRCB 1990). In addition, the lower San Joaquin River, from Mendota Pool to Bear Creek (an 88-mile stretch), is currently listed as impaired in accordance with Section 303(d) of the Clean Water Act, for exceeding boron, DDT and group "A" pesticide water quality objectives (California EPA 2021). The 303(d) list of impaired waterbodies in Table 3-1 lists all major waterbodies near the San Luis NWR Complex and the pollutants for each waterbody. The most degraded water quality occurs on the San Joaquin River and its tributaries upstream of its confluence with the Merced River.

Lee and Jones-Lee (2006) found "…the water quality in the San Joaquin River in the Central Valley floor has been significantly degraded due to runoff/discharges from irrigated agriculture, other agricultural activities (such as dairies and feed lots), municipalities and other sources. Of greatest concern are nutrients (nitrogen and phosphorus compounds), pesticides/insecticides, herbicides, heavy metals, suspended solids, PCBs, pathogens and TOC" (Lee and Jones-Lee 2006, p.iii).

In addition there is aquatic life toxicity of unknown cause. These pollutants and conditions such as water diversions cause adverse impacts to aquatic life; low DO in channels; excessive bioaccumulation of organochlorine legacy pesticides, PCBs, dioxins and mercury in fish and other aquatic life; threat of disease though contact recreation; development of carcinogens in disinfected drinking water; adverse impacts on irrigated agriculture through excessive salinity; blocking of Chinook salmon homing for spawning; turbid water and sediment accumulation; excessive aquatic weed growths; toxicity to algae; adverse impacts on the recharge of waters as part of enhanced groundwater recharge; and other yet to be identified impacts. Further, pollutants derived from the SJR could be contributing to the Delta pelagic organism decline" (Lee and Jones-Lee 2006).

The San Luis NWR approves, through issuance of a Research Special Use Permit, annual sampling of fish in Mud Slough on Kesterson Unit from which contaminant tissue samples are collected and analyzed as part of a long term monitoring effort (Grassland Bypass Project Surface Water Monitoring Annual Monitoring Report 2021).

Long term monitoring has shown decreases in contaminant levels of sampled fish within the San Luis NWR over time. However, water quality issues including higher than average levels of PFAS (poly-and perfluoroalkyl substances) in fish are emerging concerns that support ongoing monitoring and evaluation of water quality within San Luis NWR (Levy, Z.F., Balkan, M., and Shelton, J.L., 2021, Levy et al. USGS Fact Sheet 2021).

In recognition of known, suspected, or perceived water quality problems in the wetlands of the Grasslands, some of the major water quality studies that have been completed or are in progress are: the Grassland Bypass Project (1996–present); *Salinity, Boron, and Nutrient Monitoring of*

Wetland Source Waters and Discharges at the San Luis National Wildlife Refuge Complex (2002); *Evaluation of the Effects of Management of the San Luis National Wildlife Refuge Complex Wetlands on the Dissolved Oxygen Problem in the San Joaquin River Deep Water Ship Channel* (2004) and *Selenium in the Ecosystem of the Grassland Area of the San Joaquin Valley: Has the Problem Been Fixed?* (2004). These studies specifically examine the levels of selenium, salts, boron, nutrients and dissolved oxygen.

Seasonal Wetland. Photo: Rick Lewis

Selenium. Since the 1950s, agricultural drainwater flowed through the Grasslands and often was used to flood wetlands. In the early 1980s, selenium in subsurface irrigation drainage water was found to have caused malformations and reproductive failure in waterfowl at the area previously known as the Kesterson NWR. These levels were high enough to warrant the issuance of human health advisories. While selenium concentrations had declined since the early 1980s due to management efforts, those intended benefits may not yet be fully realized, in part because the time required for the ecosystem to purge is unknown and additional factors may be preventing the full recovery of the Grasslands wetland ecosystems.

Salts and Boron. A program was developed to collect sufficient salinity and boron data on the water delivered and discharged from the refuge units during wetland management operations to satisfy the immediate needs of the Central Valley Regional Water Quality Control Board plan to set and meet salt and boron objectives in the San Joaquin River. As an identified discharger of salt and boron, the San Luis NWR Complex water suppliers are required to cooperate in the total maximum daily load (TMDL) process by establishing a program of monitoring the net loads of boron and salt added to the San Joaquin River. However, data from only 1 year were collected. These data do not make it possible to reliably calculate mass balances for salt and boron. Average concentrations of both boron and salt generally increased in wetland discharges relative to concentrations in source water flowing into wetlands. Overall, the mean increase in electrical conductivity from all sources to all discharges was 9 percent. Despite limited sampling, the data acquired by this project indicate that the evapo-concentration of salt and boron in Complex waters as they flow through wetlands may be quite modest. Therefore, it is likely that refuge unit wetlands, on average, add little if any net load of salt and boron to the waters that they discharge into the San Joaquin River.

Nutrients and Dissolved Oxygen. As part of the 2002 salt and boron study described previously, a December “snapshot” survey was conducted to measure nutrients in wetland water sources and discharges. Many of the nutrient concentration measurements were below detection limits; generally, nutrient concentrations in discharged water were at about the same levels or lower than concentrations in source water. The most prolonged and acute episodes of dissolved oxygen depletion in the Stockton Ship Channel (part of the Sacramento-San Joaquin River Delta) occur during the summer months when very little or no water is discharged from refuge unit wetlands.

Drainage

The entire San Luis NWR Complex lies within the watershed of the San Joaquin River, and the landscape occupied by the refuge units has been heavily influenced by the flooding of this major river, which flows northwesterly in an erratic course across various units of the Complex. The San Luis NWR is drained by Salt Slough, the San Joaquin River and Bear Creek east of State Highway 165 and Mud Slough, Salt Slough and Los Banos Creek west of State Highway 165. The Merced NWR is drained by the Mariposa Bypass, Atwater Drain and East Bear Creek, among others. All of these lesser streams and sloughs are tributaries of the San Joaquin River or are drains into the river.

Due to the low elevation of refuge lands and the location of natural river channels, numerous sources of surface water drain onto the refuge units. Field drains, community ditches and tributaries of the San Joaquin River collect surface and subsurface drainage from nearby agricultural fields. Several irrigation districts that supply irrigation water to upslope farmlands also operate and maintain drainage channels that flow into refuge units as water proceeds to the river.

Table 3-1. 303(d) List of Impaired Waterbodies Near the San Luis NWR Complex (California Environmental Protection Agency 2021)

Waterbody	Pollutant(s)
Del Puerto Creek	Pathogens, Pesticides, high pH, Salinity/Total Dissolved Oxygen, Total Toxicity
Grassland Marshes	Metals (Selenium), Salinity/Total Dissolved Oxygen
Ingram Creek ***(from confluence with Hospital Creek to Hwy 33 crossing)***	Pathogens, Pesticides (Pyrethroids, DDT, Diuron, Chlorpyrifos), Metals (Arsenic, Nickel), Nutrients (Nitrate/Nitrite), Salinity/Total Dissolved Oxygen, Total Toxicity
Ingram Creek ***(confluence with San Joaquin River to confluence with Hospital Creek)***	Salinity/Total Dissolved Oxygen, Pesticides (Dieldrin, DDT, DDE, Chlorpyrifos, Pyrethroids), Pathogens, Total Toxicity
Hospital Creek ***(San Joaquin and Stanislaus Counties)***	Metals (Arsenic), Pesticides (DDT, DDE, Pyrethroids, Trifluralin, Dieldrin, Diuron, Chlorpyrifos, Methyl Parathion), Pathogens, Salinity/Total Dissolved Oxygen, Total Toxicity
Mendota Pool	Metals (Selenium, Mercury)
Mud Slough ***(downstream of San Luis Drain)***	Salinity/Total Dissolved Oxygen, Metals (Selenium, Boron), Total Toxicity, Pesticides
Mud Slough ***(upstream of San Luis Drain)***	Salinity/Total Dissolved Oxygen, Metals (Boron), Total Toxicity, Pesticides, Pathogens
Newman Wasteway	Salinity/Total Dissolved Oxygen, Nutrients (Dissolved Oxygen), Pathogens, Pesticides (DDE)
Orestimba Creek ***(above Kilburn Road)***	Pesticides (Azinphos-methyl [Guthion], Dieldrin, DDE, DDT, Chlorpyrifos), Pathogens, Total Toxicity, Nutrients (Dissolved Oxygen), Salinity/Total Dissolved Oxygen
Orestimba Creek ***(below Kilburn Road)***	Pesticides (Azinphos-methyl [Guthion], Malathion, Dieldrin, DDD, DDE, DDT, Chlorpyrifos, Diuron), Pathogens, Total Toxicity, Salinity/Total Dissolved Oxygen
Panoche Creek	Metals (Selenium, Mercury), Sediment, Total Toxicity
Salt Slough	Total Toxicity, Pesticides (Chlorpyrifos, Prometryn), Salinity/Total Dissolved Oxygen, Nutrients (Dissolved Oxygen), Metals (Mercury), Pathogens
San Joaquin River ***(Mendota Pool to Bear Creek)***	Metals (Boron), Pesticides (DDT, Group “A” Pesticides), Total Toxicity
San Joaquin River ***(Bear Creek to Mud Slough)***	Pesticides (DDT, Group “A” Pesticides), Metals (Arsenic, Mercury), Total Toxicity, Salinity/Total Dissolved Oxygen

Waterbody	Pollutant(s)
San Joaquin River ***(Mud Slough to Merced River)***	Pesticides (Group "A" Pesticides, DDT, Diazinon, Chlorpyrifos), Metals (Selenium, Boron, Mercury), Pathogens, Total Toxicity, Salinity/Total Dissolved Oxygen
San Joaquin River ***(Merced River to Tuolumne River)***	Metals (Mercury), Pesticides (DDT, Group "A" Pesticides, DDE), Total Toxicity, Salinity/Total Dissolved Oxygen, Other Cause (water temperature)
San Joaquin River ***(Tuolumne River to Stanislaus River)***	Pesticides (Group "A" Pesticides, DDT), Metals (Mercury), Total Toxicity, Salinity/Total Dissolved Oxygen, Other Cause (water temperature)

For the purposes of estimating return flows from the Complex to the San Joaquin River and its tributaries, the Complex has been divided into a series of drainage basins or catchment areas. These areas are defined by common drainage points where drainage leaving the managed wetland basins spills back into natural river or slough channels. Twenty-two outflow locations or points of spill from the San Luis NWR have been identified east of Highway 165; these spill points drain the San Luis, West Bear Creek and East Bear Creek units of the refuge. Seventeen outflow locations have been identified west of State Highway 165; these points drain the Blue Goose, Kesterson and Freitas units of the refuge (USFWS 2005). At the Merced NWR, five outflow locations have been identified (USFWS 2005).

Biological Resources

Vegetation and Habitat

The Central Valley contains three major plant communities—grasslands, wetlands and riparian woodland habitats—all of which occur at the San Luis NWR Complex (Schonenherr 1992). Within each habitat group, the Complex identified plant communities. The plant communities include great valley oak (*Quercus lobata*) riparian, black willow (*Salix goodingii*) riparian forest, permanent wetland, semi-permanent wetland, seasonal wetland, vernal pool, tilled cropland, irrigated pasture and native grassland. Grassland is the dominant habitat type, representing two-thirds of the landbase at the Merced and San Luis NWRs and within the acquisition boundary of the Grasslands WMA (Table 3-2) (Figure 3-2). Wetland habitats make up a third of the habitat on the Complex, whereas riparian woodland habitats are only a minor component.

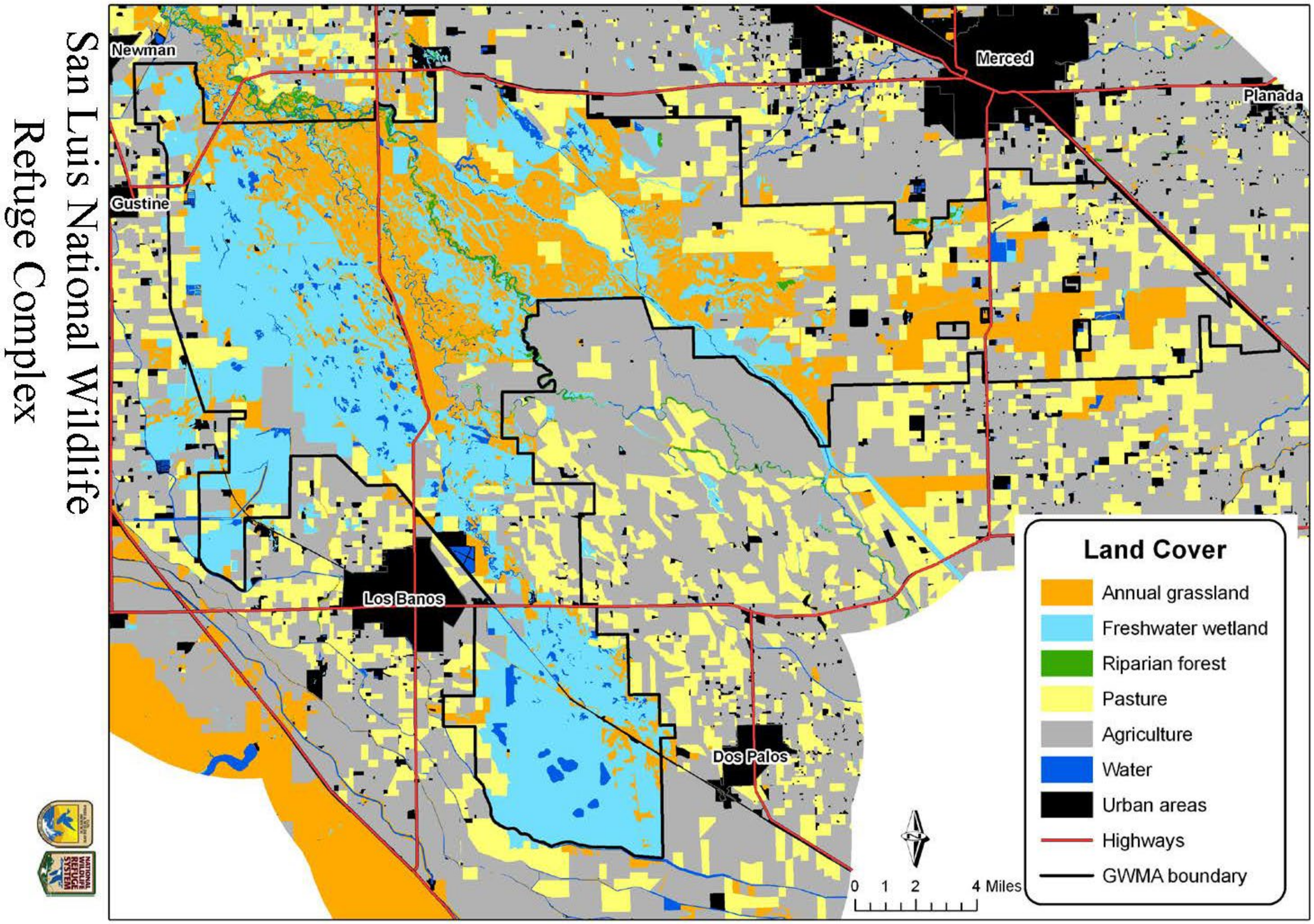
Uplands

Uplands on the Complex can be divided into three general habitat types: grasslands, croplands and irrigated pastures. These habitats are important to resident wildlife, such as the endangered San Joaquin Valley kit fox (*Vulpes macrotis mutica*), burrowing owl (*Athene cunicularia*) and migratory birds such as the lesser sandhill crane (*Grus canadensis*). The Complex supports the largest wintering population of lesser sandhill cranes (*Grus canadensis*) in the Pacific Flyway.

Table 3-2. Acres by Habitat Type at the Merced NWR, San Luis NWR and Grasslands Wildlife Management Area (based on Huber et al. 2009)

Habitat Type	Acres (percent): Merced NWR	Acres (percent): San Luis NWR	Acres (percent): Grasslands WMA Acquisition Boundary
Wetlands	3,165 (29.5)	8,803 (32.8)	86,174 (38.2)
Riparian	55 (0.5)	245 (0.9)	1,322 (0.6)
Uplands: Grasslands	6,666 (63)	17,830 (66.3)	92,638 (41.1)
Uplands: Croplands	744 (7)	0 (0.0)	44,370 (19.7)
Uplands: Other	0 (0.0)	0 (0.0)	830 (0.4)
Uplands: TOTAL	7,410 (69.7)	17,830 (66.3)	137,838 (61.2)

Figure 3-2. Vegetation Cover Type of the San Luis NWR Complex



Grasslands

Grasslands are the most common vegetative community found on the Complex. Grasslands, a mosaic of annual and perennial species, generally contain little or no woody vegetation. Most grasslands have become degraded and severely altered over the past 150 years by cultivation, livestock grazing and changes in fire regime. Natural (not land-leveled) grasslands consist of lands with undulating topography modified only by active and historic slough drainages. Non-native annual grasses, principally of Mediterranean origin, replaced most of the native perennial grasses that likely once dominated these grasslands. Many, including bromes (*Bromus* spp.), wild oats (*Avena* spp.) and foxtails (*Hordeum* spp.), now prevail within all upland habitat types. However, native grassland species, such as alkali sacaton (*Sporobolus airoides*), creeping wildrye (*Leymus triticoides*) and saltgrass (*Distichlis spicata*), are still common throughout refuge lands. Open areas between these native perennial grasses historically supported many native wildflowers and forbs. Fallow fields are considered grasslands because they have been taken out of active agricultural production. Although land leveling has occurred, no irrigation water is applied to these sites and the land develops a cover of a mostly non-native community of annual grasses and broadleaf plants. Restoration of fallow fields to a more natural state is a critical element of the management of refuge lands. Noxious invasive species, such as yellow starthistle (*Centaurea solstitialis*) and perennial pepperweed (*Lepidium latifolium*), are examples of noxious weeds that invade most upland habitats. Aggressive control of noxious species is critical to maintain native habitat diversity. Grazing, prescribed fire and herbicide applications are the primary tools used to enhance the native grassland community. Fallow fields are restored, as funding allows, to a variety of natural habitats, including riparian and wetland habitats.

Grasslands on the Complex are divided into two general groups: short grassland habitats and taller grass/forb communities (Allen and Pitkin 2000). Burrowing owls (*Athene cunicularia*), long-billed curlews (*Newmenius americanus*), mountain plovers (*Charadrius montanus*), horned larks (*Eremophila alpestris*) and other grassland birds occur in the short, grazed grassland habitat of the refuge uplands. This species group is managed according to the Grassland Bird Conservation Plan developed by California Partners in Flight (CalPIF 2000). Taller grass/forb communities provide habitat for blue grosbeak, tricolored blackbird and other bird species. This species group has been greatly impacted by the loss of habitat and fragmentation associated with the conversion of grassland to agriculture and the resulting replacement of native perennial and annual grasses and forbs by exotics (due to their competitive advantage) during periods of overgrazing and droughts (Allen and Pitkin 2000). Swainson's hawk (*Buteo swainsoni*)

Tractor Disking Wetland. Photo: USFWS

frequents both the mixed and short-grass grassland areas. Small mammals, including Heermann's kangaroo rat (*Dipodomys heermani*), the Fresno kangaroo rat (*Dipodomys nitratoides exilis*), badgers (*Taxidea taxus*) and the Federally endangered and state-threatened San Joaquin kit fox (*Vulpes macrotis mutica*), also prefer the open grassland habitat of the uplands.

Irrigated Pastures

Irrigated pasture consists of lands that have been converted from a natural condition by land-leveling, installing pipelines to facilitate flood irrigation and usually planting a mixture of domestic grasses and legumes. They are maintained by frequent irrigations and are typically grazed by cattle on a rotational basis. On the refuge units, the continued active management of irrigated pastures are important to provide shortgrass winter foraging habitat for geese, cranes and other migratory birds. They also provide summer habitat for such species as long-billed curlews (*Numenius americanus*), white-faced ibis (*Plegadis chihi*) and tricolored blackbirds (*Agelaius tricolor*). Irrigated pastures only occur at the Merced NWR and some easements of the Grasslands WMA.

Croplands

Croplands, like irrigated pastures, consist of lands that have been converted from a more natural condition by land-leveling and installation of pipelines for irrigation, and are under active management for agricultural crop production. Most of the croplands within refuge lands have been restored to a mosaic of upland, riparian and wetland habitats. A small portion of tilled croplands remains to produce winter forage for geese, cranes and other migratory birds. Tilled croplands are planted corn (grain forage) and winter wheat (green browse forage) at the Merced NWR, specifically to benefit geese and cranes. No cropland occurs at the San Luis NWR, and some easements of the Grasslands WMA have croplands of winter wheat.

While the San Luis NWR does not grow crops or maintain irrigated pasture as a wildlife management tool, the Merced NWR has utilized grain crops since its inception in 1951, as well as irrigated pasture since 1969, primarily to provide food for waterfowl and sandhill cranes and lure them away from crops on nearby private lands (USFWS 1951–1997). Currently, the refuge farming program is managed under a CAA and maintains approximately 268 acres rotated in grain corn or winter wheat, and 476 acres in irrigated pasture. The CAA allows NWRs to enter into partnerships with private parties for crop cultivation, haying and grazing on a share-in-kind basis when the activities are in aid of or benefit to the wildlife management of the area. The farming program provides critical foraging habitat for arctic-nesting geese, lesser sandhill cranes, tricolored blackbirds and other migratory wildlife.

Irrigated pasture is maintained on the Merced unit of the Refuge and managed in a short-crop condition for much of the year by cattle grazing. During late spring, summer and early fall, the pastures are irrigated with surface-delivered water on a bi-monthly rotation. The pastures are allowed to grow to a tall stature during the spring to provide waterfowl nesting and tricolored blackbird foraging habitat and then hayed back to a short stature in late May/early June. From the time of haying to December, the pastures are grazed using cattle to maintain their short stature. Periodically, these pastures need to undergo reconditioning to maintain optimal forage quality for wildlife, which may entail the addition of fertilizers, reseeding and/or invasive plant control.

Like the irrigated pastures, grain corn and winter wheat production occur on the Merced unit of the refuge. The corn production is implemented through the CAA utilizing custom farming. Custom farming is a practice in which a private farmer is contracted to oversee all the activities necessary to grow the desired crop under refuge supervision. Unlike a sharecropping program, 100 percent of the crop belongs to the refuge for wildlife benefit. The corn is rotated every third year with the fallow cornfield planted into winter wheat for green browse. The corn fields are mowed in early February to provide a carbohydrate boost to the geese and cranes for their spring migration to their nesting grounds. Winter wheat fields not rotated to corn are allowed to reach maturity and self-seed and are potential nesting sites for tricolored blackbirds.

Riparian

Like wetlands, much of the San Joaquin Valley riparian forest has been destroyed over the last 150 years. Within the Grasslands, riparian habitats have been reduced through land conversion and flood control activities, as well as impacted by uncontrolled grazing.

The riparian corridor associated with the San Joaquin River and its tributaries on Complex lands is composed of a variety of cover types and habitats. These include Great Valley mixed riparian forest, mid-successional black willow (*Salix goodingii*) stands, valley oak (*Quercus lobata*) groves, sandbar willow (*Salix exigua*) scrub, mixed riparian scrub, cattail- and tule- lined sloughs, annual grasslands and perennial native grasslands.

The most mature woody riparian habitat on Complex lands occur on the mainstem of the San Joaquin River in the San Luis, West Bear Creek, East Bear Creek and Kesterson units of San Luis NWR. The riparian corridor on all the units except Kesterson is confined within a flood-control levee. The riparian overstory is dominated by mature black willow (*Salix goodingii*). Associated with the willow are scattered Fremont's cottonwoods (*Populus fremontii*), buttonwillow (*Cephalanthus occidentalis*), small groves of valley oak (*Quercus lobata*) and dense stands of sandbar willow (*Salix exigua*). Native shrubs and forbs are sparse, but species such as California rose (*Rosa californica*), California blackberry (*Rubus ursinus*), mugwort (*Artemisia douglasiana*) and Hooker's evening primrose (*Oenothera elata*) have increased on Complex lands as the river corridor has been acquired and the cattle fenced out. Salt Slough, an anabranch tributary west of the San Joaquin River, has similar vegetation but lacks any mature valley oaks (*Quercus lobata*).

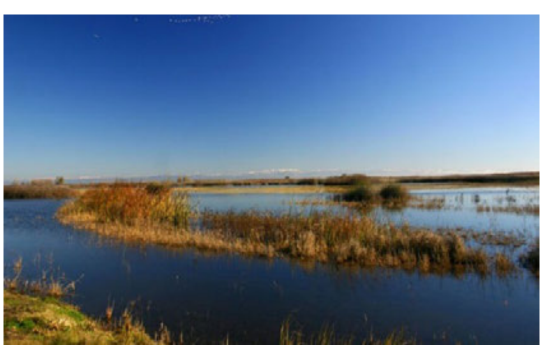
Woody riparian vegetation along other San Joaquin River tributaries within the East Bear Creek unit of San Luis NWR, the Snobird and Merced units of Merced NWR and private lands of the Grasslands WMA has been greatly reduced. The vegetation on the banks of Bear Creek, Deep Slough and Mariposa Creek primarily consists of annual grasses and non-native invasive weeds with scattered individual or discontinuous patches of willows and cottonwoods. The riparian channels are confined within flood-control levees and the woody riparian vegetation removed in the 1980s prior to Service acquisition. More trees are present in the Mariposa Creek Bypass within the original acquisition of the Merced unit, but little understory vegetation is present.

In the areas outside the flood control channels, the banks of tributaries such as Mud Slough, Los Banos Creek and Duck Slough are vegetated by intermittent patches of willow, cattail/bulrush stands, annual grasses and non-native invasive weeds. Some of the riparian channels on private lands have been eliminated in the past by leveling for agricultural development or reshaped to use as drainage ditches. However, the amount of woody riparian habitat in these areas has increased over the past 20 years. Numerous riparian restoration projects have been accomplished on Complex and private lands within grasslands in the recent past. As a result, former degraded riparian areas are being repopulated with black willow (*Salix goodingii*), Fremont's cottonwood (*Populus fremontii*), valley oak (*Quercus lobata*), buttonwillow (*Cephalanthus occidentalis* var. *californicus*), coyote bush (*Bacharris pilularis*), quail brush (*Atriplex lentiformis*), California rose (*Rosa californica*) and other native plants.

Of the three main general habitat types at the Complex—wetlands, grasslands and riparian areas—riparian habitats are the smallest by acreage at both the Merced and San Luis NWRs. Although small in acreage, these riparian woodlands dominated by woody plant species like cottonwood and willow support tremendous wildlife diversity. The riparian setting is an important transition zone between an open stream and the terrestrial environment and adjacent uplands and natural riparian ecotones provide diverse, dynamic, and complex biophysical habitats. Riparian environments can be defined several different ways, but are generally considered to be composed of stream bank, floodplain and associated forested vegetation. Riparian ecosystems harbor some of the most diverse bird communities in the arid and semiarid regions of the western United States.

At the Merced NWR, riparian woodlands are limited to narrow strips along a few waterways. At the Arena Plains and Snobird units of the Merced NWR, riparian woodlands are absent because most of the suitable areas occur between levees or are in designated floodways where woody vegetation is actively removed by levee districts. At the San Luis NWR, there is a larger acreage of riparian woodlands—most of it associated with the San Joaquin River and its tributaries and sloughs. These riparian woodlands support the greatest wildlife diversity on a per-acre basis at the Complex.

Wetlands



Merced Wetland. Photo: Rick Lewis

The San Luis NWR, Merced NWR and Grasslands WMA contain managed and unmanaged wetlands. Managed wetlands are basins or slough channels that are linked to water delivery systems or wells by which Complex staff or landowners can manipulate water flows into and out of wetlands to meet specific wildlife management objectives. The area of managed wetlands has varied over time as new lands have been acquired and restored, but by 2009, a total of 7,597 acres of wetlands were being actively managed on refuge fee-title lands. Unmanaged wetlands consist of river, creek and slough channels; basins adjacent to those channels; floodways between levees; and vernal pools where Complex staff or landowners cannot control water levels for wildlife management purposes. The hydrology of those basins is highly modified such that the channels only receive flows from drainages and releases from upstream users, except during periods of heavy rainfall. Vernal pools are filled during rainfall events. Wetlands are represented on the refuges as permanent, semi-permanent and seasonal wetland habitat types.

Permanent Wetlands

Aquatic habitats at the Complex include areas with permanent and intermittent water. Most of the habitats with intermittent or seasonal water are wetlands and vernal pools. Permanent aquatic habitats at the Complex include the San Joaquin River and its tributaries/sloughs and permanent wetlands. These habitats support a diverse array of wildlife: native and exotic fish communities (including in some cases anadromous fish); reptiles and amphibians; mammals such as river otter, mink, beaver and muskrat; and a diversity of waterbirds. These habitats are especially important foraging areas for piscivorous wildlife species and provide a summer source of water for many species.

Permanent wetlands remain flooded all year and support herbaceous and woody hydrophytes (water-loving plants). Wetlands in marshland habitats are ringed by emergent vegetation like roundstem bulrush (*Scirpus acutus*) and cattail (*Typha latifolia*). Oxbow wetlands associated with the San Joaquin River and Salt Slough are bordered by riparian forest. Unlike other permanent wetlands, Oxbows do not maintain themselves year-round through water table levels or watershed drainage. Instead, these wetlands are linked to water delivery systems and are supplied with water to maintain desired levels. Permanent wetlands make up about 5% (475 acres) of the managed wetlands on San Luis and Merced NWRs. These include Swan Lake, Blue Goose Marsh, the Windmill Pond, Oxbow Lake, Chester Marsh, Winton Marsh, Deadman Slough and South Marsh 3 West on units of San Luis NWR. The permanent wetlands on Merced NWR include the Glory Hole and Snow Goose Lake.

The only unmanaged permanent wetlands on San Luis NWR are the channels of the San Joaquin River, Salt Slough, Mud Slough, Los Banos Creek and Bear Creek. Merced NWR has unmanaged permanent wetlands on Mariposa Creek, Bear Creek and the Atwater Drain. The San Joaquin River, Mariposa Creek and most of Bear Creek are bounded by major flood control levees.

Semi-permanent Wetlands

Semi-permanent wetlands are flooded most of the year but are dry during late summer to early fall. In the San Luis NWR Complex, these wetland units normally are drawn down in July–August to germinate aquatic plants such as pondweeds (*Potamogeton* spp.) or, in the case of managed oxbows, to dry out the tree root zone and avoid killing the perimeter trees. These wetlands are then re-flooded in October–November. Units under this management regime vary by year, but approximately 155 acres of semi-permanent wetlands occur on San Luis NWR and 70 acres on Merced NWR.

Seasonal Wetlands

Managed seasonal wetlands are flooded during the fall months and maintained throughout the winter until drawdown occurs in the spring. In the San Luis NWR Complex, these wetland units are normally drawn down in late February through May, depending on management objectives, and flooded up during September–November. This habitat type makes up most of the managed wetlands on the refuge units and provides most of the food supply to support wetland-dependent migratory birds that winter in the area. A total of 5,942 acres (more than 90 units) of seasonal wetlands currently are managed at San Luis NWR and 3,325 acres (more than 40 units) at Merced NWR. Depending on the water management regime, the dominant annual plants that produce large seedheads include swamp timothy (*Crypsis schnoides*), watergrass (*Echinochloa crusgalli*), smartweed (*Polygonum* spp.), along with cocklebur (*Xanthium strumarium*) and aster (*Aster subulatus*). Seasonal wetlands also can contain perennial species such as cattail (*Typha latifolia*) and roundstem bulrush (*Scirpus acutus*). The most common vegetative species in seasonal wetlands of the Merced and San Luis NWRs are included in Table 3-3.

Table 3-3. Common Wetland Plants in Seasonal Wetlands at the San Luis and Merced NWRs

Rank by Cover	Common Name	Scientific Name	Frequency (% of occurrence; n=104)	Mean % Cover (n=104)
1	Swamp Timothy	*Crypsis schoenoides*	82.2	34.7
2	Watergrass	*Echnochloa crus-galli*	50.0	13.77
3	Cocklebur	*Xanthium strumarian*	71.0	12.93
4	Common Tule	*Scirpus spp.*	47.7	9.13
5	Alkali Bulrush	*Scirpus maritimus*	57.0	8.05
6	Smartweed	*Polygonum spp.*	43.9	5.79
7	Spike Rush	*Eleocharis spp.*	49.5	5.69
8	Joint Grass	*Paspalum distichum*	42.1	5.59
9	Bare Ground	*n/a*	52.3	5.50
10	Trefoil	*Lotus corniculatus*	28.0	5.07
11	Bermuda Grass	*Cynodon dactylon*	29.0	4.46
12	Common Cattail	*Typha laifolia*	18.7	4.17
13	Sprangle Top	*Leptochloa fascicularis*	23.4	2.92
14	Baltic Rush	*Juncus balticus*	22.4	1.91
15	Other Annual Grass spp.	*n/a*	2.8	1.82
16	Alkali Weed	*Cressa truxillensis*	15.9	1.77
17	Large Seed Dodder	*Cuscuta indecora*	13.1	1.64
18	Alkali Mallow	*Malva spp*	33.6	1.62
19	Dock	*Rumex spp.*	17.8	0.87
20	Salt Grass	*Distichlis spicata*	12.1	0.73

Unmanaged seasonal wetlands are filled locally during periods of heavy rainfall, or when floodwaters exceed the channel capacity of the river, creeks and sloughs and spread out into the floodplain and uplands. Historically, flooding was an almost annual event, but alterations in the hydrology of the San Joaquin Valley since the 1950s have reduced flooding to infrequent, but regular, occurrences. Usually, floods occur during the rainy periods from February through June. The most extensive flooding occurs on refuge fee-title and easement lands in the East Grasslands and can create thousands of acres of temporary wetlands. West of the San Joaquin River, flooding can extend from the river channel southward across the Kesterson unit of the San Luis NWR for a distance exceeding one mile. The uneven topography of the native ground making up these areas creates a mosaic of sheetwater, shallow ponds, deep channels and isolated islands that provide high quality habitat for migratory birds.

Reverse Cycle Wetlands

Reverse cycle wetlands are a variant of managed seasonal wetlands in that they are dry during the fall/winter period and flooded during spring and summer to provide invertebrate forage and cover for waterfowl broods. The units typically are flooded in February and maintained through mid-August. A total of 168 acres of reverse cycle wetlands currently are present at San Luis NWR and 85 acres at Merced NWR.

Vernal Pools

Vernal pools are a unique wetland community that has developed over geologic time, resulting in the evolution of unique plants and animals adapted to the ephemeral nature of these habitats (USFWS 2005). These habitats support diverse and largely endemic communities of plant and invertebrate species. In general, vernal pools are seasonally flooded shallow depressions that may be dry during summer and fall seasons. The upland habitat surrounding vernal pools is important to their proper ecological function due to its effects on vernal pool hydrology. Typically, vernal pools are filled by winter rains and dry slowly during the spring. However, it is not uncommon for vernal pools to go years without filling during drought conditions. Vernal pool habitats are confined to limited areas defined by topographic constraints, soil types and climatic conditions (USFWS 2005). The distribution of these seasonal wetlands once included large areas of California and Oregon; however, development has destroyed much of this habitat. Habitat loss and fragmentation due to urban development, agricultural conversion, altered hydrology and non-native invasive species are the primary threats to vernal pool ecosystems.

Vernal pools are a unique type of wetland ecosystem that develops due to a combination of factors including climate, soils and topography. Vernal pools are wetted usually during the spring months and are restricted to those areas of the world having a Mediterranean climate consisting of short mild wet winters followed by long hot dry summers. Vernal pools form on ancient soils ranging from thousands of years to millions of years old that lie above a restrictive or impermeable soil layer, generally composed of hardpan, claypan, volcanic flows or non-volcanic rock. The restrictive soil layers found beneath vernal pools in California’s Central Valley typically are hardpan or claypan. The topography of vernal pool landscapes is shallowly sloping to nearly level on the broad scale but can be quite hilly on the fine scale. Vernal pools form in the shallow depressions between hills or mounds formed by burrowing rodents—such as California ground squirrels (*Spermophilus beecheyi*), southwestern pocket gophers (*Thomomys bottae*), kangaroo rats (*Dipodomys* sp.) and mice and voles. These depressions fill with water from winter and early spring rains and remain inundated until drying out from evaporation by late spring or early summer. This cycle of extended periods of inundation followed by prolonged dry periods led to the evolution of unique plant and animal communities.

The factors leading to the formation of vernal pools usually occur over large continuous areas rather than in isolated locations, so vernal pools in the Central Valley typically occur in groups referred to as *complexes*. Grasslands, such as those found in the San Luis Refuge Complex, represent a landscape that typically supports vernal pool complexes. California vernal pools are unique in that they support a high degree of plant and animal species richness and contain a large number of California endemic species. Additionally, even though much of California's grassland habitat is now dominated by exotic grasses and forbs, vernal pools remain a haven for native plant species. Vernal pools are thought to be able to resist invasion by exotic upland plant species because of the severe ecological constraints present in the vernal pool environment. Vernal pools are specialized wetland habitats occurring within a matrix of grasslands at the San Luis and Merced NWRs. Many unique and endemic animal and plant species are associated with these habitats, and both refuges take active management measures to maintain these habitats. Areas with the most vernal pools include the West Bear Creek and Kesterson units of the San Luis NWR and Arena Plains and Snobird units of the Merced NWR.

Plant species occurring in the vernal pools of Central Valley grasslands include *Agrostis microphylla*, *Deschampsia danthonioides* var. *gracilis*, *Phalaris lemmoni* and the endemic species, *Neostapfia colusana*, *Orcuttia californica*, *O. greenei*, *O. pilosa*, *O. tennis* and *Pleuropogon californicus* (Beetle 1947). Vernal pools in the grasslands of the Merced and San Luis NWR provide habitat for the Federally endangered Conservancy fairy shrimp (*Branchinecta conservatio*), Longhorn fairy shrimp (*B. longiantenna*), vernal pool fairy shrimp (*B. lynchi*) and vernal pool tadpole shrimp (*Lepidurus packardi*) (USFWS 2009b). Migrating waterfowl feed on vernal pool plants and invertebrates. Vernal pools help moderate seasonal flooding during storms and aid in maintaining water quality by removing contaminants.

California's vernal pools provide habitat for well-developed communities of freshwater crustaceans, consisting of highly specialized species, particularly the branchiopods. Large branchiopods, those easily visible to the naked eye, include the fairy shrimps (Anostraca), tadpole shrimps (Notostraca) and clam shrimps (Spinicaudata and Laevicaudata). Smaller crustaceans common in California's vernal pools are water fleas (Branchiopoda/Cladocera), copepods (Copepoda) and seed shrimp (Ostracoda). Species documented to inhabit vernal pools within the San Luis Refuge Complex are the Conservancy fairy shrimp (*Branchinecta conservation*), longhorn fairy shrimp (*B. longiantenna*), vernal pool fairy shrimp (*B. lynchi*) and vernal pool tadpole shrimp (*Lepidurus packardi*). These four crustacean species are listed as

Federally endangered with Critical Habitat designated (68 FR 46684)[7]. Three of the four species are endemic to California: Conservancy fairy shrimp, longhorn fairy shrimp and vernal pool tadpole shrimp.

Vernal pools also provide habitat for amphibians. Native California species documented to inhabit pools within the San Luis Refuge Complex are the Pacific tree frog (*Pseudacris regilla*), western toad (*Anaxyrus boreas*), the rarer California tiger salamander (*Ambystoma californiense*) and western spadefoot toad (*Spea hammondii*). The insect communities of vernal pools also are numerous, varied and mostly comprise native species including aquatic beetles (Coleoptera-Dytiscidae, Hydrophilidae, Gyrinidae, Halipidae and Hydraenidae); aquatic bugs including backswimmers (Hemiptera-Notonectidae), water boatmen (Corixidae), water striders (Gerridae), springtails (Collembola), mayflies (Ephemeroptera), dragonflies and damselflies (Odonata); and various flies with aquatic larvae including midges (Diptera-Chironomidae) and crane flies (Tipulidae).

Plant species associated with vernal pools possess highly specialized adaptations allowing survival in their restrictive habitats. Vernal pool plant species often are annuals, allowing them to complete their lifecycles during the relatively short periods of inundation and drying. They produce dormant seeds that remain viable in the soil for many years. Not all the seeds will germinate in any given year, reducing the probability of local extirpation caused by random environmental changes such as a pool drying up early or remaining inundated for too long. Another adaptation of vernal pool plant species is their tolerance to inundation, which differs among various species. This differential tolerance to inundation results in vernal pool plant zonation, displayed as the characteristic rings of flowers that form around vernal pools as they begin to dry in the spring.

Many of the plant genera characteristics of vernal pool communities are present on the San Luis Refuge Complex including *Eryngium, Lasthenia, Psilocarphus, Plagiobothrys, Downingia, Eleocharis, Elatine, Pogogyne, Juncus, Limnanthes, Navarretia and Neostapfia. Lasthenia, Downingia, Pogogyne, Limnanthes* and *Neostapfia* are endemic to California or primarily associated with the California Floristic Province. The other genera contain at least one California endemic species. Eleven plant species are listed with Critical Habitat designated (68 FR 46684). Hoover's spurge (*Chamaesyce hooveri*) and Colusa grass (*Neostapfia colusana*) are found in pools on the Arena Plains unit of the Complex. The Refuge Complex encompasses the historic range of *Orcuttia inaequalis* and 18 of 28 presumed extant California occurrences of this species are within Merced County. Fleshy owl's clover (*Castilleja campestris* ssp. *succulenta*) has been documented with 36 occurrences in Merced County.

Based on examination of aerial photographs from 1942, vernal pools were once common on lands within the boundaries of San Luis and Merced NWRs and the Grasslands WMA. However, much of this land was deep-ripped and leveled, destroying the hydrology and hardpans of these vernal pool complexes. To date, Complex staff have identified approximately 400 individual

[7] Available online at https://www.govinfo.gov/content/pkg/FR-2003-08-06/pdf/03-18437.pdf.

vernal pools on units of San Luis and Merced NWRs. The largest concentrations of vernal pools are found on the Kesterson and West Bear Creek units of San Luis NWR and the Snobird and Arena Plains units of Merced NWR. The size of pools ranges from less than 30 square yards to over four acres. Vernal pools also have been identified on easement lands within the Grasslands WMA but have not been comprehensively mapped. Vernal pools on refuge lands and within the Grasslands WMA are classified as northern claypan vernal pools (Holland 1986). These vernal pools are found on neutral to alkaline, silica-cemented hardpan soils (Sawyer and Keeler-Wolf 1995). As pools evaporate in the spring, wildflowers such as downingia (*Downingia* spp.) and goldfields (*Lasthenia* spp.) begin to bloom, often creating showy displays. Rare annual atriplex species (*Atriplex* spp.) can be found on dry, bare vernal pool basins during the summer months.

The *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon*[8] (71 FR 11441) addresses 33 species of plants and animals that occur exclusively or primarily within vernal pool ecosystems. Twenty of these species are Federally listed (three endangered animals, two threatened animals, 10 endangered plants and five threatened plants). Two of the Federally threatened plant species (San Joaquin Valley Orcutt grass, *Orcuttia inaequalis*; Colusa grass, *Neostapfia colusana*), three of the Federally endangered invertebrates (Conservancy fairy shrimp, *Branchinecta conservatio*; longhorn fairy shrimp, *Brachinecta longiantenna*; vernal pool tadpole shrimp, *Lepidurus packardi*) and one of the Federally threatened invertebrates (vernal pool fairy shrimp, *Branchinecta lynchi*) have been documented on refuge lands. Additionally, the Federally threatened California tiger salamander (*Ambystoma californiense*) is highly reliant on this habitat type as it lays eggs and larvae develop in vernal pools.

Wildlife

California's diverse terrain and vegetative communities support diverse wildlife. The Merced NWR, San Luis NWR and Grasslands WMA contain elements of the Central Valley's three major vegetative types and have the potential to provide habitat for over 325 species. Appendix E provides a species list of fish and wildlife on the San Luis NWR Complex. A portion of the Complex still consists of fallow agricultural lands or degraded habitats; their planned restoration/management has the potential to increase the number of wildlife species and their abundance over the present distribution and abundance at the Complex.

Waterfowl

The Complex forms a major migration and wintering use area for waterfowl in the Pacific Flyway. While numbers can vary widely from decade to decade, annual peak numbers of ducks and geese recorded on the San Luis NWR, Merced NWR and Grasslands WMA have ranged from 800,000 to 1,400,000 during the past 10 winters (Service Midwinter Waterfowl Survey data). This represents about 25 percent of the waterfowl population wintering in the Central Valley of California. Thirty-two species of waterfowl have been recorded using the area. The

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[8] Available online at https://www.govinfo.gov/content/pkg/FR-2006-03-07/pdf/06-1984.pdf.

most common ducks wintering on or near the refuges include northern pintail (*Anas acuta*), green-winged teal (*Anas crecca*), mallard (*Anas platyrhynchos*), northern shoveler (*Anas clypeata*), gadwall (*Anas strepera*), ring-necked duck (*Aythya collaris*), American wigeon (*Anas americana*), wood duck (*Aix sponsa*) and cinnamon teal (*Anas cyanoptera*). Diving duck species such as canvasback (*Aythya valisineria*), redhead (*Aythya americana*), common goldeneye (*Bucephala clangula*) and bufflehead (*Bucephala albeola*) are present in smaller numbers. The most common geese include Ross's goose (*Chen rossii*), snow goose (*Chen caerulescens*) and greater white-fronted goose (*Answer albifrons*). Various subspecies of Canada and cackling geese—including the Aleutian cackling goose (*Branta hutchinsii leucopareia*), cackling goose (*B. h. minima*) and western Canada goose (*Branta canadensis moffitti*)—are present in smaller numbers. Tundra swans (*Cygnus columbianus*) are seen on a regular basis. Species seen infrequently, or as accidentals, include trumpeter swan (*C.ygnus buccinator*), brant (*Branta bernicla*), blue-winged teal (*Anas discors*), Eurasian wigeon (*Anas penelope*) and hooded merganser (*Lophodytes cucullatus*).

Long-billed Curlew. Photo: Lee Eastman

Species distribution varies throughout the area based on habitat attributes of the different refuge units. Fee-title and easement refuge lands east of the San Joaquin River (East Grasslands) are characterized by extensive floodplain grasslands interspersed with managed wetlands. Geese, especially Ross's geese (*Chen rossii*) and snow geese (*Chen caerulescens*), use this area of the Grasslands, as well as northern pintail (*Anas acuta*), wigeon (*A.nas americana*) and other ducks. Greatest use of the East unit of the Grasslands WMA occurs in January–March following late winter rainfall and green-up of the annual grasses. In years of heavy rainfall and flood events, many of the ducks normally in the West and South units of the Grasslands shift to the East unit, at least temporarily, to forage in the extensive sheetwater habitat. San Luis NWR and easement lands west of the San Joaquin River and north of Los Banos (West unit of the Grasslands WMA) are characterized by extensively managed wetlands, often with a heavy emergent cover component, and a relatively smaller amount of uplands. Dominant waterfowl species there include mallard (*Anas platyrhynchos*), green-winged teal (*Anas crecca*), northern pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), gadwall (*Anas strepera*) and ring-necked duck (*Aythya collaris*). Geese are present in much lower numbers and tend to be mostly greater white-fronted geese (*Anas albifrons*). The Grasslands WMA easement lands south of Los Banos (South unit of the Grasslands WMA) primarily consist of more saline and open managed wetlands with very little associated uplands. In this part of the Grasslands WMA, the dominant waterfowl are northern pintail (*Anas acuta*), green-winged teal (*Anas crecca*), northern shoveler (*Anas clypeata*), canvasback (*Aythya valisineria*) and snow geese (*Chen caerulescens*).

Waterfowl also use the area during the breeding season. Twelve species of duck and one goose species have been recorded as nesting on refuge lands. The most common nesting species are mallards (*Anas platyrhynchos*), gadwall (*Anas strepera*) and cinnamon teal (*Anas cyanoptera*). Wood ducks (*Aix sponsa*) are becoming more common as a nesting species as nest boxes are installed as a part of the statewide California Wood Duck Program[9].

Shorebirds

The Grasslands, representing about one-third of California's remaining wetland habitat, is one of the most important shorebird habitats on the west coast of the United States. This area has been designated as one of only 22 international shorebird reserves in the world. Populations of shorebirds are present on the refuges and easement lands throughout the year, with the highest numbers occurring during the non-breeding season. Approximately 25 species of shorebirds make use of the Grasslands throughout the year. Large-scale shorebird censuses in the area have documented 200,000 individuals (mainly western sandpipers, *Calidris mauri*; long-billed dowitchers, *Limnodromus scolopaceus*; dunlins, *Calidris alpine*; and least sandpipers, *Calidris minutilla*) during the spring, and up to 14,000 shorebirds (mainly long-billed dowitchers, *Limnodromus scolopaceus*; least sandpipers, *Calidris minutilla*; and black-necked stilts, *Himantopus mexicanus*) during the autumn (Shuford, Page, and Kjelmyr 1998). The difference in shorebird numbers between the spring and fall is due to the migratory route that many species follow. Many species tend to follow more coastal routes during the fall, and more inland routes during the spring. Populations of killdeer (*Charadrius vociferous*), black-necked stilts (*Himantopus mexicanus*) and American avocets (*Recurvirostra Americana*) breed annually in the San Luis NWR Complex.

Seasonal wetlands and vernal pools are managed to provide mud flat and shallow water habitat for foraging shorebirds. Irrigated pastures, alfalfa fields and, to a lesser extent, native uplands also are used by longer billed species for foraging, such as long-billed curlew (*Numenius americanus*), whimbrel (*N. umenius phaeopus*) and marbled godwit (*Limosa fedoa*). These habitats support large numbers of aquatic invertebrates and other insects used by shorebirds to replenish nutrient reserves loss during long migrations.

Wading/Diving Birds

Numerous species of wading and diving birds make use of the wetland, riparian and upland habitats found on San Luis NWR, Merced NWR and the Grasslands WMA. Great blue herons (*Ardea herodias*), great egrets (*Ardea alba*) and double crested cormorants (*Phalacrocorax auritus*) have established several rookeries in riparian areas on refuge and easement lands. Rookeries begin to develop in late February and young are usually fledged by July. Within wetland units, snowy egrets (*Egretta thula*), cattle egrets (*Bubulcus ibis*) and black-crowned night herons (*Nycticorax nycticorax*) establish roosting and breeding colonies in robust emergent vegetation. While large flocks of white-faced ibis (*Plegadis chihi*) are common during winter months in the

[9] https://calwaterfowl.org/conservation-programs/california-wood-duck-program

Grasslands, breeding colonies have only been documented once in the past 20 years. In 1991, a colony of approximately 5,000 adults was established on the Kesterson unit of San Luis NWR. More solitary wading species, such as Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), common moorhen (*Gallinula chloropus*) and American coot (*Fulica americana*) are common year-round and breed annually in permanent wetlands throughout the refuges and easement lands. Pied-billed grebes (*Podilymbus podiceps*) are a common year-round species in seasonal and permanent wetlands throughout the Grasslands. Western and Clark's grebes (*Aechmophorus occidentalis* and *A. clarkssii*) are common during the spring and often breed in permanent wetlands when open water and emergent vegetation are interspersed at suitable levels. Large numbers of American white pelicans (*Pelecanus erythrorhynchos*) make use of wetlands during winter months for foraging and roosting; however, this species does not breed in the Central Valley.

Birds of Prey

Red-tailed Hawk. Photo: Lee Eastman

Nearly 30 species of birds of prey (raptors) have been documented using refuge lands. Breeding species include: white-tailed kite (*Elanus leucurus*), northern harrier (*Circus cyaneus*), red-shouldered hawk (*Buteo lineatus*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), American kestrel (*Falco sparverius*), barn owl (*Tyto alba*), short-eared owl (*Asio flammeus*), great horned owl (*Bubo virginianus*), western screech owl (*Otus kennicottii*), saw-whet owl (*Aegolius acadicus*) and burrowing owl (*Athene cunicularia*). As with most of the other birds, overall abundance is greatest during the winter. Refuge lands are important foraging areas for many birds of prey. They are attracted to refuge lands because of the abundant prey base of waterfowl, other wintering birds and rodents. With the exception of Swainson's hawks (*Buteo swainsoni*), all of the breeding species also are present during the winter in great numbers. Occasional wintering species also include turkey vulture (*Cathartes aura*), golden eagle (*Aquila chrysaetos*), bald eagle (*Haliaeetus leucocephalus*), Cooper's hawk (*Accipiter cooperii*), ferruginous hawk (*Buteo regalis*) and peregrine falcon (*Falco peregrinus*).

Gamebirds

The San Luis NWR Complex supports four species of gamebirds: the California Quail (*Callipepla californica*), common snipe (*Galininago galinago*), mourning dove (*Zenaida macroura*) and ring-necked pheasant (*Phasianus colchicus*). The California Quail, although hunted in other parts of the State, is not hunted on state and Federal managed lands in GEA. The valley quail was codified as the state bird of California in 1931. It is a non-migratory, year-round resident found in riparian, wetland and grassland habitats with sufficient brush for cover. Locally, the species' population had been in decline and largely disappeared from some portions of Merced County due to the loss of riparian woodland and brush habitats to agricultural, grazing and urban developments. However, recent riparian upland restoration efforts as well as modifications to cultural uses of critical habitats, have proved beneficial to the species as its populations appear to slowly be increasing and re-colonizing restored areas. This has been especially true for areas in the eastern Grasslands and Merced NWR.

The common snipe is considered a migratory species, although a portion of the population occurs year-round on refuge lands. The snipe depart their breeding grounds in western Alaska and Canada around August and begin to arrive in the Central Valley, where some will over-winter while others continue onto their wintering grounds in Central American and northern South America. They then will begin their fall migration, returning to their breeding grounds in March. The snipe prefer wetland habitats often seen along marsh or pond edges. Snipe-hunting is permitted on both San Luis and Merced NWRs and within the Grasslands WMA from October to February.

The mourning dove is a migratory bird species with a population segment remaining year-round on refuge lands. Its range extends north to Alaska and Canada and south into Mexico. The mourning dove is found in upland habitats, where they forage for seeds in grassland and brush habitats and roost in trees. Mourning dove-hunting is not allowed on San Luis or Merced NWRs but is permitted during established seasons on the private lands composing the Grasslands WMA from September through December.

The ring-necked pheasant was introduced into California from Asia in 1857 and has since become naturalized throughout much of North America. The pheasant is found in agricultural lands and grasslands and along woodland edge habitats, where they can find cover and forage on grain, seeds, berries and insects. They often can be seen from February through August conducting courtship displays and foraging with young. Pheasant-hunting is permitted on San Luis NWR and the Grasslands WMA from November through December. Pheasant-hunting is not permitted on the Merced NWR.

Songbirds

The San Luis NWR, Merced NWR and Grasslands WMA support over 130 species of resident and migratory songbirds during various life history phases. Wetland, riparian and upland habitats support different suites of species during breeding, migration and wintering periods. A diversity of vegetation composition and structure is managed in these communities to meet the varying habitat needs of these species. Complex staff, along with partners, have conducted wide-ranging surveys to determine songbird species richness, abundance, nesting success and habitat use on refuge and easement lands. Many of the species using these areas are listed as Special Status or are priority/focal species in conservation plans (e.g., RHJV) and state/Federal species lists (see Appendix E for species list and status designation). Due to the varying habitat requirements needed by suites of songbirds, diverse ecological niches they occupy and year-round presence in the Grasslands, these taxa serve as an important indicator of ecosystem health and management effectiveness.

The San Luis NWR Complex is an important area to many resident and migratory bird species. Many species of neotropical migrants have been detected on the Complex, including: lazuli bunting (*Passerina amoena*), blue grosbeak (*Guiraca caerulea*), ash-throated flycatcher (*Myiarchus cinerascens*), western wood-pewee (*Contopus sordidulus*), black-headed grosbeak (*Pheucticus melanocephalus*), Savannah sparrow (*Passerculus sandwichensis*), horned lark (*Eremophila alpestris*), yellow warbler (*Dendroica petechia*), Nashville warbler (*Vermifora ruficappilla*), orange-crowned warbler (*Vermivora celata*), yellow-rumped warbler (*Dendroica coronata*), Pacific-slope flycatcher (*Empidonax difficilis*) and ruby-crowned kinglet (*Regulus calendula*) (Appendix E). A survey was conducted for the yellow-billed cuckoo (*Coccyzus americanus*), a rare species in the Central Valley, but none were found, although the Complex does fall within its historic range (Gains and Laymon 1984; Laymon 1998). Compared to other habitats, oak woodlands and riparian habitats support multiple vegetation layers and have the highest diversity of bird species on the Complex. By comparison, less structurally complex habitats such as grasslands have a lower diversity of bird species. Typically, natural habitats supported the greatest diversity of bird species, whereas crop fields and fallow agricultural lands supported few birds.

Bald Eagle. Photo: Rick Lewis

A species of special conservation concern is the tricolored blackbird (*Agelaius tricolor*), a species endemic to California. This species breeds in colonies of up to 50,000 birds in the uplands and wetlands on the Merced NWR and Grasslands WMA. These colonies are critical to this species breeding success, as whole colonies fail on private agricultural lands in the southern San Joaquin Valley when fields are harvested prior to fledging. Smaller colonies form annually within the wetlands of San Luis NWR. Birds establish nests in mature winter wheat, milk thistle stands and permanent wetlands with robust cattail and common tule. Tricolored blackbirds also feed on invertebrates in irrigated pastures and alfalfa fields on refuge and easement lands.

Mammals

California hosts an array of mammals, principally due to the state's large size and variety of habitats. Approximately 220 species of mammals have been documented in California, one of the most diverse state species counts in the nation. Before European settlement, tule elk (*Cervus elaphus nannodes*), grizzly bear (*Ursus arctos*), pronghorn antelope (*Antilocapra americana*), California black-tailed deer (*Odocoileus hemionus*), mountain lion (*Puma concolor*) and bobcat (*Lynx rufus*) were conspicuous in the Central Valley. The mammal composition today is quite different, however, due to the loss of suitable habitat, over-harvest and introduction of non-native plants and animals. Many of the larger species have been extirpated from the landscape.

Rodent and rabbit species make up the largest segment, approximately one-third of the mammals found on the San Luis NWR Complex. Two rabbit species occur on the San Luis and Merced NWRs, the desert cottontail (*Sylvilagus audubonii*) and black-tailed hare (*Lepus californicus*). The endangered riparian brush rabbit (*Sylvilagus bachmanii riparius*) has been proposed for reintroduction in the Complex. Both the black-tailed hare and the desert cottontail are conspicuous species at the Complex. Large rodents, which are also conspicuous on the Complex, include the aquatic muskrat (*Ondatra zibethicus*) and beaver (*Castor canadensis*) —both of which leave obvious signs and play important roles in aquatic systems. Dominant rodents at the Complex, which also act as keystone species because of their grazing/seed predation and/or tunneling, include the deer mouse (*Peromyscus maniculatus*), California vole (*Microtus californicus*) and California ground squirrel (*Spermophilus beecheyi*). The endangered San Joaquin Valley woodrat (*Neotoma fuscipes riparia*) and the introduced black rat (*Rattus rattus*) could also occur on the Complex.


Raccoons. Photo: Paul Prado

Refuge staff recently conducted an inventory of the bat community on the Refuge Complex using stationary ultrasound recorders and call identification software. From 2019–2021, nine species of bats were detected on the Refuge Complex: Brazilian free-tailed bat (*Tadarida brasiliensis*), Yuma myotis (*Myotis yumanensis*), California myotis (*Myotis californicus*), western mastiff bat (*Eumops perotis*), little brown bat (*Myotis lucifugus*), silver haired bat (*Lasionycteris noctivagans*), hoary bat (*Lasiurus cinerius*), big brown bat (*Eptesicus fuscus*) and western red bat (*Lasiurus blossevillii*). Brazilian free-tailed bats made up 89 percent of all recorded bat calls. The western mastiff bat and western red bat are Species of Special Concern[10] in California and are rated *vulnerable*.

Although the largest carnivore species of the Central Valley were eliminated during the settlement period, small and midsized carnivores are prevalent at the Complex and compose approximately one-fifth of the potential mammalian community. The most common carnivores/omnivores on the Complex include the coyote (*Canis latrans*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), northern river otter (*Lontra canadensis*), long-tailed weasel (*Neogale frenata*) and Virginia opossum (*Didelphis virginiana*); the gray fox (*Urocyon cinereoargenteus*), badger

[10] https://wildlife.ca.gov/Conservation/SSC

(*Taxidea taxus*) and mink (*Neogale vison*) also are present, but rarely encountered. The endangered San Joaquin kit fox (*Vulpes macrotis mutica*) has not been detected in years.

Other mammals that occur on the Refuge Complex include the ornate shrew (*Sorex ornatus*) and mule deer (*Odocoileus hemionus*), as well as several domestic mammals that either trespass onto the Complex or are used in the grazing program. A permanent mule deer population has been reestablished at the San Luis NWR and the Grasslands WMA, and transient deer also are periodically observed at the Merced NWR. A confined tule elk (*Cervus elaphus nannodes*) herd has been at the San Luis NWR for the past 48 years.

Amphibians and Reptiles

More than 30 species of amphibians and reptiles may occur on refuge lands. Semi-arid regions such as the Central Valley frequently possess diverse communities of both lizards and snakes. By contrast, salamander, frog and turtle communities are generally less diverse (Schoenherr 1992) and populations of native frog species appear to be in serious decline in the San Joaquin Valley. Common species of amphibians and reptiles on refuge lands that can be found within the various habitat types include: California tiger salamander (*Ambystoma californiense*), Pacific tree frog (*Pseudacris regilla*), American bullfrog (*Lithobates catesbeiana*; non-native), western pond turtle (*Actinemys marmorata marmorata*), western fence lizard (*Sceloporus occidentalis*), Gilbert's skink (*Eumeces gilberti*), western yellow-bellied racer (*Coluber constrictor mormon*), California kingsnake (*Lampropeltis getulus californiae*), gopher snake (*Pituophis melanoleucus*), western terrestrial garter snake (*Thamnophis elegans*) and common garter snake (*Thamnophis sirtalis*). The endangered giant garter snake (*Thamnophis couchi gigas*) has been documented to occur on the Grasslands WMA, and potential reintroductions sites and suitable habitat for this species exist on the San Luis and Merced NWRs. Only one poisonous snake—the western rattlesnake (*Crotalus viridis*)—occurs in the area and is restricted to the South unit of the Grasslands WMA.

Rare species that have been documented to occur on refuge lands include western spadefoot toad (*Spea hammondii*), western toad (*Anaxyrus boreas*), soft shelled turtle (*Trionyx* spp.; non-native). The California horned lizard (*Phrynosoma coronatum frontale*) and California legless lizards (*Anniella pulchra*) are the rarest species on the Refuge units and can be found near actively shifting sand dune habitats.

Fish

Habitats for fish on the refuge units include rivers, streams, permanent wetlands, oxbows and sloughs. The San Joaquin River flows through the San Luis NWR and portions of the Grasslands WMA. Various tributaries flow through the three refuge units, including Deadman Slough, Duck Slough, Salt Slough, East Bear Creek, Mud Slough, Deep Slough and Los Banos Creek. Although these waterways provide an important nexus for migratory fish, each have extremely altered flow regimes. The stretch of the San Joaquin River and tributaries on these refuge units provide a small measure of habitat connectivity for fish, including fall-run chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*) and Sacramento splittail (*Pogonichthys macrolepidotus*). Fall-run chinook salmon and California Central Valley DPS steelhead are listed under the Endangered Species Act. The Sacramento splittail was petitioned and proposed but determined not to warrant protections under the Act. Appendix E provides the species list of fish known to occur or have the potential to occur at these refuge units.

Historically, California supported over 90 freshwater species of native fishes and the Sacramento-San Joaquin Valley sustained approximately 60 native species (Schoenherr 1992). Although a diversity of aquatic habitats still exists in the Central Valley, the natural assemblages of Central Valley fish communities have been degraded by altered flow regimes, levee construction/maintenance and associated loss of floodplain, reduction in riparian habitats, water diversions, the introduction of exotic fish species and other factors. At the San Luis NWR, Merced NWR and Grasslands WMA, many native fish species have been extirpated or severely reduced in number, but several still occur, including fall-run chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), Pacific lamprey (*Lamptera tridentata*), river lamprey (*Lamptera ayresi*), hitch (*Lavinia exilicauda*), Sacramento splittail (*Pogonichthys macrolepidotus*), Sacramento blackfish (*Orthodon microlepidotus*), Sacramento sucker (*Catostomus occidentalis*), tule perch (*Hysterocarpus traski*) and prickly sculpin (*Cottus asper*). Some of these species are dependent on large river systems; others use sloughs and other backwater habitats. Introduced species now dominate many of the aquatic habitats of the Central Valley, including those at these refuge units. Thirty-six introduced fish species are present in the Central Valley (Schoenherr 1992). Aquatic habitats of these refuge units are now dominated by warm water non-native species, including black bass (*Micropterus salmoides*), common carp (*Cyprinus carpio*), bluegill (*Lepomis macrochirus*), threadfin shad (*Dorosoma petenese*), red shiner (*Cyprinella lutrensis*) and striped bass (*Morone saxatilis*).

Although these refuge units were originally established to benefit migratory birds and endangered species, the Complex the potential to benefit and enhance populations of native fish. The restoration of floodplain habitats on these refuge units, including riparian forest, and a return to more natural water regimes have the potential to benefit many natives dependent on floodplains for spawning and rearing purposes (Moyle 2002). A large initiative among a consortium of groups to restore the San Joaquin River and salmon runs holds promise for improved lentic habitats to benefit native fish populations on the San Luis NWR Complex.

Invertebrates

The Complex provides habitat for both aquatic and terrestrial invertebrates. Past surveys have been limited to sampling vernal pools for the presence of tadpole and fairy shrimp, and it is believed that the aquatic and terrestrial invertebrate fauna is representative for the Central Valley. Refuge staff conduct systematic surveys of the invertebrate fauna in the vernal pools at San Luis NWR and Merced NWR yearly, and have recorded species of interest such as the conservancy fairy shrimp (*Branchinecta conservatio*), longhorn fairy shrimp (*Branchinecta longiantenna*), vernal pool fairy shrimp (*Branchinecta lynchi*), vernal pool tadpole shrimp (*Lepidurus packardi*), versatile fairy shrimp (*Branchinecta lindahli*), California fairy shrimp (*Linderiella occidentalis*) and California clam shrimp (*Cyzicus californicus*), as well as various orders and classes of invertebrates such as Coleoptera, Hemiptera, Diptera, Copepoda, Ostracoda and Cladocera.

Non-systematic field observations have detected the presence of representatives from nine of the 13 insect orders with aquatic species, as well as two types of native bees. In addition, 55 species of native bees were documented on San Luis NWR during surveys by Gordon Frankie and Robbin Thorp from 1994 to 2000. In 2022, incidental bumblebee surveys on the refuge documented the presence of Crotch's bumblebee (*Bombus crotchii*) at the San Luis NWR pollinator garden. Crotch's bumblebee is listed as a species of special concern in California and an IUCN endangered species. Monarch butterfly (*Danaus plexippus*) is a candidate species for listing under the ESA that uses the San Luis and Merced NWRs.

Future work on invertebrates may include surveys for the endangered valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), listed vernal pool invertebrate species and native bee inventories, depending on funding availability.

Threatened and Endangered Species

Nine Federally listed endangered species and eight Federally listed threatened species are known to occur or potentially occur on the Complex. The nine Federally listed endangered species that occur or potentially occur on San Luis NWR, Merced NWR and the Grasslands WMA include: the San Joaquin kit fox (*Vulpes macrotis mutica*), Fresno kangaroo rat (*Dipodomys nitratoides exillis*), least Bell's vireo (*Vireo bellii pusillus*), giant garter snake (*Thamnophis gigas*), blunt-nosed leopard lizard (*Gambelia sila*), conservancy fairy shrimp (*Branchinecta conservatio*), longhorn fairy shrimp (*Branchinecta longiantenna*), vernal pool tadpole shrimp (*Lepidurus packardi*) and hairy orcutt grass (*Orcuttia pilosa*).

Western Fence Lizard. Photo: Paul Prado

The eight Federally listed threatened species that occur or potentially occur on San Luis NWR, Merced NWR and the Grasslands WMA include: California tiger salamander (*Ambystoma californiense*), valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), vernal pool fairy shrimp (*Branchinecta lynchi*), Colusa grass (*Neostapfia colusana*), Hoover's spurge (*Euphorbia hooveri*), yellow-billed cuckoo (*Coccyzus americanus*), Central Valley rainbow trout (*Oncorhynchus mykiss*) and Central Valley spring-run chinook salmon (*Oncorhynchus tshawytscha*). The monarch butterfly is an ESA candidate species.

San Joaquin Valley kit fox (*Vulpes macrotis mutica*) were common historically within the area that now makes up the San Luis NWR, Merced NWR and Grasslands WMA. However, historical accounts and subsequent Complex monitoring indicate that on-refuge kit fox populations have declined over the years. San Luis NWR Complex staff have been conducting operational surveys, research and habitat management for San Joaquin Valley kit fox (*Vulpes macrotis mutica*) on refuge lands since the 1980s. Efforts have included a radio telemetry study on distribution/home range and analysis of food habits in the mid-1980s, as well as spotlight surveys conducted on an almost annual basis. The presence of kit fox and their den sites on and near the San Luis NWR and Merced NWR were periodically documented in the 1980s and early 1990s. The last documented observation of the species was in March 2000, when a single individual was observed at Merced NWR. Extensive surveys on units of San Luis NWR and Merced NWR were conducted from 2005 to 2009 using a scat-detecting dog and motion-sensing cameras, with no detections of any kit fox or den site. Habitat management on refuge lands for kit fox has included grazing of native uplands to maintain short-grass habitat and creating artificial den sites.

Several Federally listed species were historically present on lands that are now the refuge but are no longer known to occur there. The area is within the historic range of the Fresno kangaroo rat (*Dipodomys nitratoides excilis*). Although the species has not been documented on refuge or easement lands, limited surveys have been conducted and Fresno kangaroo rats (*Dipodomys nitratoides excilis*) may potentially be present on suitable habitat east of the San Joaquin River. Prior to the 1950s, blunt-nosed leopard lizards (*Gambelia sila*) were present on what is now the Arena Plains unit of Merced NWR (Bert Crane personal communication), but none have been seen in recent years. The refuges also are within the historic range of the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*). This species is dependent on elderberry (*Sambucus mexicanus*) for its existence. Very little elderberry habitat exists on the refuge and presence of the beetle has not been documented. However, elderberry has been incorporated into the mix of native shrubs planted as part of riparian restoration in recent years, and valley longhorn beetle populations may become established in the future as the habitat matures.

Least Bell's vireo (*Vireo bellii pusillus*) and yellow-billed cuckoos (*Coccyzus americanus*) were both once common nesting birds in riparian habitat throughout the Central Valley. Nesting by least Bell's vireo (*Vireo bellii pusillus*) had not been documented in the Central Valley for over 60 years. However, nesting was documented in 2005, 2006 and 2007 in a riparian restoration project site at the San Joaquin River NWR (45 miles north of San Luis NWR). In 2011, a least Bell's vireo's (*Vireo bellii pusillus*) nest was discovered on the San Luis NWR. Additionally, a pair of least Bell's vireos were seen at Merced NWR in 2012. Ongoing restoration and management are resulting in expansions of on-refuge riparian habitat that could potentially support least Bell's vireo (*Vireo bellii pusillus*) populations. Similarly, yellow-billed cuckoos[11] (*Coccyzus americanus*) have not been observed on the refuge is recent years, but suitable habitat is now present. San Luis NWR, Merced NWR and Grasslands WMA are within the historic range of the giant garter snake (*Thamnophis gigas*). Widespread surveys by Service personnel and contractors on Federal, state and private lands in Merced County have been ongoing since the early 1990s. No giant garter snakes (*Thamnophis gigas*) have been documented on San Luis NWR or Merced NWR. However, localized populations on the CDFW-managed Volta Wildlife Management Area and private lands adjacent to the WMA, including Service easement lands, have been found in the Grasslands. Because of the connectivity of wetlands in the Grasslands WMA, giant garter snakes (*Thamnophis gigas*) may move throughout the easement lands.

Prior to the 1950s, Chinook salmon (*Oncorhynchus tshawytscha*) were seasonally abundant in the San Joaquin River at the San Luis NWR. However, dam construction and water diversions upstream of the refuges eliminated those historic runs. Chinook salmon (*Oncorhynchus tshawytscha*) and Central Valley steelhead trout (*Oncorhynchus mykiss*) still occur on a regular basis in the San Joaquin River corridor downstream of the confluence of the Merced River. Due to a lack of suitable habitat, CDFW operates a fish barrier at the confluence to divert salmon away from the San Joaquin River into the Merced River, where suitable habitat still exists. Despite that, a few salmon get past the barrier and end up stranded in Salt Slough and Mud Slough, where they ultimately die before reaching any spawning habitat. Because of this situation, there currently is no management being done for salmon on refuge lands in Merced County. After 19 years of litigation, a 2006 court settlement was reached that mandates restoration of the San Joaquin River and salmon populations. An interagency group was formed and is tasked with the job of implementing this restoration. As a result, Complex staff have become more active in salmon recovery and management on refuge lands in Merced County. Depending on what decisions are made in the future as part of the San Joaquin River Restoration Program[12] (SJRRP), the Complex may become more actively involved in habitat management to promote recovery of salmon populations.

Conservancy fairy shrimp (*Branchinecta conservatio*), longhorn fairy shrimp (*Branchinecta longiantenna*)*,* vernal pool fairy shrimp (*Branchinecta lynchi*) and California tiger salamanders (*Ambystoma californiense*) are widespread in vernal pools throughout San Luis NWR, Merced NWR and, to a lesser extent, easement lands of the Grasslands WMA. Complex biological staff inventory all vernal pools on newly acquired lands to determine presence of vernal pool fauna and periodically monitor those pools. Due to concerns about take of a listed species associated with the more intensive sampling techniques, sweep net surveys have focused on determining presence/absence rather than absolute population size. Those surveys suggest that the three species of fairy shrimp are variable in distribution and relative abundance, likely due to inundation levels of the pools and the seasonality of sampling. Vernal tadpole shrimp (*Lepidurus packardi*) are the most widespread and abundant and occur in more of the sampled vernal pools

[11] Western DPS including California is threatened (79 FR 59991)
[12] https://www.restoresjr.net/

than any other species. California tiger salamanders (*Ambystoma californiense*) are widespread but tend to be more associated with the deeper vernal pools.

Colusa grass (*Neostapfia colusana*) has been documented within two vernal pool basins on the Arena Plains unit of Merced NWR. Plant surveys elsewhere on San Luis NWR and Merced NWR have failed to find any other populations. At present, only a single population within one of those pools exists. That site is monitored on an almost annual basis and, based on weather and timing of the pool drying up, the Colusa grass (*Neostapfia colusana*) population size has ranged from a few plants to over 3,000. In 1995, the pool was inundated by an illegal spill from an adjacent turkey waste fertilizer processing plant that covered the pool bottom with nitrogenous waste, and for years the number of Colusa grass plants present never exceeded 25. However, in 2019 during a year of good rainfall, over 1,000 Colusa grass plants were documented in the pool. Colusa grass has been documented on only one other site (private lands in the East Grasslands) in Merced, and potentially may occur on other private lands within the East unit of the Grasslands WMA. Another listed plant species, hairy Orcutt grass (*Orcuttia pilosa*), may be present on refuge or easement lands, but its current status is unknown.

California-listed endangered and threatened species occurring on the Complex include: greater sandhill crane (*Grus canadensis tabida*), bald eagle (*Haliaeetus leucocephalus*), Swainson's hawk (*Buteo swainsoni*), yellow-billed cuckoo (*Coccyzus americanus*), willow flycatcher (*Empidonax traillii*), bank swallow (*Riparia riparia*), tricolored blackbird (*Agelaius tricolor*) and delta button celery (*Eryngium racemosum*). Most of the greater sandhill cranes (*Grus canadensis*) winter elsewhere in the Central Valley. The limited numbers (< 20) present on the San Luis NWR, Merced NWR and Grasslands WMA usually are found in association with the much more abundant lesser sandhill crane subspecies (*G. c. canadensis*). Swainson's hawks (*Buteo swainsoni*) are a local breeding bird that nest in cottonwoods and willows in the riparian corridors. Large numbers migrate through the area in July and August enroute to the wintering areas in Central/South America. Yellow-billed cuckoos (*Coccyzus americanus*), willow flycatchers (*Empidonax traillii*) and bank swallows (*Riparia riparia*) have been observed in the past as rare migrants/transients during spring through fall but are not local nesters. Although there are historic records of bank swallow colonies in Merced County, no recent records of bank swallow nesting have been documented. Refuge staff participated in the 2021 Statewide Bank Swallow Colony survey and did not observe any bank swallows. Tricolored blackbirds have established successful breeding colonies on San Luis and Merced NWRs of varying sizes and locations throughout the years and are found on the refuges year-round. Bald eagles have been observed more frequently in recent years on the Merced and San Luis NWRs. In 2022, a bald eagle pair was documented nesting at Merced NWR. This is the first known record of bald eagle nesting on the Merced refuge. In February 2023, a bald eagle pair was observed nesting on the West Bear Creek unit of San Luis NWR. Delta button celery (*Eryngium racemosum*) occurs on heavy clay soils within the floodways between the levees at San Luis NWR, Merced NWR and Grasslands WMA, and in the floodplain on the Kesterson unit of San Luis NWR. Populations vary by year, with thousands of plants present in summers following flood events.

Figure 3-3. Public Use Facilities at the San Luis NWR

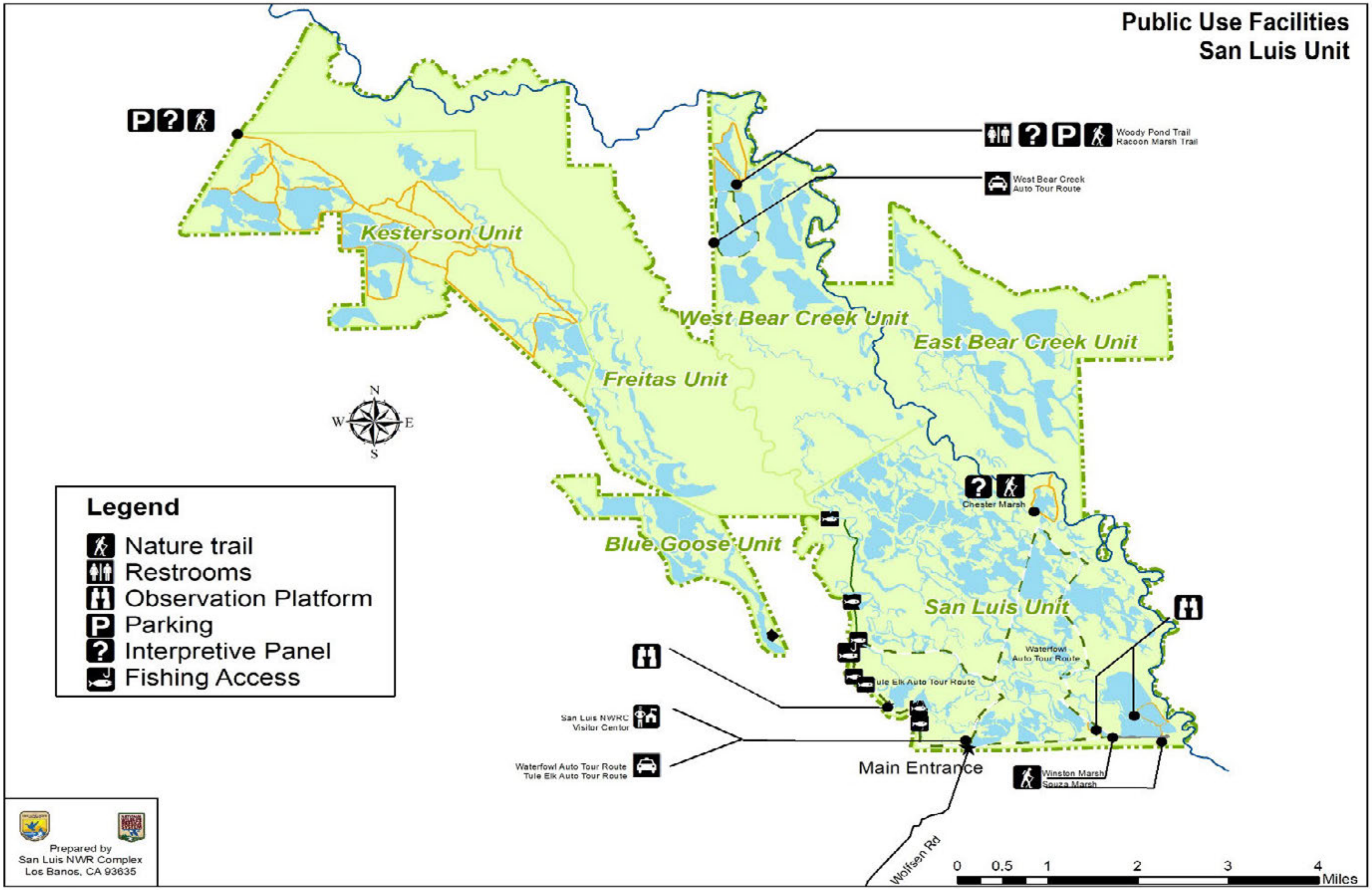
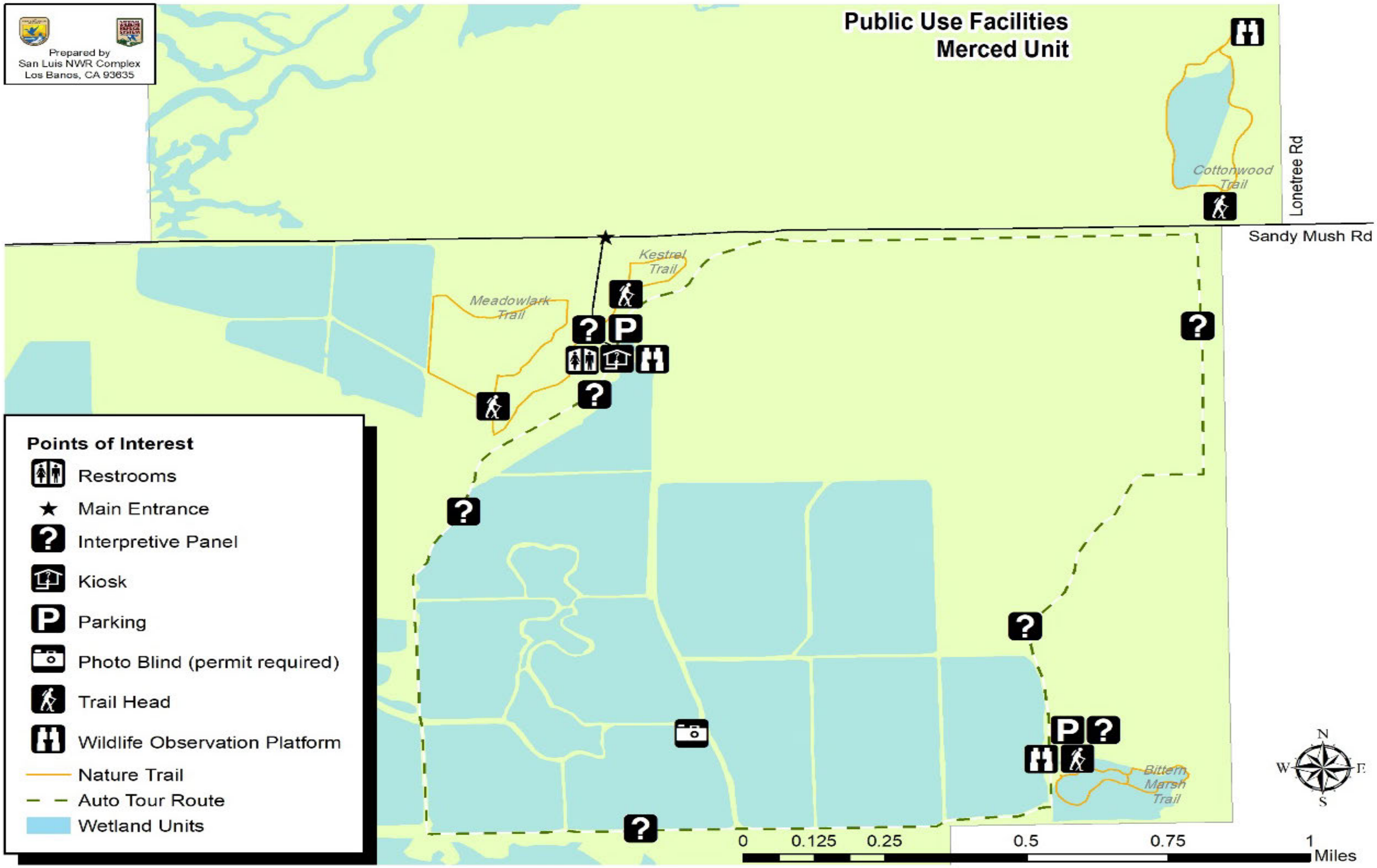


Figure 3-4. Public Use Facilities at the Merced NWR



Visitor Services

Public use activities at NWRs focus on wildlife-dependent activities and include as priorities: wildlife observation, interpretation, photography, hunting, fishing and environmental education. All six of these priority public uses occur between the San Luis and Merced NWRs, although fishing is not allowed at Merced NWR.

Information about visitor services on the San Luis and Merced NWRs can be found in the Visitor Services Plan (Appendix G), which is incorporated by reference into this document. The Visitor Services Plan includes detailed information about recreational opportunities, objectives and strategies and implementation procedures.

Information about visitor services on the San Joaquin River NWR can be found in the Final Comprehensive Conservation Plan for the San Joaquin River NWR: https://ecos.fws.gov/ServCat/Reference/Profile/8271.

The Grasslands WMA consists entirely of individual private lands. As these lands are privately held, there is no public access or visitation allowed. Please visit the San Luis, Merced and/or San Joaquin River NWRs for public access.

Visitor Services Management Policy

A variety of sources provide policy and guidance to manage visitor service programs on NWRs. The Service Manual (605 FW 1) provides the policy for wildlife-dependent recreation including hunting, recreational fishing, wildlife observation, wildlife photography, environmental education and interpretation. The policy also provides guiding principles for each of the wildlife-dependent recreation programs.

The following criteria guide our wildlife-dependent recreation programs (605 FW 1.6):

A. Promotes safety of participants, other visitors and facilities
B. Promotes compliance with applicable laws and regulations and responsible behavior
C. Minimizes or eliminates conflict with fish and wildlife population or habitat goals or objectives in an approved plan
D. Minimizes or eliminates conflicts with other compatible wildlife-dependent recreation
E. Minimizes conflicts with neighboring landowners
F. Promotes accessibility and availability to a broad spectrum of the American people
G. Promotes resource stewardship and conservation
H. Promotes public understanding and increases public appreciation of America’s natural resources and our role in managing and conserving these resources
I. Provides reliable/reasonable opportunities to experience wildlife
J. Uses facilities that are accessible to people and blend into the natural setting
K. Uses visitor satisfaction to help define and evaluate programs

Law Enforcement

The San Luis NWR Complex (San Luis NWR, Merced NWR and Grasslands WMA) plays a critical role in providing and protecting important habitats for endangered and threatened species, migratory birds of the Pacific Flyway and resident wildlife. Public use programs at the Complex attract many people from all walks of life to enjoy wildlife throughout the year. The Complex provides protection to both the public and natural resources through its law enforcement program. The program consists of both prevention and protection components.

In the prevention role, law enforcement and the rest of the Complex work to prevent criminal acts against persons and property, accidents and damage to the resource. This is accomplished through identifying security problems and safety hazards before they become a problem, coordination with other state and Federal agencies and through proactive high-visibility patrols via vehicles, aircraft, watercraft, OHVs and foot. Proper signage, barriers, maintaining public use infrastructure, brochures, websites and educational contacts also aid in preventing many resource crimes.

In the protection role, law enforcement safeguards the visiting public, employees and contractors, government facilities, personal property and natural and cultural resources from state and Federal criminal acts, negligence, accidents and other hazardous conditions. The Complex accomplishes this through the application of the criminal codes of the U.S. Government, the State of California, local and municipal governments and easement/title documents through civil actions, as well as by working in cooperation with other local, state and Federal resource and law enforcement agencies.

The Region's law enforcement program consists of one patrol captain and four full-time Federal wildlife officers assigned to the Central California Patrol Zone, which includes Stone Lakes NWR, Tulare Basin WMA, San Luis NWRC, San Francisco Bay NWRC, Hopper Mountain NWRC and Kern NWRC. These officers are responsible for any law enforcement and public safety issues on San Luis NWR (six units), Merced NWR (three units) and the San Joaquin River NWR and Grasslands WMA (three units). In addition to the Federal wildlife officers assigned to the region, the patrol captain (who directly supervises the Federal wildlife officers) provides support on the Complex, especially during periods of high use or low staffing levels.

The Complex's law enforcement officers work closely and coordinate their activities with other local, state and Federal law enforcement and public resource officials, and occasionally assist them on details outside the refuge units' boundaries. Law enforcement relies heavily on other agencies at times due to limited law enforcement staff and the segmented-scattered positioning of individual refuge units in the Complex. The most common violations encountered are marijuana cultivation and other narcotics violations, resource violations (hunting and fishing), vandalism, arson, theft, firearms violations and motor vehicle code violations.

Refuge Facilities and Maintenance

Refuge facilities and maintenance activities of these facilities are essential functions on the Merced and San Luis NWRs for resource and public use management and protection.

The Grasslands WMA, consisting of easements on private lands, does not have any Federally owned facilities or associated maintenance requirements.

Roads

The Merced NWR has 30 miles of gravel roads, seven parking lots and 52 miles of service roads—some of which are improved dirt roads or unimproved (grass-covered) roads. The San Luis NWR contains 60 miles of gravel roads, 46 parking lots and 110 miles of service roads that may be improved dirt roads or unimproved grass-covered roads. Gravel roads are traveled year-round and provide public access to refuge lands via auto tour routes 365 days a year and to hunter parking lots during the state waterfowl hunting season (approximately late October to February). These roads also provide access to key infrastructure needed to operate the water conveyance system, as well as provide for safety as they insure rapid access of law enforcement, emergency and fire personnel to the refuge. Improved dirt roads frequently parallel major managed wetland basins and provide access to both sides of major water delivery canals to facilitate maintenance of the water conveyance system. Unimproved dirt roads are grass-covered and provide dry season (May to October) access to managed wetland units and certain uplands.

The road maintenance program at the San Luis NWR Complex prioritizes maintaining 24.6 miles of auto tour routes (open to public access 365 days per year). The management of these auto tour routes and other mission-critical, all-season roads (which provide access to safety personnel and key water management locations) require maintaining five inches of compacted three-fourths aggregate base course-gravel on the road surface. This activity requires regular maintenance, including spraying and mowing of roadsides to halt weed encroachment and grading with a road grader or using a box scraper drawn by a tractor approximately once every three to four weeks—more frequently if rainfall is frequent or severe. Gravel is purchased from local quarries and added to roadways as needed. The maintenance and improvement of improved dirt roads includes the prohibition of driving on these roads after rains. Improved dirt roads also require mowing, spraying and occasional grading, whereas the maintenance of unimproved dirt roads requires only mowing. The maintenance of the road infrastructure at the San Luis NWR Complex in terms of capital and force account expenditures is second only to the maintenance of the water conveyance infrastructure at the Complex.

Buildings

The Merced unit of the Merced NWR has a maintenance/headquarters shop compound comprising a 3,000-square-foot maintenance shop, 360-square-foot flammable liquids/oil storage room, 1,000-square-foot wood shop, 1,600-square-foot residence, 360-square-foot oil/herbicide house, 1,000-square-foot ATV shed and 1,344-square-foot welding shop and parking garage. The maintenance shop serves as the principal work area for Merced NWR field staff. The refuge maintains two 300-square-foot public restrooms, a 5,000-square-foot barn and a 20,000-square-foot livestock corral north of Sandy Mush Road; these facilities are used for refuge visitors and the station's grazing program. The Arena Plains unit maintains a 1,000-square-foot mobile home. The Snobird unit has a 180-square-foot shed, 1,556-square-foot horse barn, 1,200-square-foot small pole barn, 2,905-square-foot barn, 3,500-square-foot large pole barn and 1,344-square-foot meeting room. Many of these structures no longer serve the mission needs for the Complex.

The San Luis NWR Complex's more than 16,000-square-foot headquarters and visitor center is located at the San Luis NWR. The San Luis unit of the San Luis NWR houses a fenced and gated maintenance shop compound comprising a 6,000-square-foot maintenance shop, 1,200-square-foot flammable liquids storage room, 1,215-square-foot refuge maintenance office, 2,706-square-foot fire bunkhouse capable of housing 12 individuals, 200-square-foot herbicide room and 200-square-foot all-terrain vehicle garage. Field staff work from the maintenance shop compound at the refuge. The refuge also maintains a 2,975-square-foot fire station on the Blue Goose unit of the refuge adjacent to State Highway 165; field fire personnel work from this fire cache, which also houses the station's fire apparatus.

Fencing

The Merced NWR has 51 miles of boundary fence with signage and 15 miles of internal fences to contain domestic livestock (cattle and sheep) managed by Complex partners under CLMA. These efforts aim to control invasive weeds and meet other upland habitat management objectives set by the Complex. The San Luis NWR has a perimeter of 36 miles of boundary fence and signage and 22 miles of internal fences used for upland management activities. Fencing is constructed of four strands of wires (three barbed wires with a bottom strand of smooth wire) equipped with stays to prevent deer from becoming entangled. Wooden fence posts are typically spaced 80 feet apart with steel posts (t-posts) set at 16-foot intervals on each 80-foot span. Wooden posts are slowly being replaced with steel (pipe) posts to facilitate the use of prescribed fire in upland habitat management actions. In addition to the standard wire fence, the San Luis NWR has 5.2-miles of high game fence constructed in 1974 by force account (some components replaced in 2004) that encloses 762 acres of upland and wetland habitats that support a thriving resident tule elk herd. This fence is built of wooden posts that extend 9.5 feet above ground level and 8-foot-high panels of high tensile game fence.

Access by the public to these refuges is via automatic electric gates. At the Merced NWR, public access is controlled from Sandy Mush Road at the Merced unit with an automatic metal gate that opens a half hour before sunrise and shuts a half hour after sunset. Likewise, the San Luis NWR has three automatic metal gates that open a half hour before sunrise and shut a half hour after sunset.

River Levees, Dikes and Berms

The Merced NWR includes 23 miles of earthen river levees, dikes and berms that augment the water conveyance system and assist by influencing the retention and direction of surface water flows. Largest of these structures are the Eastside Bypass, Deep Slough and Bear Creek levees. The San Luis NWR includes some 50 miles of earthen river levees, dikes and berms that augment the water conveyance system. Largest of these structures are the San Joaquin River and Bear Creek levees, which run for 14 and 6 miles, respectively, on refuge lands. Although these structures are owned by the USACE, the levees are maintained by the Lower San Joaquin Levee District (LSJLD) and, to a minor extent, by the Service. Maintenance of the river levees is similar to the maintenance of graveled roads on the refuges. Levee banks must be kept clear of woody vegetation, overhanging limbs and the burrowing of rodents including the California ground squirrel, which is controlled by LSJLD via application of rodenticide (diphacinone bait) using bait tubes specially designed to exclude non-target species such as Heermann's kangaroo rat (California Department of Pesticide Regulation 2004). This is the only permitted use on the Complex of chemical control techniques due to the risk of threatened and endangered species being impacted in the event of a catastrophic levee breach and flooding caused by California ground squirrel burrowing.

Wetland Units and Water Infrastructure

For both the Merced and San Luis NWRs, the most complex and time-consuming aspect of their management is the wetland units and the associated water conveyance infrastructure.

Merced NWR

The Merced NWR contains 49 managed wetland basins varying in size from 5 to 150 acres with water depths in these units that vary from a few inches to 7–8 feet. To efficiently convey the 15,000 acre-feet of delivered water and up to 20,000 acre-feet of surface and groundwater—appropriated and used under existing water rights—onto and off these units is the activity that most occupies the three full-time maintenance staff stationed at Merced NWR on an annual basis.

The Merced unit makes up approximately 5,500 acres of the 10,262 acres of Merced NWR; its water is distributed via a 15-plus mile pipeline system. Deadman Creek is used to transport up to 15,000 acre-feet to the refuge. This water is available from March through October, at a maximum delivery rate of 45 cubic feet per second. In combination with the main pump station/pipeline and a couple of internal canals, this water is available to all portions of the Merced unit (including the Lonetree unit). The surface water is supplemented from 15 wells connected to the pipeline system, with an additional four wells independent of the pipeline. The capacity of wells varies from 1,200 gallons per minute (gpm) to 2,300 gpm.

The central feature of the Merced unit's water distribution system is the Main Pump Station located east of the shop/headquarters on Deadman Creek. The station consists of five lift pumps feeding into the pipeline. A flashboard dam downstream of the pumping station is used to back water to the station. This same flashboard dam is used to divert water to the canal. From the station, each wetland and agricultural field is connected to the water supply through the pipeline.

Drainage water and floodwater from the Merced unit can be moved from the refuge through two independent lift pump stations. Independent drainage is provided to each wetland unit and agricultural field. The drain system consists of six major drain locations. Five of the drain points feed into the Eastside Bypass, which drains into the San Joaquin River. A singe drain location in the unit's north drains through a series of small upland channels that eventually drains into the Eastside Bypass.

The Arena Plains unit is approximately 2,500 acres and maintains six wetlands comprising 482 acres in managed wetlands. Water for these wetlands is conveyed by two deep wells and intermittently with treated wastewater from the Atwater wastewater treatment plant via the Atwater/Peck Drain. All drainage and floodwater from the Arena Plains unit drains into the Eastside Canal and into the San Joaquin River.

The Snobird unit is 1,900 acres in size, with wetland restoration work starting in 2010. There are five deep wells and three small lift pumps designed to draw water from a disconnected portion of the Atwater drain. The water supplies available for use from the drain are excess amounts from the Eastside Canal. All drainage and floodwater from the Snobird unit drains into either the Bear Creek or Deep/Brevel Slough.

Historically, water control structures at Merced NWR comprised metal pipes and headwalls and wooden board bulkheads. Since the 2000s, the use of high-density polyethylene (HDPE) pipe and precast concrete weirs with wooden (redwood) headwalls and either redwood or western red cedar bulkheads with removable boards for water flow manipulation have been the structures of choice. These structures vary in size from 3 by 4 feet to 5 by 7 feet and typically are matched with 24-inch, 30-inch or 36-inch diameter pipe of length between 20 and 40 feet, depending on the site. Structures require compaction of earth underneath and surrounding them to achieve desired results, proper installation of plastic pipe may require the compaction of gravel underneath the weir on some sites to achieve maximum longevity of the structure, adding a prohibitively expensive step to this installation. A database is maintained at Merced NWR to track water control structure replacement. The typical structure lasts for a period of 10 to 25 years. Chief reasons for failure of structures are rusting and collapse of pipe walls due to the often highly saline and alkaline environmental conditions on the refuge and compaction or erosion caused by the settling of earth, flooding and occasionally the burrowing of rodents.

American Kestrel with Prey. Photo: Rick Lewis

San Luis NWR

The San Luis NWR comprises 26,878 acres, of which 4,413 acres (excluding East Bear Creek) comprise managed wetland basins. Over 90 percent of the managed wetland basins at San Luis are seasonal wetland basins. These basins are inundated fields or ponds that are managed primarily to grow seed and produce invertebrates for migratory waterfowl, shorebirds and other wetland-dependent wildlife. These wetlands are shallow—typically only a few inches to a few feet, but occasionally up to several feet in depth—and are flooded from September or October through March and are dry for the rest of the year (except for summer irrigations) (USFWS 2005).

The San Luis NWR contains 124 managed wetland basins varying in size from 2 to 177 acres, whereas water depths in these units vary from a few inches to 7–8 feet. To efficiently convey the 50,380 acre-feet of delivered water and up to 20,000 acre-feet of surface and groundwater—appropriated and used under existing water rights—onto and off these units is the activity that most occupies the seven full-time maintenance staff stationed at San Luis NWR. The maintenance burden and high recurrent cost of maintaining the entirely artificial water conveyance systems needed to meet wetland habitat management objectives for trust resources—principally migratory birds—make the San Luis NWR one of the most intensively managed refuges in the country.

On the San Luis NWR, 35 miles of major earthen water delivery canals, a greater mileage of subsidiary canals and managed drains, and 384 water control structures (which regulate water depths in canals, ditches and wetland units and direct water flows where needed) require nearly constant maintenance. Eight different major canals are on the San Luis NWR; these are the Refuge A, B, C, D and E canals east of State Highway 165 and the San Luis, Santa Fe, Miller and Lux, Fremont and Cottonwood canals west of State Highway 165. Major canals—defined here as canals no less than 15 feet in length and up to 30 feet wide and up to 12 feet deep—are characterized by relatively rapid sedimentation (silt and organic matter accumulation). In addition to mechanical and chemical control of aquatic plants in these canals during the growing season, these canals require mechanical removal of sediment approximately every 3–8 years to retain water volume capacity and the desired two-to-one slope ratio required to maximize the gravity fed efficiency of water delivery. Generally, the subsidiary canals, wetland basins and drains require de-silting every 15–20 years.

Historically, water control structures on the San Luis NWR comprised metal pipes and headwalls and wooden board bulkheads. Since the 1980s, the structure of choice has been the use of polymer-coated galvanized corrugated metal pipe matched with precast concrete weirs with wooden (redwood) headwalls and either redwood or western red cedar bulkheads with removable boards for water flow manipulation These structures vary in size from 3 by 4 feet to 5 by 7 feet and typically are matched with 24-inch, 30-inch or 36-inch diameter pipe of length between 20 and 40 feet, depending on the site (an inlet or outlet from a wetland basin, a siphon under a canal, or an in-line structure within a water delivery canal or drain). In-line applications may require the setting of up to three 5 by 7-foot concrete weirs matched with three 40-foot lengths of 36-inch diameter pipe, whereas siphons may run 120 feet or more. Because of their great depth, siphons are difficult structures to replace.

The refuge contains multiple structures made of HDPE pipe and precast concrete weirs set in the late 1990s and early 2000s. These structures have failed at a greater rate than the polymer-coated galvanized corrugated metal pipe structures. While both structures require compaction of earth underneath and surrounding them to achieve desired results, proper installation of plastic pipe requires compaction of gravel underneath the weir to achieve maximum longevity of the structure, adding a prohibitively expensive step to this installation. A database is maintained at San Luis NWR to track water control structure replacement. An average of 15 structures are replaced at the refuge annually, whereas the typical structure lasts for a period of 10 to 25 years. Chief reasons for failure of structures are rusting and collapse of pipe walls due to the often highly saline and alkaline environmental conditions at the refuge and compaction or erosion caused by the settling of earth, flooding and occasionally the burrowing of rodents.

A vital part of the San Luis NWR’s infrastructure is the capacity to provide water supplies to managed wetland basins even when delivered water supplies (delivered to the refuge boundaries) by gravity feed are suspended (usually for maintenance of the water conveyance system upstream), or due to water scarcity. In recent years, these annual interruptions of the delivered water supply have occurred more frequently and been longer in duration even during the fall and winter months, which are the months corresponding to the maximal water need of the refuge to provide for the life history requirements of migratory waterfowl and waterbirds. Fortunately, the refuge has a series of lift pumps (a pump and motor to capture surface water) and wells, which pump groundwater in a similar fashion and serve to augment or even substitute for delivered water supplies.

The East Bear Creek unit of the San Luis NWR is entirely dependent on the functioning of a pumping plant and pipeline constructed in 2008 to flood a 1,000-acre wetland restoration project. Starting in November 2008, four lift pumps capable of providing 120 acre-feet per day of water have functioned to deliver water to this unit. A redesign of the pumping plant by the USBR is scheduled for construction in 2024 and includes refurbishment of pumps, installation of a new inlet and fish screen, modification of the fill mode bypass system and modification to the electronics and computer systems of the pumping plant.

The San Luis unit of the refuge has six lift stations and seven lift pumps. The southern boundary of the unit is bounded by the Refuge Lift Canal, which supplied the entire refuge with water from 1967–1985. This facility can lift a maximum of 60 acre-feet of water daily through a series of three lift stations. These lift stations can handle the entire water right that the Service holds to Salt Slough (19,910 acre-feet). The San Luis unit harbors a water stop loss recovery system at Deadman Slough, a relict channel of Salt Slough that serves as an overflow channel for Salt Slough during flood events and also serves as a sump for some 2,776 acres of seasonal wetlands on the San Luis unit. As drainwater accumulates in Deadman


Green-winged Teal. Photo: Paul Prado

Slough, it is pumped back into the refuge via the Refuge Lift 6 or Lift 4 Canals. When Deadman Slough is too low to permit functioning of Lift 4 or 6, Lift 5—which pumps out of Salt Slough into Deadman Slough—is turned on to fill the Deadman Slough reservoir to such a level to permit pumping of Lift 4 and/or 6. The capacity of Lifts 4, 5 and 6 is approximately 30 acre-feet per day.

Operable groundwater wells are found on the San Luis unit (four), West Bear Creek unit (three), East Bear Creek unit (two) and Blue Goose unit (two). These assets can provide up to 6 acre-feet of water per day, each at a high pumping cost in electric power or diesel fuel relative to delivered water or lift pumps. An additional constraint posed to the use of these wells is the high relative concentrations of soluble salts and other contaminants (selenium and arsenic) found in this water. For this reason, well water is used sparingly at San Luis NWR and only when needed to meet important habitat objectives.

Other Improvements and Mobile Assets

The Merced and San Luis NWRs contain numerous physical assets. These refuges maintain 111 hunting blinds, a photography blind, four comfort stations, a boat launch facility, a fishing platform, six wildlife observation decks and seven major visitor contact stations. Refuge mobile assets include the following: 10 agricultural tractors, two road graders, three backhoes, two bulldozers, two front end loaders, two excavators, two forklifts, two dump trucks, two water tenders and heavy equipment implements including rotary and flail mowers, scrapers and stubble and finish disks. Assorted herbicide spray equipment, trailers and all-terrain vehicles are maintained to support refuge operations throughout the Complex.

Cultural Resources

Cultural resources are physical remains, sites, objects, records, oral testimony and traditions that connect us to our nation’s history and the land’s past. Cultural resources include archaeological and historical artifacts, sites, landscapes, plants, animals, sacred locations and cultural properties that play an important role in the traditional and continuing life of a community.

This more than 150-year history of agriculture as a major activity in Merced County has caused some challenges when assessing the area for archaeological activity. The soil in many areas has been manipulated by plowing or altering the grade, which may have destroyed historical evidence. Cultural resources, especially archaeological sites, are fragile and nonrenewable. Most consist of worked stone, fire-altered rocks and organically enriched soil on or close to the surface. When compared to the surrounding landscape and contemporary cultural features—such as roads, ditches and structures—archaeological sites are small and subtle. Little formal cultural resources survey work has been conducted on refuge land in Merced County. A formal cultural resources survey was conducted at the San Luis NWR and Merced NWR by Haversat and Breschini in 1985. The survey resulted in finding 38 archaeological sites at the San Luis NWR and one site at the Merced NWR. Most of these sites were categorized as *base camps*, which are occupied by several families on a year-round or seasonal basis (Haversat and Breschini 1985). One of the sites identified at the San Luis NWR was a historic ferry crossing used in the late 1800s.

Prehistory

Merced County is in the homeland of several Native American groups collectively known as the Northern Valley Yokuts. The adjacent Tribe was the Miwok, and as neighbors the Yokuts and Miwok probably traded, intermarried and shared many cultural practices (Silverstein 1978). Valley oak acorns and salmon were dietary staples, as were tule elk, antelope and jackrabbit (Levy 1995). Major Northern Valley Yokuts settlements were located within a short distance of the San Joaquin River and along major tributaries. Villages were typically built on ground higher than the surrounding area, situated to best exploit the rich subsistence resources without being consistently flooded. Yokuts would mainly congregate in the winter; during spring, summer and fall, groups would disperse to gather different resources (Jensen 1996). Villages typically consisted of four or five to several dozen structures. Each house served as a home to one family. Large villages may have had a great communal earth lodge for ceremonial use.

History

Spanish colonization of California began with the readily accessible coastal areas, avoiding the interior valleys during the 18th century. Early in the 19th century, military explorers and missionaries moved away from the coast and to the inland valleys. Early settlement by the Spanish in California was accomplished through the mission system, where livestock and farming were mainstays. The arrival of the Spanish into California shifted the use of the land from hunting/gathering to an agrarian use. By the 1820s many Native Americans were assimilated into the mission system. The Spanish introduced cattle and sheep and at the height of the mission period California had head of 400,000 cattle and 300,000 sheep (Schoenherr 1992).

During the late 1840s, the Spanish/Mexican influence in California declined, particularly during the gold rush years; however, livestock production continued as a major agricultural activity. A German immigrant named Henry Miller arrived in California in the mid-1800s and began acquiring land to build a cattle empire in the San Joaquin Valley, and by 1900 Miller was operating the largest cattle operation in the United States. The headquarters for Miller's operation was in Los Banos. In this part of the Valley, he also created and built large irrigation canals to transport water from the San Joaquin River to agricultural land. Agriculture continued to be the primary land use of the Valley into the 1900s. Irrigated agriculture was common in the 1850s but became widespread during the 1900s, as it is today. The Central Valley remains an agricultural center today with primary agriculture products being dairy, beef, grapes, orchard crops, row crops and cotton. Hay and alfalfa production for livestock forage also are common agricultural products.

Social and Economic Environment

The San Luis and Merced NWRs and Grasslands WMA are all within Merced County, California, in the northern end of the San Joaquin Valley.

The refuges are bordered primarily by private lands and state-owned lands. Private lands are mostly agricultural (row crops and pasture), as well as duck hunting clubs (seasonal wetlands). The state lands are primarily wildlife areas and one state park. Merced County has a general plan that outlines land use policies.

Refuge and easement lands are in the vicinity of several major transportation routes including State Highways 152, 165, 140, 33 and 99 and Interstate 5. Many small, paved county roads provide for local transportation and agricultural activities. These roads and larger highways provide the access to the refuges' public entrances and parking lots.

Like most of California, Merced County has experienced rapid population growth. In the first 150 years of statehood, California grew from fewer than 100,000 citizens in 1850 to almost 36.4 million in 2006 (U.S. Census Bureau 2007). The Central Valley has been one of the fastest-growing regions of California. Between 1980 and 1995, Merced County increased by 46 percent, outpacing California's overall increase of 35 percent (Umbach 1997). In 2010, Merced County's population was 255,793; in 2020 it was 281,202 (U.S. Census Bureau 2022). Merced County's population is 55 percent white, 3.2 percent Black or African American, 7.5 percent Asian, 0.9 percent American Indian, 0.2 percent Hawaiian or other Pacific Islander and 29 percent other race (U.S. Department of Commerce 2021). Merced County is 59.6 percent Hispanic or Latino (of any race). Merced County has a total minority population of 72.4 percent.

The rapidly growing population has led to a diverse workforce in Merced County, with the following employment industries in 2020: non-service-related employment (farming, forestry, mining, construction, etc.) at 26.9 percent; service-related employment (utilities, transportation, real estate, healthcare, etc.) at 54 percent; and government at 17.2 percent (U.S. Department of Commerce 2021). Merced County agriculture commodities grossed $3,401,610,000 in 2020. This represents an increase of 7 percent from 2019 (Merced County Department of Agriculture 2020).

Unemployment in Merced County in 2020 was 12.2 percent, whereas in California unemployment was 10.1 percent that same year (U.S. Department of Commerce 2021). California's 2019 per capita income was $36,955; Merced County's per capita income was $23,011 (U.S. Department of Commerce 2021). Merced County's percent of families in poverty in 2019 was 17.2 percent, compared to 9.6 percent for the state of California.

The report *Banking on Nature 2017: The Economic Contributions of National Wildlife Refuge Recreational Visitation to Local Communities*[13] (Caudill and Carver 2019) detailed the findings

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[13] Available online at https://www.fws.gov/sites/default/files/documents/USFWS_Banking_on_Nature_2017.pdf#:~:text=The%202017%20Banking%20on%20Nature%3A%20The%20Economic%20Contribution,engine%20adding%20over%2041%2C000%20jobs%20to%20local%20communities.

from 80 NWRs, including the San Luis NWR and Merced NWR. The study considered money spent for food, lodging, transportation and other expenses when it calculated the economic activity related to refuge recreational use. The study found that, for San Luis NWR, visitor recreation expenditures for 2017 were $3.9 million, with non-residents accounting for $2.7 million or 68 percent of the total. Expenditures on non-consumptive activities (such as wildlife observation and photography, interpretation, hiking and auto tours) accounted for 82 percent of spending. Spending in the local area generates and supports economic activity. The contribution of recreational spending in the local communities surrounding the refuge was associated with about 46 jobs, $1.7 million in employment income, $469,000 in total tax revenue and $5.9 million in economic output (Caudill and Carver 2019).

For Merced NWR, the *Banking on Nature Study* found that visitor recreation expenditures for 2017 were $1.1 million, with non-residents accounting for $728,000 or 67 percent of the total. Expenditures on non-consumptive activities accounted for 96 percent of spending. The contribution of recreational spending in local communities was associated with about 13 jobs, $472,000 in employment income, $129,000 in total tax revenue, and $1.6 million in economic output (Caudill and Carver 2019).

Chapter 4: Refuge Management Direction

Introduction

This chapter focuses on the vision, goals, objectives and strategies selected for the management of the San Luis NWR Complex (Merced NWR, San Luis NWR and Grasslands WMA). During the preparation of this CCP, the Service examined and analyzed various management alternatives for the San Luis NWR Complex to best achieve the mission of the Refuge System and its purposes, vision statement and goals; it also considered the existing resources and infrastructure of the overall Complex as outlined in Chapter 3, and the Complex's management concerns and opportunities. Agencies, non-governmental organizations and the public provided input used to develop the management alternatives, which were examined for both natural resource management and public use activities at the Complex. These alternatives were considered and their impacts were reviewed in an EA as part of this plan's compliance with NEPA (Appendix D).

Vision Statement

Our vision of the future conditions on the San Luis and Merced NWRs and Grasslands WMA is:

The San Luis NWR, Merced NWR and Grasslands WMA together make up the heart of California's largest contiguous freshwater wetlands, providing vital habitat for waterfowl and other migratory birds as well as assemblages of resident wildlife. Together, these lands are managed as a vital link in a chain of wetlands along the Pacific Flyway, providing refuge for millions of migratory birds; it is a unique area of incredible beauty and biodiversity offering permanent and seasonal wetlands, riparian corridors and native grasslands. These areas will be preserved for their ecological importance and for the wildlife that depends upon them, from native chinook salmon making the arduous journey to historic spawning grounds, to majestic tule elk bugling amid the grasslands, to sandhill cranes emitting their clarion call, and to flocks of waterfowl large enough to darken the sky. Here, visitors reconnect to the rich wildlife heritage of the San Joaquin Valley—participating in a variety of wildlife-dependent recreational activities and uses. Complex staff are committed to protecting and preserving wildlife and their habitats in the face of ongoing challenges from climate change, urban expansion and continued habitat degradation. As such, the Complex will contribute to the mission of the National Wildlife Refuge System.

Goals

Goals guide the future direction of the Complex by describing desired end results and providing management direction. Goals are directly tied to the Complex vision, refuge purposes, and the Refuge System mission. Each goal is supported by objectives providing quantitative benchmarks that indicate progress toward achieving goals.

Five broad goals were developed for the natural resource and public use alternatives selected for the management of the San Luis NWR Complex. They are consistent with the Complex purposes, ecoregion goals, Refuge System goals, Refuge Improvement Act, Service policy and international treaties. The CCP goals are as follows:

Goal 1: Migratory Birds and Biological Diversity

Conserve, protect, manage, restore and enhance natural habitats and associated plant and wildlife species of the Northern San Joaquin Valley on Complex lands, with an emphasis on supporting an abundance and natural diversity of migratory birds including waterfowl, shorebirds, waterbirds, raptors, songbirds and other wildlife. (Merced and San Luis NWRs).

Goal 2: Threatened and Endangered Species

Contribute to the recovery of threatened and endangered species as well as the protection and management of populations of endemic Central Valley wildlife and Special Status wildlife, plants and habitats. (Merced and San Luis NWRs).

Goal 3: Ecological Processes, Ecosystem Management and Partnerships

Maintain, enhance and restore natural ecological processes to promote healthy, functioning ecosystems for wildlife on Complex lands by developing strong relationships with partners, research institutions, and other local, state and Federal agencies. Coordinate the natural resource management of the Complex's natural resources within the larger context of the Central Valley/San Francisco Ecoregion and Pacific Flyway. (Merced and San Luis NWRs).

Goal 4: Visitor Services and Public Use

Provide the public with opportunities for compatible, wildlife-dependent recreation and other uses to enhance understanding, appreciation and enjoyment of natural resources on the Complex. (Merced and San Luis NWRs).

Goal 5: Wildlife Conservation Easement Management

Manage the Service's easement program on private lands for the benefit of wildlife and explore the potential for additional wildlife easement from willing sellers within the approved easement acquisition boundary. (Grasslands WMA).

Objectives and Strategies

Objectives are concise statements of what the Service wants to achieve, how much the Service wants to achieve, when and where the Service wants to achieve it and who is responsible for the work. Objectives derive from goals and provide the basis for determining strategies, monitoring refuge accomplishments and evaluating the success of strategies.

Objectives in this CCP are a combination of objectives developed solely for the CCP and those that were developed during RAMP in 2021[14]. Objectives developed during RAMP focus only on one "resource of concern," which for the San Luis NWR Complex was the riparian ecosystem.

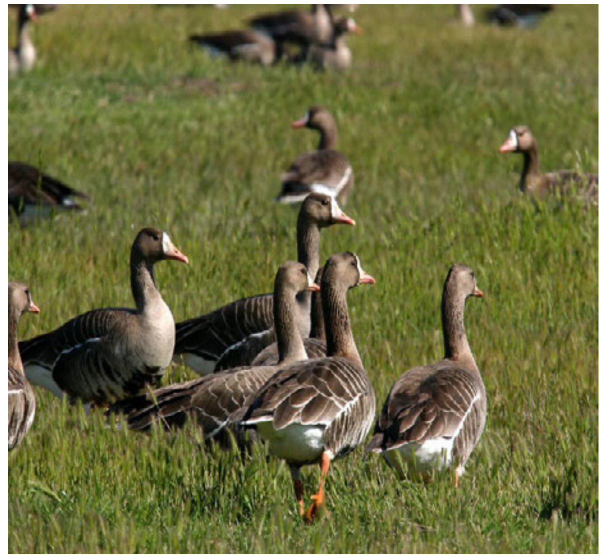
Each objective and strategy are given a unique numeric code for easy reference. The first digit corresponds to the goal, the second to the objective and the third to the strategy.

[14] https://ecos.fws.gov/ServCat/Reference/Profile/131617

Goal 1 Objectives and Strategies

Goal 1: Migratory Birds and Biological Diversity (Merced and San Luis NWRs)

Conserve, protect, manage, restore and enhance natural habitats and associated plant and wildlife species of the Northern San Joaquin Valley on Complex lands, with an emphasis on supporting an abundance and natural diversity of migratory birds including waterfowl, shorebirds, waterbirds, raptors, songbirds and other wildlife.



Greater White-fronted Geese. Photo: Rick Lewis

Objective 1.1: Seasonal Wetlands Management

Manage over 6,500 acres of seasonal wetlands on San Luis and Merced NWRs to meet the habitat needs of migratory waterfowl, shorebirds and other seasonal wetland-dependent species.

Rationale 1.1:

The severe loss of wetlands worldwide (Mitsch and Gosselink 2000) has significantly increased their importance to wetland-dependent organisms. In California alone, nearly 95 percent of wetland habitats have been lost or degraded (Heitmeyer, Connelly, and Pedersen 1989). The altered hydrology and loss of historic wetlands in California's Central Valley require that natural resource managers actively manage wetland habitats by manipulating water through its delivery and retention, controlling vegetation, and mimicking natural hydrological regimes in order to provide a diversity of habitats for wetland-dependent wildlife species. Most wetlands in California's Central Valley are managed as seasonal wetlands. Typically, seasonal wetlands are flooded in late summer/early fall stable water levels are maintained throughout the winter, with drawdowns occurring in late winter to early spring. Moist soil plants germinate and grow throughout the spring and summer, sometimes with one to three irrigations, and the cycle is repeated.

Wetlands support a tremendous abundance and diversity of wildlife on the San Luis and Merced NWRs. Since water supply on the refuge has little connection to natural hydrological regimes and instead is dependent on the Central Valley Project infrastructure, managing seasonal wetlands efficiently is vital to providing migratory bird habitat and food on the refuge. The GEA encompassing San Luis and Merced NWRs winters more than two million waterfowl and more than 25,000 sandhill cranes and is one of only 22 international shorebird reserves in the world. Seasonal wetland management supports the objectives stated in The North American Waterfowl Management Plan (USFWS et al. 1986, 1998), the CVJV Implementation Plan (CVJV 2020), and the Central Valley and Bay-Delta Region Conservation Actions of the California Wildlife Action Plan.

Seasonal Wetlands Management Strategies:

Manage over 110 units on San Luis and Merced NWRs as seasonal wetlands for the benefit of waterbirds, including 35 wetlands on the San Luis unit, nine wetlands on the West Bear Creek unit, 18 wetlands on the Kesterson unit, five wetlands on the East Bear Creek unit, four wetlands on the Freitas unit, and five wetlands on the Blue Goose unit of the San Luis NWR; and 39 seasonal wetlands on Merced NWR.

Secure and provide adequate water supplies for seasonal wetland units during flood-up, maintenance flows and irrigations for seasonal wetland units using delivered water, lift pumps and deep wells.

Maintain and manage water levels of flooded seasonal wetlands throughout the winter using properly functioning water control structures and screw gates, maintenance flows and staff gauge readings.

Manipulate wetland drawdown schedules of seasonal wetlands to provide habitat for waterfowl and shorebirds and germinate moist soil plants.

Identify seasonal wetland units more conducive to growing swamp timothy, watergrass, smartweed and other preferred waterfowl food plants due to soil type and water quality and prioritize management regimes at seasonal wetland units based on ability to produce preferred waterfowl food plants.

Maintain shallow water and mudflat habitats in seasonal wetlands for spring migrant shorebirds.

Time irrigations of developing wetland food plants to maximize benefits to plants and water usage in seasonal wetlands.

Prepare wetlands prior to flood-up to maximize habitat suitability for waterbirds through planned mowing, burning and disking of wetland vegetation to create open water, reduce undesirable plants (e.g., cocklebur) and clear loafing areas. Employ a disking cycle of approximately 6 years for seasonal wetland management.

Conduct full and partial rehabilitations of seasonal wetland units using a combination of herbicide application, prescribed fire and disking to remove rank vegetation, create open water areas and increase wetland food plant production in seasonal wetlands.

Initiate flood-up in seasonal wetlands to coincide with waterfowl and shorebird fall migration while maximizing available water.

Maintain water control structures, delivery canals, lift pumps and deep wells to ensure efficient water management in seasonal wetlands.

Annually monitor wetland plant productivity in seasonal wetlands using qualitative/quantitative methods to determine management effectiveness. Conduct quantitative surveys of wetland plants in seasonal wetlands on a 3-year cycle.

Conduct monitoring of all seasonal wetlands to determine waterbird density, distribution and habitat affinities throughout the non-breeding season.

Conduct analyses of wetland plant abundance and waterbird density in seasonal wetlands in relation to wetland management practices.

Develop annual wetland management plans employing the Complex's wetland database and develop associated flood-up, drawdown, and disturbance (mowing, disking and burning) plans for all seasonal wetlands.

Annually update the San Luis NWR Complex's wetland management database with habitat objectives and water and vegetation management actions to track changes over time and assist with wetland management planning.

Use the San Luis NWR Complex's wetland management database to create annual reports on management actions and determine if planned actions were successful.

Objective 1.2: Permanent/Semi-Permanent/Reverse Cycle Wetland Management

Manage approximately 860 acres of permanent, semi-permanent and reverse cycle wetlands on San Luis NWR and Merced NWR to meet the summertime habitat needs of locally nesting migratory birds and other wetland-dependent wildlife.

Rationale 1.2:

The altered hydrology and loss of historic wetlands in the Central Valley of California requires that resource managers actively manage wetland habitats through delivering water, manipulating water levels and controlling vegetation to provide a diversity of habitats for wetlands dependent wildlife. This loss has been especially severe in wetlands that provide year-round and summertime habitat. Although most wetlands management on the Complex is focused on meeting the migration and wintering needs of waterfowl, shorebirds, cranes and other migratory birds, there is a need to provide summer habitat for marsh nesting waterbirds, colonial nesting birds, locally nesting waterfowl and other wetland-associated wildlife. The 860 acres of permanent, semi-permanent and reverse cycle wetlands represent about five to 10 percent of the total wetland habitat base for San Luis NWR and Merced NWR.

Permanent/Semi-Permanent/Reverse Cycle Wetland Management Strategies:

1.2.1. In years when refuge receives Level 4 water supplies, incorporate management of permanent, semi-permanent and reverse cycle wetlands into the annual habitat management planning process.

1.2.2. In years when refuge receives Level 4 water supplies, manage approximately 370 acres as permanent wetlands on San Luis NWR and 150 acres of permanent wetlands on Merced NWR to provide habitat for marsh nesting birds and escape cover for molting waterfowl.

1.2.3. Manage approximately 200 acres as semi-permanent wetlands on San Luis NWR and 10 acres of semi-permanent wetlands on Merced NWR with drawdown and flood-up timed to optimize germination and growth of native pondweeds.

1.2.4. In years when refuge receives Level 4 water supplies, manage approximately 140 acres as reverse cycle wetlands on San Luis NWR and 85 acres of reverse cycle wetlands on Merced NWR to provide optimal foraging habitat for duck broods and other wildlife.

1.2.5. Maintain stable water levels in permanent wetlands, and semi-permanent and reverse cycle wetlands when flooded, to provide summer water and habitat for wildlife and to limit encroaching emergent vegetation.

1.2.6. Maintain a regular schedule of staff gauge water level readings to monitor water levels and ensure delivery of water to maintain prescribed water levels and provide maintenance flows.

1.2.7. Conduct annual evaluations to see if management objectives are being met, units need to be rehabilitated or water control structures need to be replaced.

1.2.8. Periodically dry up permanent wetlands to control non-native fish populations and promote submerged aquatic vegetation growth through improved water clarity, oxidize bottom sediments to improve soil productivity and set back emergent growth to maintain open water.

1.2.9. Maintain long-term productivity of semi-permanent wetlands by periodically disking and burning vegetation in basin to reduce emergent vegetation cover and maintain soil productivity.

1.2.10. Periodically dry up reverse cycle wetlands and conduct prescribed burning in basin to reduce emergent vegetation cover and maintain soil productivity.

1.2.11. Record unit prescriptions, results from management activities, staff gauge readings and other records, and incorporate into the Complex's wetland database.

Objective 1.3: Other (Unmanaged) Wetlands Management

Maintain approximately 4,000 acres of unmanaged wetlands and enhance floodplain functions on San Luis NWR and Merced NWR to meet biodiversity goals and provide both annual and periodic wetland habitat for migratory birds and other wetland-dependent wildlife.

Rationale 1.3:

Although most of the regularly flooded wetlands on the refuges are under direct management, varying amounts of on-refuge wetland habitat are either unmanaged or not under control by the Complex. These include the San Joaquin River and associated creek/slough channels, natural basins that flood from high water tables or overflow from adjacent sloughs, and open grassy floodplain channels that periodically are inundated from winter heavy rains. In addition, large areas of floodplain on both San Luis NWR and Merced NWR (thousands of acres) can be inundated for varying amounts of time during major flood events. These periodically flooded wetlands provide a remnant approximation of natural hydrologic events in the GEA. They also contribute to the biodiversity of the NWRs, form high quality wildlife habitats and provide groundwater recharge. Vernal pools also are considered unmanaged wetlands but are addressed elsewhere in this chapter.

Other Wetlands Management Strategies:

Black-necked Stilt. Photo: Rick Lewis

Inventory and map high water table/overflow basins and incorporate them into the wetlands database as unmanaged wetlands for the Merced and San Luis NWRs.

Inventory and map river/slough channels (maximum and minimum channel width) and incorporate them into the wetlands database as unmanaged wetlands for the Merced and San Luis NWRs.

Retain the natural features of unmanaged wetlands such as overflow basins and floodplain channels on native uplands and floodplains to promote floodplain hydrological processes when possible.

Contribute to flows of the San Joaquin River, Salt Slough, Mariposa Creek and other associated creeks and sloughs by routing drainage from managed wetlands into those systems at the Merced and San Luis NWRs.

Evaluate existing man-made berms across floodplain channels on newly acquired lands and remove as necessary to restore ability of channels to convey waters across the floodplain during periodic flood events.

Design restored wetland basins and infrastructure within previously altered floodplains to accommodate and facilitate high water flows during flood events.

Actively pursue opportunities to divert floodwaters from within levees onto floodplains at the Merced and San Luis NWRs.

Objective 1.4: Water Quantity

Maintain and use the 74,415 acre-feet of delivered water supplied under the CVPIA (Level 2 and Level 4) to the Merced NWR (16,000 acre-feet) and San Luis NWR (58,415 acre-feet) for the purposes of wildlife and habitat management, with an emphasis on wetland management for waterfowl, shorebirds and other waterbirds. Continue to use non-CVPIA water sources, equating to approximately 200 acre-feet from riparian water rights and 8,000 acre-feet from groundwater for Merced NWR; and 3,600 acre-feet from riparian water rights and 1,000 acre-feet from groundwater for the San Luis NWR, to meet wildlife management goals.

Rationale 1.4:

Adequate water supplies are in high demand and short supply in the San Joaquin Valley of California. Approximately 70 percent of the existing wetlands on both Merced and San Luis NWRs have sufficiently reliable water supplies to manage at optimal levels. The remaining 30 percent of wetlands either remain dry due to lack of water or are sporadically flooded when intermittent water sources and/or funding become available. The refuges also are challenged by the timing when water is available. Surface water deliveries correspond to agricultural irrigation cycles that begin in April and end in September or October. However, most of the managed wetlands are flooded during the autumn when the irrigation season is ending; they hold water throughout the winter and are drained during the spring. As a result, surface water is not available in sufficient quantities to manage the wetlands when it is most needed. Consequently, the refuges, particularly Merced NWR, must rely on groundwater pumping (which is more expensive, less efficient and of lower water quality) or other more costly sources of water. The wildlife-friendly agricultural production occurring on the Merced NWR is better aligned to the current water delivery schedule and does not suffer the same constraints; however, it also requires a significant quantity of water. Any reduction of the water supply will negatively affect one or both management programs.

The potential impacts of climate change on water availability are of serious concern to both Merced NWR and San Luis NWR. Temperature increases will cause less precipitation to fall as snow, resulting in a reduction in the amount and reliability of water available in Central Valley reservoirs, which would lead to increased demands and rising water costs, thereby increasing competition between a growing urban population, the agriculture industry and wildlife needs. Additionally, the increased demands for electricity will make it more costly for the refuges to operate lift pumps and deep wells, making it more difficult to manage wetland habitat and the wildlife beneficial agricultural program on Merced NWR. It is imperative that the Merced and San Luis NWRs maintain the water quantities currently secured under the CVPIA while continuing to seek and identify additional water sources to meet their full wetland and other wildlife management needs.

Water Quantity Strategies:

Continue to work with the MID to secure and maintain the full 16,000 acre-feet (13,500 acre-feet of Level 2 and 2,500 acre-feet of Level 4) water allotments authorized to the Merced

NWR by the CVPIA to effectively manage 1,360 acres of wetlands and 770 acres of wildlife beneficial crops.

Continue to research water rights or funding to secure an additional 4,000 acre-feet (for a total of 20,000 acre-feet) of water to manage 1,360 acres of wetlands (16,320 acre-feet) and 770 acres of wildlife beneficial crops (2,300 acre-feet) for the Merced unit of the Merced NWR.

Continue to research water rights or funding to secure 1,300 acre-feet of water to manage 129 acres of wetlands for the Lonetree unit of the Merced NWR.

Continue to research water rights or funding to secure 5,000 acre-feet of water to manage 497 acres of wetlands for the Arena Plains unit of the Merced NWR.

Continue to research water rights or funding to secure 2,500 acre-feet of water to manage 250 acres of wetlands for the Snobird unit of the Merced NWR.

Continue to work with the Grassland Water District, Henry Miller Reclamation District, San Luis Water District and Stevinson Water District (San Luis NWR) to secure the full 58,415 acre-feet (50,380 acre-feet of Level 2 and 8,035 acre-feet of Level 4) water allotments, under CVPIA, for the San Luis, Kesterson, Blue Goose, Frietas, West Bear Creek and East Bear Creek units of the San Luis NWR.

Continue to research water rights or funding to secure an additional 5,000 acre-feet (for a total of 36,207 acre-feet) of water to manage 2,778 acres of wetlands for the San Luis and West Bear Creek units of the San Luis NWR.

Continue to research water rights or funding to secure a total of 13,295 acre-feet of water to manage 1,000 acres of wetlands for the East Bear Creek unit of the San Luis NWR.

Continue to research water rights or funding to secure an additional 3,000 acre-feet (for a total of 18,310 acre-feet) of water to manage 1,637 acres of wetlands for the Freitas, Blue Goose and Kesterson units of the San Luis NWR.

Identify and secure funding through CVPIA to provide pumping costs for wetland management program on the East Bear Creek unit of the San Luis NWR.

Secure full water pumping and wheeling costs through CVPIA to the San Luis NWR boundary.

Clarify the water delivery schedule for the Merced NWR to determine whether MID can prematurely stop delivery due to water shortages or other causes under the FERC settlement and CVPIA. Participate in the FERC re-licensing process for MID to secure an extended water delivery season without limits on CFS amounts as well as extending the water delivery area (to include the Lonetree, Snobird, Arena Plains and East Bear Creek units).

Continue to identify and secure year-round sources of delivered water for the Merced NWR and San Luis NWR.

Work with irrigation districts to limit the effects of temporary shutdowns of water deliveries to the Merced NWR and San Luis NWR.

Document and report annual water use for surface-delivered water from the irrigation districts and other water suppliers, ground well sources and other water sources.

Maintain water delivery infrastructure in good working order.

Identify potential water conservation projects at the Complex and implement when the projects are funded.

Secure funding to improve the efficiency of the water delivery infrastructure.

Secure funding to improve the energy efficiency of ground wells and lift pumps.

Continue to work with CAA partners to provide groundwater pumping costs for wetland management on the Arena Plains and Snobird units of the Merced NWR.

Document and maintain all water rights granted to the Merced NWR and San Luis NWR.

Investigate the impacts of water seepage and evaporation on wetland and agricultural management to the Merced NWR and San Luis NWR.

Identify strategies and funding to maintain existing water supplies while securing additional sources of water to effectively counter the effects of climate change.

Develop annual water delivery schedules for the Merced and San Luis NWRs.

Maintain and update the Complex's water database on water use and deliveries for the Merced and San Luis NWRs.

Prepare the annual USBR water management plans for the Merced and San Luis NWRs.

Objective 1.5: Water Quality

Ensure that Complex water supplies, including delivered water, meet CVRWQCB and other standards/guidelines for use on wetlands and that discharges from managed wetlands do not exceed total daily maximum load limits established by that board or exceed other standards/guidelines.

Rationale 1.5:

Maintaining and ideally improving water quality is an essential part of Complex operations and is critical to maintaining the health and productivity of fish and wildlife communities. Water discharges from the refuges should not contribute to the degradation of the San Joaquin River; a goal that is complicated by the fact that the San Luis NWR and private lands within the Grasslands WMA often are delivered water that has been mixed with surface drainwater, and these waters in turn drain from refuge lands into the San Joaquin River.

Water Quality Strategies:

Collect published reports and documents on the water quality of existing and potential water supplies to determine potential water quality problems.

Develop a monitoring program to determine the baseline water quality for Complex lands and monitor Complex water supply quality.

Determine the soil salt and pH tolerances of key plant and animal species on the San Luis NWR and determine the current status and rate of change of these parameters in refuge soil and water.

Ensure that water applied to Complex wetlands does not exceed two parts per billion (ppb) selenium (minimum CVRWQCB standards).

Ensure adequate quantities of delivered water are available to permit maintenance flows sufficient to prevent salinization of soils in seasonal wetland basins.

Encourage research into salt, carbon, methylmercury and selenium flux into and out of Complex wetlands.

Work with NRCS and upstream landowners to reduce sediment loads of drainwater coming onto the Complex by implementing recommendations outlined in the USDA Sediment Reduction Plan and, where possible, implement those same recommendations on the Complex to further reduce sediment flow into the San Joaquin River.

Work with the USFWS Sacramento Ecological Services Office to fund and implement water quality and contaminants assessments at the Complex.

Participate in the CVRWQCB process to establish total maximum load limits of salts, boron and other constituents in the San Joaquin River.

Work with other agencies and partners to improve the quality of delivered water to the Complex.

Maintain and update the Complex's water database on salinity levels of delivered water.

Objective 1.6: Grasslands Management

Protect and manage grassland habitats (more than 24,000 acres) to benefit native vegetation and wildlife species.

Rationale 1.6:

Grassland ecosystems of North America have declined by 80 percent since the mid-1800s (Knopf 1994), with less than 1 percent of California's original grasslands remaining due to conversion to cropland, development, wildfire suppression and introduction of non-native plant species. In California, grasslands currently are one of the state's most threatened ecosystems (Noss, LaRoe, and Scott 1995), with approximately 90 percent of the species listed in the Inventory of Rare and Endangered Species in California occurring in grassland ecosystems (Skinner and Pavlik 1994). Perennial and annual grasslands provide numerous important habitat components, including foraging areas, nesting and thermal and escape cover, for a variety of wildlife species on the refuges. Complex grasslands are managed by grazing, herbicide application, mechanical treatments and prescribed fire to control invasive weeds, reduce non-native annual grass growth, increase native perennial grass growth and encourage the growth of native forbs. These management techniques also are used to maintain short grass forage for arctic nesting geese, sandhill cranes and other migratory birds, reduce vegetative structure for kit fox and burrowing owls and maintain vernal pool communities. Research conducted in refuge grasslands must consider current ratios of native to non-native species, historical use of grazing on refuge grasslands, and current and future climates (Corbin, Dyer, and Seabloom 2007).

Grassland Management Strategies:

1.6.1. Implement the grassland management portion of the Complex's Habitat Management Plan to manage more than 24,000 acres of grasslands for wildlife.

1.6.2. Incorporate grassland management into the annual habitat management planning process and update the upland habitat management database annually.

Cattle grazing grassland. Photo: USFWS

1.6.3. Develop a more refined grassland habitat classification system for upland areas at the Complex incorporating plant composition/structure and soil criteria. Develop and update the GIS baseline layer of upland habitats and upland management units for the Complex.

1.6.4. Conserve, protect, enhance and restore a variety of perennial and annual grasslands based on soil types, hydrology or other abiotic and biotic features.

1.6.5. Manage grasslands at the Complex with a combination of appropriate grazing, herbicide application, mechanical treatments and prescribed fire regimes.

1.6.6. Maintain a minimum of 10,000 acres of short grass habitat conditions at the Complex for arctic nesting geese, sandhill cranes, vernal pool communities and other dependent species through grazing, prescribed fire, mowing and other methods.

1.6.7. Maintain a minimum of 10,000 acres of tall grass habitat conditions for breeding and nesting wildlife at the Complex.

1.6.8. Map and control the spread of exotic invasive plant species: perennial pepperweed, yellow starthistle, five-hook bassia, poison hemlock and other invasives with appropriate herbicides, mechanical methods (mowing, disking), grazing and prescribed burns.

1.6.9. Treat at least 2,000 acres of grassland habitat annually with prescribed fire to enhance native plant species, reduce noxious weeds, increase nutrient levels of forage for native wildlife and reduce hazardous fuel loads.

1.6.10. All grazing programs used for grassland management at the Complex will be implemented though the CAA process. All CAAs will develop an annual grazing plan indicating locations, habitat objectives, stocking levels, timing of grazing, trigger points for livestock entry and exit, restrictions and other management issues.

1.6.11. Restore 30 acres of grassland habitat annually at the Complex using native plants seeds and plugs derived from local ecotypes.

1.6.12. Enhance topographic features of former agricultural lands through de-leveling and mound construction to benefit native wildlife and vegetation species.

1.6.13. Protect hydrology of grassland habitat by controlling runoff from surrounding flooded lands. Enhance hydrological function of grasslands through the removal of unnecessary berms or other obstructions.

1.6.14. Enhance topographic features for selected wildlife species (burrowing owl and kit fox, for example).

1.6.15. Conduct and evaluate periodic baseline grassland vegetation surveys at the Merced and San Luis NWRs.

1.6.16. Conduct biological monitoring to determine changes in the community and species diversity following the use of management techniques and to assess the effectiveness of these techniques in meeting management goals and increasing overall biodiversity.

1.6.17. Conduct surveys of grassland habitats to determine wildlife abundance, distribution, and habitat use of native and non-native grassland habitats. Focal species include sandhill crane, long-billed curlew, arctic nesting geese, kangaroo rat species and other small mammals.

1.6.18. Develop a list of grassland habitat indicator species (plants, invertebrates, mammals, birds and herps) that best indicate habitat changes in hydrologic factors, vegetation cover, composition and biodiversity and that capture the variability of the Complex's grassland habitats. Develop indicator metrics and methods for monitoring indicator species of grasslands that best meet objectives, such as number of individuals per unit, by season, reproductive success, species distribution and seasonal habitat. Regularly monitor target indicator species of grasslands.

1.6.19. Support management-oriented research within grassland habitats focused on wildlife and vegetation species.

1.6.20. Incorporate grassland management practices as needed that support the objectives of the Grassland Bird Conservation Plan (CalPIF 2000), the Central Valley and Bay-Delta Region Conservation Action Plan (CDFW 2005) and other national resource plans.

Objective 1.7: Croplands (Agricultural Lands) Management

Manage approximately 750 acres of agricultural lands (corn, winter wheat and irrigated pasture) on the Merced NWR to meet a portion of the habitat requirements of lesser sandhill cranes, arctic-nesting geese and other migratory and resident wildlife. The San Luis NWR no longer manages any type of agricultural land.

Rationale 1.7:

Over the past century, many species of migratory and resident wildlife have become dependent on agricultural lands during part of their annual life cycle. There is a long history of cranes, geese, ducks and other migratory birds using the croplands and pastures of the GEA. The Merced NWR has grown crops since its inception in 1951, primarily to provide food for cranes and waterfowl and lure them away from private agricultural crops. Management of agricultural lands for the benefit of migratory birds and resident wildlife is an integral part of the Refuge Farming and Grazing Program. Currently, this program is managed under a CLMA, a partnership with a private party for crop cultivation, grazing and haying under refuge management supervision.

Croplands Management Strategies

Create an Annual Farming and Grazing Plan to determine the acreage and locations of corn, alfalfa and winter wheat crops to be grown for wildlife winter forage. Crops are rotated periodically to increase efficiency and wildlife foraging values.

Coordinate with the selected private party listed in the CAA to prepare the soil, plant the seed, irrigate, fertilize and maintain the crops through maturity.

Ensure no genetically modified crops, including Roundup Ready® Corn, will be used on refuge lands.

Ascertain the vegetative status and wildlife value of each irrigated pasture within the refuge. Rehabilitation of the irrigated pastures periodically is needed to maintain optimal wildlife forage quality.

Coordinate with the selected private party listed in the CAA to irrigate, graze and hay the field for the benefit of wildlife. Grazing irrigated pasture maintains short-cropped winter wildlife foraging habitat.

Coordinate with the selected private party listed on the CAA to control exotic and invasive weeds on refuge agricultural lands using only pre-approved herbicides and other techniques. Investigate alternative crop options/management activities in response to changes in climate and water resources.

Monitor the use of croplands and irrigated pastures by wildlife (e.g., sandhill crane, geese). Monitor crop yield production to ascertain program value and ascertain target wildlife use of these areas based on crop yield.

Objective 1.8: Riparian Flooding Duration and Extent

Over five years (2021–2026), riparian conditions will be considered healthy and functioning when the extent of winter and spring (January–April) floods cover 30 to 50 percent of the riparian ecosystem and last less than or equal to 30 days.

Rationale 1.8:

Riparian forests and other riparian plant communities provide habitat for a wide variety of resident and migratory wildlife, including rare and endangered species (Moyle 2002; RHJV 2004). Loss and degradation of historic riparian habitat in the Central Valley of California requires that resource managers actively protect, restore, enhance and manage those remaining areas to optimize the resource benefits provided by these habitats. Most of the on-refuge riparian forest habitat occurs along the mainstem of the San Joaquin River, Salt Slough, associated tributaries and oxbows in the San Luis, West Bear Creek, East Bear Creek and Freitas units of San Luis NWR. A lesser amount of riparian forest is present along Mariposa Creek (Eastside Bypass) and plantings along Deadman Creek at the Merced NWR.

Riparian Flooding Duration and Extent Strategies:

The Refuge Complex, as a stakeholder of the Upper San Joaquin River Regional Flood Management Plan[15], has proposed several multi-benefit projects to reduce impacts of flooding to adjacent communities while enhancing refuge habitats. The goal is to facilitate short-duration low-level flooding, while deterring long-duration high-level flooding.

Objective 1.9: Riparian Habitat Extent

From 2021 to 2031, maintain 3,500–4,699 acres of riparian ecosystem in the *Good* category across the three refuges within the Complex.

Riparian Habitat Extent Strategies include:

Incorporate riparian forest management into the San Luis NWR Complex’s annual upland habitat management planning process and implement RAMP.

Monitor and document riparian forest habitats at the San Luis and Merced NWRs and incorporate the information into habitat maps and upland habitat management database for the Complex.

Document the vegetative composition of riparian forest habitats at the San Luis and Merced NWRs.

Conduct regular wildlife surveys to assess wildlife use of riparian habitats.

Install fences if needed around riparian habitats to exclude livestock and prevent grazing damage at the San Luis and Merced NWRs.

Reduce infestation of riparian corridors by non-native invasive weeds, such as perennial pepperweed, through herbicide application or other techniques.

[15] Available online at https://usjrflood.org/2015/03/09/final-rfmp/.

Enhance riparian habitat by eliminating or reducing non-native invasive trees and shrubs through manual removal, herbicide application or other techniques.

Limit the amount of roads, grazing and unnecessary disturbance adjacent to riparian habitats to reduce negative edge effects, such as brown-headed cowbird nest parasitism.

Restore degraded riparian habitats on Complex lands by natural regeneration and/or active management techniques to restore riparian woodlands in suitable areas.

Support management-oriented research on riparian habitats and associated wildlife.

American Bittern. Photo: Rick Lewis

Objective 1.10: Vernal Pool Habitat Management

Maintain existing vernal pools, associated plant communities and surrounding micro-watersheds to protect these unique habitats and their fauna/flora, such as populations of vernal pool fairy shrimp, *Brachinecta lynchi*; vernal pool tadpole shrimp, *Lepidurus packardi*; and California tiger salamander, *Ambystoma californiense*.

Rationale 1.10:

Approximately 75 percent of all vernal pools in California's Central Valley were lost by 1997, due to land conversion to agricultural croplands and more recently as a result of conversion of historic cattle grazing lands to other uses and widespread urbanization (USFWS 1998, 2005). Vernal pool/alkali meadow conservation, management and restoration are among the mandated purposes of the refuges. Multiple species of fairy shrimp, as well as vernal pool tadpole shrimp and California tiger salamanders, depend on vernal pools for survival. The most important components of preserving vernal pools are maintaining their natural hydrology. Because vernal pools are supplied entirely by rainwater, to protect vernal pool habitats, the integrity of the underlying clay pan of the basin and topography of the micro-watershed must be preserved. During dry years, an additional problem is the encroachment of upland plant species in dry vernal pools, resulting in thatch accumulation that hinders the growth of vernal pool plant species.

Vernal Pool Habitat Management Strategies:

Inventory and map the locations and sizes of vernal pools on the Complex's GIS database.

Document the annual water status and phenology of vernal pools.

Conduct and evaluate regular surveys to assess wildlife use of vernal pool habitats.

Conduct and evaluate periodic vernal pool vegetation surveys.

Support restoration and management-oriented research in vernal pool habitats at the Complex.

Continue the policy of no alteration of the topography of vernal pools.

Use grazing, prescribed fire, herbicides, mowing and other techniques as needed, to maintain short grass plant communities, reduce invasive plant species and reduce thatch accumulation in proximity to vernal pool/alkali meadow habitats.

Incorporate vernal pool management into the annual habitat management planning process and annually update the upland habitat management database.

Protect the hydrology of vernal pool/alkali meadow habitats by controlling runoff from surrounding flooded managed wetlands.

Restore additional acres of vernal pool habitat as opportunities arise, particularly at disturbed sites at the Snobird unit of the Merced NWR.

Objective 1.11: Aquatic Habitat

Maintain and restore aquatic habitats at the San Luis NWR Complex for the benefit of fish and wildlife.

Rationale 1.11:

The quantity and quality of aquatic habitats has declined dramatically, since California's Central Valley was settled in the mid-1800s, due to hydraulic mining; water quality degradation; introduction of exotic fish and plant species; construction of dams, dikes and levees; water diversions; and river and stream canalization. With many aquatic species, including some anadromous fish, on the verge of extinction, the management of aquatic habitats is an important aspect of refuge management.

Aquatic Habitat Strategies:

Map the locations and types of aquatic habitats on the Complex’s GIS database.

Document wildlife and fish use of aquatic habitats at the Refuge Complex.

Repair eroded stream and riverbanks where appropriate to reduce sedimentation and stabilize trees and shrubs to protect aquatic habitats at the Refuge Complex.

Protect aquatic habitats by excluding livestock from grazing in close proximity to aquatic habitats.

Support restoration and management-oriented research in aquatic habitats at the Complex.

Support the restoration of the San Joaquin River and its tributaries, including increased flows.

Reduce or eliminate exotic invasive plants from aquatic habitats at the Complex.

Monitor monthly flows at lentic habitats at the Complex.

Objective 1.12: Migratory Bird Management

Protect, restore and enhance populations of migratory birds and their habitats at the Merced and San Luis NWRs.

Rationale 1.12:

As Federal trust species, migratory birds are managed under the Service's Migratory Bird Program to conserve migratory bird populations and their habitats for future generations through careful monitoring, effective management and supporting national and international partnerships that conserve habitat for migratory birds and other wildlife. The San Luis NWR Complex provides critical habitat for waterfowl and other migratory bird species, including winter residents, summer (breeding) residents and Neotropical migrants that are dependent on the Refuge Complex for resting/refueling habitat. Monitoring is necessary to determine population status, assess population trends, determine causes for poor productivity, identify solutions, determine habitat restoration needs and assess restoration success.

Migratory Bird Management Strategies

Manage upland and riparian areas (more than 10,000 acres) to optimize breeding/nesting habitat for summer resident migratory birds.

Manage upland and riparian areas (more than 10,000 acres) to optimize resting, foraging and roosting habitat for migratory birds.

Manage wetland habitats (more than 11,000 acres) to optimize use by migratory birds during peak use times—autumn, winter and spring migration.

Maintain water in leveled and unleveled seasonal wetlands to provide habitat for migratory birds from late August through early May.

Manage seasonal wetlands as moist soil units to grow seed and produce invertebrates for migratory waterfowl and other waterbirds.

Long-billed Curlew. Photo: Paul Prado

Manage unleveled wetlands, consisting of natural basins, seasonally flooded channels and vernal pools, to provide a variety of habitats for foraging and loafing sites for migratory birds.

Manage semi-permanent wetlands to provide migratory waterfowl and waterbird habitat when seasonal wetlands are dry.

Use permanent wetlands as year-round habitat for select migratory bird species and as reservoirs for the supply of water to other habitats and to hold their runoff.

Protect and restore riparian habitat as breeding grounds, overwintering areas, dispersal corridors and migration resting areas for riparian birds.

Maintain grassland habitats for grassland birds, using prescribed burns and livestock grazing, to reduce non-native annual grass growth, increase native perennial grass growth and encourage the growth of native forbs.

Continue the livestock grazing program to control weeds and provide short grass stature for cranes and geese on irrigated pasture and native uplands.

Continue to use prescribed fires as a tool to manage uplands to reduce invasive species, release nutrients back into the soil and stimulate native plant growth for use as habitat and food for sandhill cranes and geese.

Manage croplands of irrigated pasture, corn and small grains to produce food and cover crops for migratory birds, as a supplement to food that occurs naturally in wetland habitats.

Maintain closed areas to allow migratory waterfowl and other waterbirds the opportunity to feed and rest without disturbance; provide opportunities for molting, preening, pair bonding and fat storage; and improve hunting success.

Implement nest box and nest platform programs as needed to enhance select migratory bird populations at the Complex.

Document Complex use by, or presence of, migratory bird species.

Conduct regular surveys for migratory birds.

Continue to conduct surveys of colonial-nesting waterbirds to track population trends, document new colonies and abandonment of colonies and provide information for public use planning.

Continue to monitor, manage habitat and control public use to conserve and protect greater and lesser sandhill cranes and other migratory birds.

Continue to monitor the abundance, diversity and habitat use of grassland birds.

Continue to monitor mourning doves as requested in support of the National Dove Management Plan.

Develop and implement a raptor monitoring protocol for the Complex.

Conduct and support management-oriented research on migratory bird species.

Conduct periodic coordinated mist netting/banding activities to collect population and distribution data on riparian songbirds.

Conduct periodic coordinated surveys (including banding) as needed with partners such as Point Blue Conservation Science, California Partners in Flight, CVJV, CDFW and other Pacific Flyway entities for selected migrating bird species.

At the Complex, support conservation plans such as the Grassland Bird Conservation Plan (California Partners in Flight) and the California RHJV Conservation Plan, through cooperation and management.

Objective 1.13: Waterfowl Management

Ensure significant, robust use by waterfowl—ducks, geese and swans—of the Merced and San Luis NWRs by protecting, managing and enhancing wetland and upland habitats, monitoring waterfowl use, providing disturbance free areas and conducting a disease control program.

Rationale 1.13:

Migratory birds are Federal trust species under the jurisdiction of the Service. Their conservation, management and restoration are among the mandated purposes of the Refuge System. Both Merced NWR and San Luis NWR were established primarily because of their importance as wintering habitat for waterfowl in the Pacific Flyway. As such, most of the refuge wetlands and uplands management is focused on meeting the habitat needs of wintering, and to a lesser extent, locally nesting, waterfowl. Surveys, banding and other monitoring are necessary to determine population status and effectiveness of habitat management at the Refuge Complex level, and to contribute to Flyway/nationwide efforts to assess and manage waterfowl populations. Direct population management activities, such as disease control and installing nest boxes, are necessary to maintain population size and health and to enhance the productivity of the waterfowl resource.

Waterfowl Management Strategies:

Manage more than 5,000 acres of seasonal, permanent and semi-permanent wetlands and more than 8,000 acres of native uplands at the San Luis NWR to provide wintering habitat for more than 200,000 ducks and geese.

Manage more than 1,700 acres of seasonal, permanent and semi-permanent wetlands, more than 350 acres of cropland/irrigated pasture and more than 3,000 acres of native uplands at the Merced NWR to provide wintering habitat for more than 200,000 ducks and geese.

Graze, burn and/or mow more than 10,000 acres of Complex grasslands (including more than 50 percent of the Arena Plains unit of the Merced NWR, more than 50 percent of the Snobird unit of the Merced NWR and more than 50 percent of the East Bear Creek unit of the San Luis NWR) to provide short grass habitat for arctic nesting geese.

Maintain undisturbed, tall vegetation, particularly adjacent to permanent and reverse-cycle wetlands, on more than 10,000 acres to provide nesting cover for breeding ducks and other birds on all units of the San Luis and Merced NWRs.

Produce at least 350 acres of grain corn and winter wheat on Merced NWR to attract and hold ducks and geese by providing high energy winter forage.

Complete the restoration of seasonal wetlands at the East Bear Creek unit of San Luis NWR (900 acres) and the Snobird unit of Merced NWR (175 acres) to benefit wintering ducks and geese.

Provide more than 2,600 acres and 700 acres of wetlands within sanctuary zones on San Luis and Merced NWRs, respectively, to provide waterfowl species with habitat free of disturbance.

Conduct bi-monthly waterfowl surveys on the Refuge Complex's seasonal wetlands from mid-August (i.e., at flood-up) through May (i.e., until drawdown). Analyze annual and seasonal trends in seasonal wetland use by waterfowl at the Refuge Complex.

Qualitatively evaluate the Refuge Complex's moist soil food production and wintering waterfowl habitat conditions annually and maintain in the Refuge Complex's wetland database.

Annually monitor abundance and distribution of Aleutian cackling geese and conduct neck-collar observations if appropriate in Merced County in support of DMBM population monitoring efforts.

Monitor and control avian disease outbreaks in waterbirds at the Merced and San Luis NWRs.

Evaluate waterfowl nesting, brood-rearing and molting habitats at the Refuge Complex.

Facilitate as-needed pre-season duck banding and waterfowl banding efforts by others in accordance with the Pacific Flyway Project to meet or exceed Refuge Complex banding quotas.

Maintain and monitor wood duck nest boxes on the Refuge Complex.

Participate in the CVJV as a member of the Waterfowl Working Group and serve on technical committees as assigned.

Document the patterns of the waterfowl community at the Merced and San Luis NWRs and their use of wetlands.

Coordinate as needed with Pacific Flyway entities including USFWS DMBM, CDFW and USGS National Wildlife Health Research Center, and other organizations to assist in and conduct surveys and monitoring such as the November dark goose surveys, December white goose surveys and the four mid-winter waterfowl surveys.

Support management-oriented research on breeding and wintering waterfowl.

Objective 1.14: Shorebirds and Other Waterbirds Management

Ensure significant, robust use by waterbirds (i.e., shorebirds, wading birds, grebes) of the Merced and San Luis NWRs by protecting, managing and enhancing wetland and upland habitats, monitoring waterbird use and providing disturbance free areas. Specifically, by 2024 and across the Complex, the "fair" annual nesting population size of great blue herons (*Ardea herodias*) at known rookeries will be at least 201; the annual nesting population size of great egrets (*A. alba*) at known rookeries will be at least 26; and the annual nesting population size of double crested cormorants (*Phalacrocorax auratus*) at known rookeries will be at least 26.

Rationale 1.14:

Ruby-crowned Kinglet. Photo: Rick Lewis

The CVJV 2020 Implementation Plan identifies 10 focal species of shorebirds and waterbirds, which breed or winter in the San Joaquin River basin of the Central Valley, where the refuges of the Complex are located. In total, this region provides breeding and wintering habitat for more than 35 species of shorebirds and other waterbirds, including egrets, herons, rails, ibises and grebes (CVJV 2020). Seven of the 10 focal species identified by the CVJV are found on the Refuge Complex, including Western grebe, snowy egret, least bittern, American white pelican, white-faced ibis, black tern and sandhill crane. The U.S. Shorebird Conservation Plan and CVJV Implementation Plan (CVJV 2020) address population and habitat objectives for healthy shorebird populations. Complex management strategies seek to support and further these objectives. Monitoring of shorebirds and other waterbirds is necessary to determine population status, assess population trends, determine causes for poor productivity, identify solutions, determine habitat restoration needs and assess restoration success.

Shorebirds and Other Waterbirds Management Strategies

Manage Complex wetlands, uplands and riparian areas to provide habitat for more than 25,000 shorebirds, 15,000 sandhill cranes and a diversity of other waterbird species.

Protect and manage more than 3,700 and 1,500 acres of seasonal wetlands on San Luis NWR and Merced NWR, respectively, to benefit wintering waterbirds populations throughout the Refuge Complex.

Protect and maintain more than 850 and 160 acres of permanent/semi-permanent/reverse cycle wetlands on San Luis NWR and Merced NWR, respectively, for breeding waterbird species.

Provide over 2,600 acres and 700 acres of wetlands within sanctuary zones on San Luis NWR and Merced NWR, respectively, to provide waterbird species with habitat free of disturbance.

Manage over 8,000 and 3,500 acres of native uplands on San Luis NWR and Merced NWR, respectively, through grazing and prescribed fire to provide wintering habitat for sandhill crane and other waterbird species.

Manage cropland and irrigated pasture on the Refuge Complex to provide foraging habitat for sandhill crane, long-billed curlew, whimbrel, white-faced ibis, and other shorebird and waterbird species.

Manipulate drawdown and flood-up schedules to provide suitable shallow water and mud flat habitat for shorebird species during autumn and spring migration periods.

Stabilize water levels in permanent, semi-permanent, and reverse-cycle wetlands during the breeding season to prevent nest flooding or abandonment.

Manage seasonal wetlands to provide shallow water habitat for roosting and loafing sandhill cranes.

Identify new colonial nesting waterbird colonies and protect all established ones in wetlands and riparian zones (heron rookeries) from disturbance.

Maintain dense stands of robust emergent vegetation in seasonal and semi-permanent wetlands for use as roost sites for non-breeding snowy egret, white-faced ibis, least bittern, black-crowned night herons and other waterbird species.

Identify and protect white-faced ibis breeding colonies on San Luis and Merced NWR's lands.

Maintain a mosaic of open-water and dense cover in permanent and semi-permanent wetlands to meet the breeding habitat requirements of a diversity of waterbird species, including white-faced ibis, snowy egret, least bittern, black-crowned night heron, western grebe, Clark's grebe, pied-billed grebe, American coots and common moorhens.

In years when refuge receives Level 4 water supplies, protect, enhance or restore large, permanent and semi-permanent wetlands (30 to 50 acre-minimum) with short-to-medium height vegetation for migratory waterbirds.

Conduct bi-monthly surveys during the non-breeding season of wetlands to determine abundance, diversity, distribution and habitat use of shorebird and other waterbird species using the Complex.

Conduct surveys of permanent and semi-permanent wetlands to determine the occurrence and reproductive success of breeding colonial and non-colonial shorebird and waterbird species.

Conduct monthly monitoring of heronries to determine location, size, the species present and number of nests, breeding pairs and young.

Participate in state- and region-wide coordinated survey efforts for a variety of shorebird and waterbird species.

Support research to identify and assess the spatial patterns of shorebird/waterbird habitat use during the breeding and non-breeding season, investigate forage species preference and determine species response to management activities.

Establish partnerships with local universities and nonprofit groups to conduct monitoring and research activities.

<u>Objective 1.15: Ungulate Management</u>

The San Luis NWR Complex will protect and conserve a healthy, ecologically viable population of the endemic species, California tule elk (*Cervus elaphus nannodes*), to provide a display herd for public viewing, transplant stock for establishing and augmenting free-ranging elk herds in other California locations and a location for on-site elk research (in compliance with the 1974 MOU with CDFW). The Refuge Complex also will protect and conserve a healthy, ecologically viable population of the native deer species, black-tailed deer (*Odocoileus hemionus*). Since the restoration of native species is a goal consistent with the implementation of the Refuge Improvement Act, the Refuge Complex also will consider the feasibility of a future reintroduction of pronghorn antelope (*Antilocapra americana*).

Rationale 1.15:

Historically, it is estimated that California's Central Valley was inhabited by large numbers—up to 500,000 tule elk and "untold thousands" of pronghorn antelope and black-tailed deer. Human activity ultimately resulted in the extirpation of black-tailed deer and pronghorn antelope from the Central Valley, and the near extinction of tule elk. Because the San Luis NWR Complex and associated Grasslands WMA represent the largest contiguous expanse of suitable habitat remaining in the Central Valley, management on behalf of these native ungulate species is critical in assisting the State of California with meeting its tule elk meta-population management goals, and to restoring and maintaining some of the natural biodiversity of the Central Valley.

Ungulate Management Strategies:

Black-tailed Deer. Photo: Karl Stromayer

Maintain the physical and ecological integrity of the 760-acre enclosure for tule elk at the San Luis Unit of the San Luis NWR.

Monitor and maintain the 5.2-mile circumference high-tensile game fence surrounding the enclosure.

Conduct annual monitoring of exotic/invasive plant species to create vegetation maps of the elk enclosure, to assist in targeting control activities.

Control populations of exotic/invasive plant species within the enclosure with prescribed fire, mowing and herbicide applications.

Reduce the threat of wildfire in the enclosure by disking fire breaks inside the fence perimeter.

Maintain adequate and suitable elk forage and cover within the enclosure by controlling exotic/invasive plant species populations, managing grasslands and providing adequate water supplies to support dense emergent wetland plant growth (round stem bulrush and cattail) and riparian vegetation.

Maintain adequate and suitable/year-round water sources within the enclosure through water management practices (i.e., maintaining water control and delivery structures such as canals and sloughs) for the elk herd.

Utilize Complex law enforcement resources to protect the elk herd from poaching and other harassment.

Manage the elk population, so as not to exceed the enclosure's 50 to 80 animal carrying capacity, through capture and translocation of surplus individuals to other populations throughout the state in cooperation with the CDFW.

Manage the San Luis NWR elk population in cooperation with the State of California to meet the state's tule elk metapopulation management goals.

Conduct regular monitoring of the elk herd and document information including quarterly estimates of population size and annual births/deaths and conduct annual collection/removal of dropped antlers from within the enclosure.

Maintain and update elk management documents such as the CWD Plan, Johnne's Disease Management Plan and the MOU (1974) with the CDFW regarding California's Tule Elk Management Plan.

Monitor the elk herd for disease/health issues.

Proceed with phase three of the GEA Tule Elk Reintroduction Feasibility Study to examine potential alternatives for expanding the habitat available for tule elk on the Refuge Complex and throughout the Grasslands WMA, and to propose strategies for addressing any issues related to a possible free-roaming elk herd.

Consider possible expansion of the existing elk enclosure to increase available habitat, and ultimately the size of the San Luis NWR tule elk herd.

Utilize refuge law enforcement resources—in coordination with CDFW—to protect the existing black-tailed deer population at the Complex from poaching and other harassment.

Work with Cal Trans to implement the installation of "deer warning" signs along State Highway 165 in the interest of black-tailed deer conservation and public safety.

Utilize accepted habitat management practices to maintain suitable habitat for black-tailed deer, including grazing and prescribed fire to improve forage and control undesirable broadleaf vegetation throughout the Refuge Complex.

Maintain and update the Deer Herd Management Plan Implementation Program (2003), a cooperative effort between the Service and CDFW to reestablish black-tailed deer in Merced County.

Monitor black-tailed deer abundance on the San Luis NWR Complex.

Conduct a pronghorn antelope feasibility study to investigate the potential for reintroducing this species to the GEA.

Objective 1.16: Upland Wildlife Management

Develop strategies to maintain and restore the recent biodiversity of upland wildlife species in the GEA, with emphasis on the Merced and San Luis NWRs.

Rationale 1.16:

Uplands in the northern San Joaquin Valley are rangelands characterized by grasses, herbs, forbs and shrubs. Plant stature as well as plant species composition and soils are key variables in determining characteristics of upland vegetation communities. Fire and grazing are other key determinants of upland plant community structure and composition and are largely controlled by human actions, as are events such as periodic inundation, which once occurred quite commonly in the ecoregion. The loss of naturally occurring grazing patterns (i.e., by native ungulates) as well as the control of flooding and fire events means that active management will be needed to maintain the full complement of upland wildlife communities in the GEA.

Upland Wildlife Management Strategies:

Prescribed Burn. Photo: USFWS

Identify key, endemic and threatened or endangered upland wildlife species and document their distribution and abundance across the Complex's uplands with a focus on providing a description of the upland wildlife community of the Northern San Joaquin Valley.

Complete a vegetation map of the GEA, including the Merced and San Luis NWRs, with a focus on upland habitats.

Maintain and update the upland habitat management database to monitor planned and actual (realized) upland habitat management actions on the San Luis and Merced NWRs.

Employ grazing, burning, mowing and other techniques to produce a target quantity (10,000 acres) of short grass habitat for a suite of species including arctic nesting geese, long billed curlew, lesser sandhill cranes, kit fox, kangaroo rats and coastal horned lizard, among others.

Ensure a target quantity (10,000 acres) of non-disturbed upland habitats is available for nesting birds (both passerines and non-passerines) on the San Luis and Merced NWRs.

Categorize and define the upland wildlife communities of the upland habitats of the Complex lands.

Develop an integrated pest management plan to control invasive plant and animal species and prevent the introduction of new invasive plant and animal species into upland habitats.

Refine the total amount, distribution, locations and patch size of annually disturbed uplands based on a balance of wildlife needs on the San Luis and Merced NWRs.

Encourage new/continue ongoing research into key upland shrub species such as iodine bush, coyote bush and quail brush (*Atriplex* spp.). Emphasis will include the role of fire and grazing in influencing (if at all) the distribution and abundance of each species.

Encourage new research and continue ongoing research into bat, rodent, lagomorph, mesocarnivore and carnivore species distribution and abundance in upland habitats.

Encourage new research and continue ongoing research into reptile and amphibian species distribution and abundance in upland habitats.

Objective 1.17: Passerine Use in Riparian Habitats

By 2024, at least nine out of 18 representative bird species are detected at least once during 3 years of surveys at San Luis NWR, and at least six are detected at least once during 3 years of surveys at Merced NWR.

Rationale 1.17:

The presence of riparian passerine birds indicates high quality riparian and floodplain ecosystems both because passerines historically have depended on these areas and because several species are sensitive to vegetation composition, structure, and connectivity (Meents et al. 1984). Riparian areas on the Refuge Complex provide important habitats for a diverse community of birds along the Pacific Flyway. Riparian vegetation is the principle breeding habitat for passerines in the Central Valley; the least Bell's vireo (*Vireo vellii pusillus*) is associated with dense, shrubby early to mid-successional riparian habitats, and yellow warbler (*Setophaga petechia*) is associated with riparian thickets, especially willows (Dybala et al. 2017). In addition, passerines, particularly the least Bell's vireo and the yellow warbler, are sensitive to riparian connectivity/fragmentation as well as diversity in plant successional stages (Dybala et al. 2020). Passerine presence and population size is useful for monitoring the effects of management actions on the Refuge Complex's riparian ecosystems because passerines are common enough to provide sufficient sample sizes for analyses, represent a range of life histories and vegetation associations and provide information about different aspects of the riparian ecosystems (Dybala et al. 2017).

Passerine Use in Riparian Habitat Strategies:

Encourage new research and continue ongoing research into passerine bird habitat use of uplands.

Plant appropriate suites of riparian vegetation (trees, woody shrubs, forbs, grasses) that are matched to the soils, hydrology and specific wildlife needs to increase passerine bird use.

Objective 1.18: Fisheries Management

Coordinate with the staff of the USFWS Anadromous Fisheries Recovery Program and other fisheries professionals to ensure that wetlands, aquatic and riparian habitats support and enhance rearing, migration and spawning habitat for native fish species.

Rationale 1.18:

The native and unique fish communities of the Central Valley have been severely impacted and depleted by habitat destruction and the introduction of exotic fish species. Most fish at the Complex are non-native species. Restoration of part or all the native assemblage of Central Valley fish species is a priority for the Merced and San Luis NWRs.

Fisheries Management Strategies:

Update and develop inventories of fish species present in the established and restored waterways of the Merced and San Luis NWRs.

Ascertain the historical fish communities of the northern San Joaquin Valley in particular at the Merced and San Luis NWRs.

Develop a fisheries management program that is compatible with other Refuge management objectives and maximizes habitat benefits to listed and Special Status fish species.

Work with partners to evaluate floodplain rearing potential, conduct monitoring to document actual use by and benefits to listed and Special Status species and resolve any fisheries issues on Complex lands.

Install fish screens as needed on Complex riverine lift pumps to avoid mortality of Special Status species of fish.

Seek funding sources and establish partnerships to develop and implement riparian floodplain restoration projects when funded.

Work and coordinate with CDFW and the USFWS Fisheries Offices to develop and implement fisheries restoration efforts.

Investigate the potential impact of the restoration of the San Joaquin River on fisheries of the Merced and San Luis NWRs.

Investigate the potential impact of the reintroduction of Chinook salmon to the San Joaquin River on the vegetation and wildlife of the streams, aquatic and riparian habitats of the Merced and San Luis NWRs.

Objective 1.19: Nuisance Wildlife Management

Ensure nuisance wildlife populations on the Merced and San Luis NWRs stay at levels that do not threaten the viability of Federal trust species or other species of management concern and do not cause damage to facilities, equipment or infrastructure. Issues of depredation by migratory birds and other wildlife on proximate private property must also be addressed when appropriate.

Rationale 1.19:

The refuge planning policies within the Service's Refuge Manual (7 RM 14.1) establishes Service policy on controlling wildlife and plants in the Refuge System to assure balanced wildlife and fish populations that are consistent with the optimum management of the Refuge. Control measures become necessary when native or non-native wildlife populations interfere with the ability to attain refuge objectives or pose a threat to human health. Control programs are designed to maintain environmental quality and conserve and protect wildlife resources. The techniques are based on a broad systematic approach using all the information available on the ecology of the nuisance animal or plant species. Beavers dam water control structures, delivery and drainage canals and wetland basin low flow channels, impacting the refuges' moist-soil management capabilities by affecting the rate at which water can be moved into and out of managed wetlands. Beavers and muskrats also burrow into the sides of dikes and water control structures, compromising water conveyance systems. Nutria burrow into canals and can cause significant damage to native plant communities from their feeding activities, and their exponential reproductive capability can lead to significant damages within a short temporal period. Burrowing activity along the sides of dikes doubling as roads as well as the removal of materials used to dam water control infrastructure pose significant human health risks. California ground squirrels burrow into roads, flood control levees and dikes, which compromise their integrity and functionality. Feral pigs eat native wildlife including ground nesting birds, disturb soils and damage native plant communities through their rooting activities and negatively impact water quality indirectly through disturbance and directly through defecation in waterways. Migratory birds such as geese and sandhill cranes depredate crops by foraging in nearby agricultural fields, particularly during drought years when food resources are scarce. Tricolored blackbirds can be of concern to nearby dairies when they establish nesting colonies within silage fields and target their feeding activities on silage and grain stores.

Nuisance Wildlife Strategies

Develop and implement a nuisance wildlife management plan for both the Merced and San Luis NWRs within 10 years.

Use a variety of means to address the negative impacts made by beaver and muskrat, to the extent practicable, to protect water conveyance systems, sensitive refuge habitats and preclude nuisance flooding.

Use a variety of means to address the negative impacts made by feral pigs, to the extent practicable, to protect sensitive refuge habitats and native wildlife populations. Consider preparing a feral hog management plan at a Complex level.

Use a variety of means to address the negative impacts of burrowing rodent species and other nuisance wildlife, as necessary, in and around buildings, equipment, vehicle parking areas and sensitive habitat areas.

Use a variety of means to address the issues of depredation and other negative impacts occurring on private property adjacent to NWRs by migratory birds and other wildlife species when appropriate.

Develop a surveying and monitoring program to identify nuisance wildlife problems and the abundance and distribution of nuisance wildlife to assist in plan development and program implementation.

With partners, eradicate nutria (Myocastor coypus) from the GEA via trapping, camera trapping, scent detection dogs, geotagged nutria, e-DNA and other means.

Objective 1.20: Fire Management

Protect and enhance Complex resources, including properties, structures, cultural resources, trust species (including endangered, threatened and species of special concern), and their associated habitats through fire suppression, preparedness, prevention and implementation of fuels projects on the Merced and San Luis NWRs.

Prescribed Burn. Photo: USFWS

Rationale 1.20:

The DOI fire management policy requires that all NWRs, with vegetation that can sustain fire, must have an FMP that details fire management guidelines for operational procedures and values to be protected/enhanced. These fire management goals and objectives have been developed under the assumptions that prescribed fire has positive effects on vegetation, wildlife habitat and cultural resources when the appropriate burning conditions and techniques are employed; that uncontrolled wildland fire has the potential for negative impacts on many resources including public safety; and that the use of Minimum Impact Suppression Tactics in the suppression and control of fire can minimize environmental damage.

Wildfire Management Strategies

1.20.1. Maintain, update and implement the San Luis NWR Complex's FMP.

1.20.2. Ensure firefighter and public safety through compliance with the FMP.

1.20.3. Maintain a fire management crew of 10 firefighters (seven permanent and three seasonal firefighters). In addition to the fire funded personnel, maintain a contingent of at least 15 collateral firefighters consisting of Complex staff and others from the fire management zone.

1.20.4. Maintain firefighting equipment, consisting of two type 3 engines, two type 6 engines and one 1500-gallon water tender, a stand-alone fire station and a bunk house.

1.20.5. Maintain a suppression response capability appropriate to meet expected wildland fire complexity by monitoring the dispatch office, located at the Sierra National Forest headquarters and neighboring cooperating agencies California Department of Forestry and Fire Protection (CAL FIRE), for information regarding wildfire activity (or potential activity) that could impact the refuges' wildlife and habitat resources. At a minimum, always maintain one staffed engine for wildfire suppression throughout the year.

1.20.6. Conduct annual fuel-load inventories throughout the Merced and San Luis refuges to determine total amount of hazardous fuel loads and use this information with computer modeling software to calculate fire behavior outputs such as rate of spread, heat per unit area and flame length.

1.20.7. Conduct fire patrols during the fire season to detect fire activity (at earliest moment) with the potential to impact the Merced and San Luis NWR resources.

1.20.8. Direct or conduct mechanical fuel treatments, such as disking and mowing, to reduce/control amounts of hazardous fuel loads and create fire breaks, as needed.

1.20.9. Suppress all wildfires on the Merced and San Luis NWRs. During the initial attack of wildfires, utilize resource advising and analysis to determine fire behavior patterns and suppression tactics that could potentially benefit resources.

1.20.10. Use prescribed fire, where appropriate and as needed, to reduce hazardous fuels.

1.20.11. Employ prescribed fire to allow a natural phenomenon (i.e., fire) to continue to be a vital ecological process on Merced and San Luis NWR lands.

1.20.12. Use prescribed fire as a management technique to improve habitat for native wildlife and control invasive weeds.

1.20.13. Treat a minimum of 6,500 acres of Merced and San Luis NWR lands with prescribed fire each year.

1.20.14. Document all fire activity for both wildfires and prescribed fires in the appropriate official database(s).

1.20.15. Reduce human-caused fires by maintaining firebreaks along highways and using fire patrols.

1.20.16. Use appropriate suppression tactics and strategies to minimize long-term impacts of wildfire suppression actions.

1.20.17. Maintain a fire weather station on the San Luis NWR.

1.20.18. Conduct fire effects monitoring to document wildlife/habitat responses to fire on Merced and San Luis NWRs.

1.20.19. Educate the public regarding the role of fire concerning natural resources within the Merced and San Luis NWRs.

Objective 1.21: Exotic/Invasive Species Management

Conduct an invasive species management program to reduce the area coverage of non-native invasive plants/animals at the Complex that adversely impact native plant and wildlife communities and meet Complex habitat management objectives.

Rationale 1.21:

Prescribed Burn. Photo: USFWS

Invasive non-indigenous (exotic) species have become the single greatest threat to the Refuge System and the Service's wildlife conservation mission. Millions of acres within the Refuge System are infested with invasive weeds (Audubon 2002). Invasive species cause widespread habitat degradation, compete with native species, and contribute significantly to the decline of trust species (USFWS 2002). The National Strategy for Management of Invasive Species (USFWS 2002b) has been developed within the context of the National Invasive Species Management Plan, as called for by Presidential Executive Order 13112, and functions as the internal guidance document for invasive species management throughout the Refuge System. This plan has four goals: 1) increase the awareness of invasive species issues, both internally and externally; 2) reduce the impacts of invasive species to allow the Refuge System to more effectively meet its fish and wildlife conservation mission and purpose; 3) reduce invasive species impacts on the Refuge System's neighbors and communities; and 4) promote and support the development and use of safe and effective integrated management techniques to deal with invasive species. The Central Valley is occupied by a diversity and abundance of exotic, invasive species that are harmful because they crowd out or replace native species that are important to wildlife natural diversity and ecosystem function. These species often dominate old agricultural fields and early successional stages of restoration sites.

Exotic, Invasive Species Control Strategies:

Develop and implement an integrated invasive pest management plan for the Merced and San Luis NWRs. Within the plan, include weed management strategies for individual pasture units, cropland fields, native upland units, riparian habitats and wetland/aquatic habitats. Incorporate specific needs and constraints associated with invasive management of wetlands, riparian and upland habitats and integrated pest management principles, such as grazing, mowing, burning and herbicide application, into the management plan.

Develop and implement annual herbicide plans, prescribed burn plans, grazing and mechanical treatment plans to prioritize invasive species projects and locations.

Inventory the occurrence and map the distribution of non-native invasive weeds and incorporate into the GIS database to allow monitoring through time.

Continue to annually monitor and map invasive plant species occurrence at the elk enclosure and Lonetree unit of the San Luis NWR and Merced NWR, respectively.

Maintain and update a list of priority invasive plant species at the Complex and ensure all Complex employees can identify invasive plants.

Conduct regular monitoring to assess results of control activities and to detect the presence of any new infestations of current or newly established species.

Control invasive and exotic species using prescribed fire, grazing, herbicide treatment, mowing, disking or other proven techniques.

Seek to eradicate new populations of invasive species considered rare in occurrence on Merced and San Luis NWR lands and waterways.

Seek to eradicate rapidly spreading, invasive species (such as perennial pepperweed, yellow starthistle, stinkwort and water hyacinth) in areas where distributions are very low in overall density or when small, isolated patches are present.

Continue to control invasive plants along roadsides, canals and other facilities in recognition of the role they play as key vectors for the spread of invasive species.

Monitor the effectiveness of control efforts for each invasive species on the refuges.

Obtain approval for all herbicide use on the Merced and San Luis NWRs through the Service's PUP system. Use all herbicides according to label directions and restrictions.

Continue to participate as a member of the multi-agency Northern San Joaquin Valley Weed Management organization.

Seek opportunities for funding invasive species management activities through local, state and Federal initiatives.

Conduct, facilitate and/or support research to identify invasive plant biology and ecology and evaluate techniques for controlling invasive plant species.

Objective 1.22: Invasive Tree/Shrub Management in Riparian Habitats

Over 5 years (2021–2026), on average across the Complex, refuges will prevent an increase or reduce the current percent cover (to between 5 and 10 percent) of saltcedar (*Tamarix* spp.), Arundo (*Arundo donax*), tree tobacco (*Nicotiana glauca*) and tree-of-heaven (*Ailanthus altissima*) in surveyed riparian ecosystems.

Rationale 1.22:

Invasive species impact riparian and floodplain ecosystems by changing geomorphology, fire regimes, hydrology, microclimates, nutrient cycling and productivity (Dukes and Mooney 2004). Invasive plants are present at varying degrees throughout the complex and, if left untreated, will crowd native plants and reduce the quality of habitat for wildlife. Several key invasive plant species are known to have direct, negative impacts on riparian resources in the San Joaquin Valley, including (but not limited to) saltcedar (*Tamarix* spp.), arundo (*Arundo donax*), tree tobacco (*Nicotiana glauca*), tree-of-heaven (*Ailanthus altissima*), poison hemlock (*Conium maculatum*) and black mustard (*Brassica nigra*). Many of these species are well established within the riparian ecosystem with persistent seedbanks. The effort to eradicate them will be costly and extensive (personal communication with SNLC staff, February 18, 2021). Additionally, it may not be possible to eradicate some invasive species.

Invasive Plant Management in Riparian Habitats Strategies:

Remove invasive plant species in riparian habitats using mechanical and chemical methods.

Remove coyote brush and replace it with wild rose and other native plants in riparian brush rabbit refugia.

Implement prescribed burns as a management strategy in the fall season to remove dense understory fuels and provide a mosaic of successional habitat types across the landscape, providing micro-niche habitats for riparian habitat-dependent wildlife species.

Plant appropriate suites of riparian vegetation (trees, woody shrubs, forbs, grasses) that are matched to the soils, hydrology and wildlife needs.

Objective 1.23:

Invasive Poison Hemlock Management in Riparian Habitats

Over 5 years (2021–2026), on average across the complex, refuges will prevent an increase or reduce the current percent cover (10–30 percent) of poison hemlock (*Conium maculatum*) in surveyed riparian ecosystems.

Rationale 1.23

See Rationale 1.22.

Invasive Poison Hemlock Management in Riparian Habitats Strategies:

See Rationale 1.21 and 1.22.

Objective 1.24: Monitoring

Monitor fish and wildlife populations and their habitats to ensure the best information is available for management decisions.

Rationale 1.24:

Monitoring wildlife populations, the habitats they depend on and ecosystem processes on the Complex is critical to evaluating the effectiveness of management prescriptions, success of habitat restoration and guides conservation planning. The outcomes of a variety of monitoring programs serve as the foundation for decision-making in all facets of Complex management. Techniques used to manage wetlands and uplands, such as water management, grazing, integrated pest management, prescribed fire and habitat restoration, are implemented based on data generated through monitoring efforts and evaluations. Complex personnel will continue to use a science-based, adaptive management system to pursue the National Refuge System mission of conserving, managing and restoring fish, wildlife and plant resources and their habitat (Refuge Improvement Act 1997). In partnership with state fish and wildlife agencies, universities, non-government agencies and volunteers, data on the refuge's wildlife, habitats and management activities will be used within this framework to meet conservation challenges in the years to come.

Monitoring Strategies:

Develop a comprehensive wildlife and habitat inventory and monitoring plan for the Complex within 5 years.

Require that written proposals for new monitoring programs include literature reviews to ensure that the latest peer-reviewed techniques are employed, methods are scientifically valid and study designs will adequately answer the questions posed.

Require that proposals for new monitoring programs are reviewed by biologists or managers to ensure that they are scientifically sound and contain clear objectives.

Design and develop monitoring programs that are compatible with Complex objectives, in partnership with state fish and wildlife agencies, universities, non-government agencies, and volunteers, to provide insight into ecological questions concerning habitat, wildlife and public use management.

Focus monitoring efforts on measuring vegetative diversity and abundance, water quality and quantity and wildlife response to management actions designed to maintain and restore habitat quality and quantity.

Utilize monitoring programs to evaluate the effectiveness of management techniques, including grazing, prescribed burning, water management, integrated pest management and management of wetlands and uplands.

Utilize monitoring programs to evaluate the effectiveness of habitat restoration.

Use a science-based adaptive management system to use the results of scientific monitoring in making effective management decisions to meet Complex goals.

Develop and update the Complex's species catalog of species occurrence, both animal and plant, at the Complex and its units.

Conduct bi-monthly monitoring of all Complex seasonal wetlands to determine the abundance, density, species richness and habitat affinities of Refuge waterbird species.

Conduct bi-monthly surveys of Complex upland habitats to determine the abundance, density, species richness and habitat affinities of long-billed curlew, arctic nesting geese, sandhill crane, black-bellied plover, northern harrier, white-faced ibis and burrowing owl.

Conduct individual surveys of focal species to serve as an index of long-term trends. Species include tule elk (quarterly), sandhill cranes (monthly), vernal pool fauna (annually), snow and Ross's geese (annually), wood duck nesting (annually), bats (monthly) and colonial nesting waterbirds (monthly).

Conduct breeding bird point count survey every 2–3 years or as needed in riparian and upland habitats to determine abundance and habitat use of neotropical migrant and resident songbirds.

Conduct bi-monthly monitoring of water quality and quantity at Complex supply inlets and outlet points to determine the flow volume, salinity, dissolved oxygen, pH, temperature and other water quality parameters.

Conduct baseline surveys for wildlife species for which existing or historical numbers and occurrences are not well known.

Conduct pre- and post-restoration monitoring of wildlife abundance and habitat characteristics to allow for analysis of restoration effectiveness and success.

Conduct baseline surveys for wildlife species on newly acquired or restored lands.

Grow the analytical capabilities of the Complex through updating of statistical analysis software and the Refuge GIS system.

Integrate GIS and spatial analysis into wildlife/habitat monitoring and adaptive management programs.

Develop a Complex GIS database that includes spatial layers on boundaries, acquisition parcels, habitat (baseline vegetation classification and other characteristics), soils, elevations, habitat management units, water systems, management practices, infrastructure, visitor services facilities, wildlife breeding colonies, threatened and endangered species records, wildlife concentration areas and other features.

Continue habitat mapping of the Complex's seasonal, semi-permanent, reverse cycle and permanent wetlands and vernal pools to facilitate delineation into monitoring/management units that can be analyzed to assess the effectiveness of management techniques on individual units.

Continue habitat mapping of the Complex's upland habitats (including riparian habitats) to facilitate delineation into monitoring/management units and track the effectiveness of grazing, integrated pest management, prescribed fire and mechanical treatment on migratory and resident birds, small mammals, reptiles, amphibians and vernal pool invertebrates.

Encourage and support monitoring projects by university, nonprofit and government agencies on Complex fish and wildlife populations, habitats and ecosystem processes.

Provide training for all staff, including biologists, managers, fire personnel and key wage grade employees to learn and maintain a level of proficiency with hardware/software and monitoring methodologies.

Objective 1.25: Research

Conduct and support research on the natural resources at the refuges by Complex personnel and independent researchers from a variety of scientific disciplines to address relevant natural resource issues.

Rationale 1.25:

The San Luis and Merced NWRs and Grassland WMA support a variety of research partnerships with other government agencies, universities and NGOs. Researchers investigate a wide range of biological and physical phenomena. These include topics on wildlife biology (distribution/diversity/abundance, reproductive success, impacts of contaminants), vegetative analysis (taxonomic descriptions, species composition/structure, exotic species impacts, landscape level vegetation classification/mapping) and physical analysis (water quality/quantity, contaminant levels, soils, hydrological modeling). Study proposals are evaluated by refuge staff to assure that the research is compatible with the refuge and that the results will contribute to wildlife and habitat management. The information gathered is used in the adaptive management of the refuge and easement lands.

Ross' geese. Photo: Mike Peters

Research Strategies

Develop and prioritize a list of research topics pertinent to natural resource issues at the Complex. Seek funding to implement research projects on priority topics.

Cooperate with universities, nonprofit groups and other government agencies to conduct research on fish and wildlife species, their habitats and ecosystem processes.

Ensure research objectives are consistent with Complex management objectives at the local, landscape or regional scale.

Conduct field experiments with adequate controls and replication to determine the effectiveness of management techniques and impacts on wildlife populations.

Conduct research on the interactions between wetland management techniques, wetland plant production, water quality/quantity and waterbird density across seasonal wetlands.

Conduct research on the effects of prescribed fire on grassland habitats and wildlife communities.

Determine the effectiveness of prescribed fire in reducing noxious weeds while enhancing native vegetation.

Conduct research on the effects of grazing on grassland habitats and wildlife communities.

Conduct research of water quality and quantity issues, focusing on the salinity of Complex source and outflow waters.

Cooperate and support university and other government agency researchers on investigation into organic carbon, methylmercury, salinity and nutrient loads in Complex water supplies and outflows.

Support university researchers conducting ongoing investigations into coastal horned lizards, small mammals, tule elk, water quality, shorebirds and upland invertebrates.

Encourage university graduate students to conduct master's and doctorate research on Complex lands on a diversity of topics.

Require that proposals for research programs are reviewed by biologists or managers to ensure that they are scientifically sound, contain clear objectives and are consistent with refuge management and policies.

Publish results of scientific research in peer-reviewed journals.

Continually update the analytical capabilities of the Complex by upgrading statistical, data management and GIS software.

Objective 1.26: Science Based Management

Ensure Complex staff use the best available science for managing the natural resources of the San Luis NWR Complex.

Rationale 1.26:

Limited resources available to the Complex necessitates that all efforts and resources directed at any management action/activity be successful, efficient and effective. Employing the best available science in developing and implementing all actions at the Complex will lead to more productive and successful results in natural resource management.

Science-Based/Driven Management Strategies:

Use the best available science in identifying, developing and implementing management programs at the Complex.

Ensure all Complex staff have access to the scientific literature.

Ensure that all Complex employees adhere to the USFWS Scientific Integrity Policy.

Establish an electronic database/filing system for all natural resource/visitor services reports on the Complex or reports pertaining to relevant issues.

Restructure all Complex files into a more readily accessible system for Complex employees.

Maintain all electronic natural resource databases for the Complex and develop such databases on an as-needed basis.

Maintain and develop written protocols, plans and standard operating procedures for all major management activities at the Complex.

Encourage Complex staff and provide opportunities to attend professional society meetings of natural resource specialists, interact with university and independent researchers and seek to publish Complex research projects in refereed scientific publications.

Encourage Complex staff and provide opportunities to work on inter-agency working groups on natural resource issues.

Conduct monthly staff discussions/presentations focusing on management, monitoring and research activities involving both natural resources and visitor services at the Complex.

Objective 1.27: Facilities and Equipment Maintenance

Maintain, repair and protect refuge facilities, equipment and infrastructure at the Merced and San Luis NWRs.

Rationale 1.27:

Periodic maintenance and renovations of existing facilities, equipment and infrastructure are necessary to ensure safety and accessibility for Complex staff and visitors, as well as effective and efficient habitat management practices. Existing facilities and infrastructure include maintenance shops, residences, boundary and internal fencing, deep wells, lift pumps, pipelines, roads, canals and ditches, auto tour routes, trails, observation decks, parking lots and kiosks, as well as the visitor center and administration offices on the San Luis NWR. Existing equipment includes heavy and light motorized equipment, as well as power and hand tools.

Facilities and Equipment Strategies:

Maintain and continuously update the real property and personal property inventories for the Merced and San Luis NWRs.

Maintain accurate, up-to-date field records on maintenance and repairs to facilities, equipment and infrastructure for the Merced and San Luis NWRs.

Seek funding to maintain facilities, equipment and infrastructure on the Merced and San Luis NWRs.

Conduct routine preventative, corrective and emergency maintenance and repairs on all facilities, equipment and infrastructure on the Merced and San Luis NWRs.

Map and document all facilities and infrastructure on the Merced and San Luis NWRs.

Black Phoebe. Photo: Rick Lewis

Improve the energy efficiency and reduce the carbon footprint, where possible, of all facilities, equipment and infrastructure on the Merced and San Luis NWRs.

Maintain, repair and protect all government living quarters on the Merced and San Luis NWRs.

Eliminate, by appropriate means, all unnecessary facilities, equipment and infrastructure on the Merced and San Luis NWRs.

Ensure all facilities, equipment and infrastructure on the Merced and San Luis NWRs meet all required safety standards and are secure from theft or damage.

Protect all facilities and equipment from fire and other natural elements.

Annually maintain boundary, closed area and other public-use signs.

Maintain and upgrade electric gates at existing access points for the public at the Merced and San Luis NWRs.

Ensure that the Complex maintains a secure lock and key control program for all facilities.

Objective 1.28: Law Enforcement

Protect the refuges' wildlife, habitat and ecosystem resources; provide a safe environment for the public; and ensure compliance with regulations through effective law enforcement on the San Luis and Merced NWRs.

Rationale 1.28:

A law enforcement presence at the NWRs is crucial for the protection of the public and natural resources. An increasing number of facilities and visitors necessitate an adequate level of safety and security through an enhanced law enforcement presence. Illegal activities, such as drug cultivation, poaching, theft, break-ins and vandalism have been detected on refuge lands. Strict law enforcement with the support of law enforcement agencies is necessary to provide a safe environment for visitors and staff. In addition, a common belief among neighboring landowners is that public ownership, easements or access could result in increased vandalism and theft of agricultural equipment, poaching and disregard of private property rights. A well-planned and coordinated law enforcement program is necessary to address these private lands concerns. This objective also helps to achieve Central Valley and Bay-Delta Region Conservation Action Q in the California Wildlife Action Plan (CDFW 2005).

Law Enforcement Strategies

Develop MOUs with local and other law enforcement agencies to improve coordination, safety and program effectiveness and coordinate efforts in areas of special concern.

Provide public education as part of law enforcement programs preventive strategy. As needed, seek assistance for a sufficient level of law enforcement from various agencies to address these issues.

The Regional Refuge Law Enforcement (RLE) program provides one patrol captain and five full-time Federal wildlife officers assigned to the Central California Patrol Zone, with at least two to provide coverage to the San Luis NWR Complex.

To the extent possible, RLE maintains a daily law enforcement presence within the San Luis NWR Complex to ensure that violations are deterred or successfully detected and investigated and the violators are apprehended.

Update, annually or as needed, the law enforcement management plan for the San Luis NWR Complex.

Offer annual training to non-commissioned personnel on the Complex regarding law enforcement activities and issues, and prevention strategies.

Objective 1.29: Safety

Provide facilities and lands that are safe for all employees and visitors and for public use and management activities through annual inspections and routine maintenance on the Merced NWR and San Luis NWR.

Rationale 1.29:

Visitor and staff safety is the highest priority for the San Luis NWR Complex. It is important to have and implement comprehensive safety strategies. The Complex is committed to training staff in the most current safety standards and practices, maintaining facilities, coordinating with law enforcement partners, providing an effective monitoring program to provide the safest environment possible and identifying and correcting safety issues.

Safety Strategies

Administer and monitor required permits, licenses and inspections on a repetitive basis under the Federal Facility Compliance Act and Service policy.

Use signs, brochures/fact sheets and the Complex’s website to provide Complex regulations to the visiting public.

Conduct patrols by law enforcement staff at the San Luis and Merced NWRs to ensure compliance with regulations, public safety and natural resource protection.

Routinely examine and maintain public-use facilities at the San Luis and Merced NWRs to identify and correct unsafe conditions.

Promptly replace, upgrade, or temporarily close any facility that poses a public safety hazard.

Minimize injuries to staff and visitors through preventive measures and be prepared to respond to injuries if they occur.

Ensure that safety procedures, designated personnel and equipment and supplies (e.g., first-aid kits and fire extinguishers) are in place and kept current.

Post and familiarize all staff with the Continuity of Operations Plan for the San Luis NWR Complex.

Conduct monthly staff safety meetings covering pertinent topics, quarterly safety committee meetings and annual safety inspections to ensure that facilities and lands are safe for public and staff use.

Train and refresh staff in CPR and basic first aid.

Maintain existing access roads and parking areas by grading, mowing and replacing culverts, as needed, for public vehicle access, law enforcement and habitat management activities.

Maintain secondary roads and pathways for public pedestrian traffic by grading, mowing and replacing culverts, as needed.

Help protect Complex visitors, neighbors and employees through fire prevention, fuel hazard reduction and fire trespass programs.

Extinguish all wildfires immediately on the San Luis and Merced NWRs by following the Complex's dispatch plan. Evacuate the public from the Complex in the event of wildfire in public-use areas.

Maintain a current knowledge and status of local wildlife diseases that are potentially transmitted to humans and manage visitation access accordingly. Provide timely information to the public.

Continue to prohibit the use or possession of alcoholic beverages while hunting (50 CFR 32.2j). In addition, prohibit the consumption or possession of an open container of alcohol within public areas on the San Luis and Merced NWRs.

Conduct an annual safety inspection of all Complex programs and facilities. Correct all deficiencies identified in the inspection.

Objective 1.30: Maintain Sanctuary

Continue to allot, at minimum, 60 percent of the Merced and San Luis NWR landbase as sanctuary (i.e., closed) to provide high-quality resting, foraging and nesting habitat for waterfowl and other wildlife.

Rationale 1.30:

Sanctuaries are areas on the refuge that are closed to public use. They provide places where human-caused disturbances are reduced, thereby reducing the interruption of wildlife activities such as foraging, resting, breeding, sheltering, feeding nestlings and other maintenance activities. Sanctuaries are especially important during high visitor use periods. They also are important for wildlife to avoid predation by other wild animals, because they can devote less energy to avoiding humans and more to avoiding predators. In some cases, short-term sanctuaries may be established on the refuge to protect a sensitive nesting colony or site. These seasonal sanctuaries may impose public access restrictions at some nesting sites for species with a low tolerance for human disturbance.

The 2,490.9-acre Arena Plains and 1918.6-acre Snobird units both consist of large continuous expanses of vernal pools, grasslands and upland habitat critical to numerous wildlife species in California. Both units maintain a mosaic of grassland and wetland habitats (including vernal pools) in support of native wildlife and plant species (i.e., short and tall stature vegetative structure, burned vs. non-burned areas). Due to the presences of these mosaic habitats, these areas provide vital wintering ground for migratory waterfowl, sandhill cranes (*Grus canadensis*) and numerous other shorebirds of the Pacific Flyway. Additionally, because these areas have never been cultivated, they support a tremendous diversity of endemic, rare and endangered plant and animal life once abundant throughout California's Central Valley. Examples of current plant and wildlife use for these areas include nesting long-billed curlew, which require areas of little or no disturbance for successful nesting, and endemic Colusa grass found in vernal pool areas. They also hold potential for endangered species such as blunt-nosed leopard lizard, California tiger salamander and present fairy shrimp. Due to the valuable natural resources the Arena Plains and Snobird units serve to the refuge, both units should be designated as sanctuaries and anthropogenic disturbances by common visitor refuge activities should be minimized to preserve the integrity of sensitive plant and wildlife habitat.

Sanctuary Strategies:

Maintain closures of the Arena Plains and Snobird units to provide sanctuary areas.

Provide migrating waterbirds a balanced and effective network of feeding and resting areas.

Minimize disturbance to feeding and resting waterbirds in areas designated as sanctuary.

Maintain the ecological integrity of vernal pool complexes on Arena Plains and Snobirds units and for the ecological integrity of endangered species.

Protect the ecological integrity of existing Colusa grass pools.

Protect the ecological integrity of sand dune habitat within the Arena Plains Unit.

Goal 2 Objectives and Strategies

Goal 2: Threatened and Endangered Species (Merced and San Luis NWRs)

Contribute to the recovery of threatened/endangered species as well as the protection and management of populations of endemic Central Valley wildlife and Special Status wildlife, plants and habitats.

Objective 2.1: Threatened and Endangered Species Management and Partnerships

Contribute to the recovery of Federal and state listed threatened and endangered species through direct management activities and participation in species recovery teams and working groups.

Rationale 2.1:

Federally listed threatened, endangered and candidate species are trust responsibilities under the jurisdiction of the Service. State threatened and endangered species, by refuge policy, are treated for management and avoidance purposes the same as the Federally listed species. San Luis NWR and Merced NWR collectively provide habitat for more than 20 Federal and state listed threatened and endangered species. Maintaining and managing refuge habitats on which they depend, pursuing other measures as needed and participating in species recovery efforts will aid in the protection and recovery of these species. The Complex will aid in the protection and recovery of these species by maintaining and managing the habitats on which they depend, pursuing other measures, as needed, and participating in species recovery efforts.

Threatened and Endangered Species Management Strategies:

Coyote. Photo: Rick Lewis

Protect, conserve, maintain, enhance and, where appropriate, restore habitat for threatened and endangered species at the Complex.

Support recovery activities for species identified in Service recovery plans for threatened and endangered species at the Complex.

Provide foraging and denning habitat for San Joaquin kit fox by maintaining 10,000 acres of annual/perennial grasslands in a short-cropped condition through grazing and prescribed fire.

Protect populations of fairy shrimp (multiple species), vernal pool tadpole shrimp, California tiger salamander and Colusa grass by maintaining existing vernal pools, associated plant communities and surrounding micro-watersheds through grazing, prescribed fire and avoidance measures. Continue the Complex-wide policy of no alteration of the topography of native uplands.

Incorporate planting of appropriate tree-shrub species and mid-story plants into riparian restoration/enhancement plans to meet the habitat needs of least Bell's vireo, southwestern flycatcher and yellow-billed cuckoo.

Manage uplands through grazing, mechanical treatments and prescribed fire to provide open, bare-ground habitat for Fresno kangaroo rats and blunt-nosed leopard lizards.

Incorporate planting of elderberry into riparian and upland restoration/enhancement plans to meet the needs of the valley elderberry longhorn beetle.

Protect giant garter snakes as needed by implementing avoidance measures, including conducting surveys and complying with seasonal operating restrictions, prior to any planned canal dredging or other earth-moving activities where hibernation may be disturbed.

Directly participate in recovery planning as a member of species recovery teams or species working groups as assigned.

Support recovery activities for threatened and endangered species identified in Service and State of California recovery plans.

Assist in the development and implementation of reintroduction and introduction programs to restore extirpated populations and meet recovery goals as identified in species recovery plans.

Assess the habitat suitability of San Luis and Merced NWRs for the potential reintroduction of riparian brush rabbits (RBRs). A *Proposal for the Translocation of Riparian Brush Rabbits* (2022) was been drafted and submitted to the FWS Ecological Services Division, which is, in turn, developing a Biological Opinion to support that proposal. A plan has been approved (USFWS 2022, Reinitation of Intra-Service Formal Consultation on the Trapping, Vaccination, and Emergency Translocations of Riparian Brush Rabbits at San Luis National Wildlife Refuge Complex) to translocate up to 200 RBR—but no more than 10 percent of the local population—from San Joaquin River NWR to suitable habitat on San Luis NWR. To evaluate the habitat suitability, connectivity and flood risk for RBR on San Luis NWR, a mapping project, *Riparian Brush Rabbit Habitat Suitability Modelling in the South Delta and San Luis NWRC,* was completed by Dr. Scott Phillips in 2022 (CSU Stanislaus). RBR release sites on San Luis NWR will be selected based on optimal habitat characteristics. All animals released will be vaccinated against the rabbit hemorrhagic disease virus to increase adult survivorship and maintain population levels. Released animals will be monitored to assess survival and disbursement via radio collars, camera traps or other methods.

If applicable to the Complex, during extreme climate events, biologists will monitor and feed stranded RBRs and/or rescue RBR in jeopardy of drowning or starvation.

Provide nesting habitat for tricolored blackbirds through prescribed fires of old tule/cattail stands to promote new growth favorable for nesting, plantings of triticale and winter wheat and maintaining seasonal wetlands. Enhance foraging habitat for tricolored blackbirds in the spring through maintaining irrigated pastures.

Objective 2.2: Riparian Brush Rabbit Habitat Extent

Over 10 years (2021–2031), the percentage of potential RBR habitat above the floodplain mark (the highest water level of the 2017 flood) at the Complex is maintained at >16 percent.

Rationale 2.2:

Due to historic habitat modifications such as land use change, development and alterations to the hydroperiod of the San Joaquin River, the riparian ecosystem has been dramatically reduced in spatial extent compared to its historic distribution. Currently, a lack of willing sellers allowing the Service to purchase land, residential development, urban flood protection and other relatively small-scale projects continues to disconnect areas of the riparian corridor and limit opportunities for the Complex to expand its restoration efforts. The reduction in riparian extent impacts the resiliency of species, especially riparian obligate species like the RBR (USFWS 2020b). Understanding the extent of the riparian ecosystem on the Complex will inform management actions, such as potential translocation of RBRs to unoccupied areas.

Riparian Brush Rabbit Habitat Extent at San Luis Complex Strategies:

Increase the amount of riparian forest habitat whenever possible and ensure that a mix of riparian forest growth stages exist.

Monitor the status of riparian habitat extent and quality through GIS modeling using the latest imagery available or through on the ground assessments.

Objective 2.3: Riparian Brush Rabbit Habitat Quality

For 10 years (2021–2031), maintain 51–74 percent of the riparian ecosystem across the San Luis Complex classified as high- to moderately high-quality RBR habitat.

Rationale 2.3:

The current recovery plan for the RBR requires the establishment of three additional self-sustaining, wild populations outside of Caswell Memorial State Park. Because the extant populations are isolated from potential habitat at historical sites, reintroductions from existing populations are required. From 2002 through 2013, RBRs were released on the San Joaquin River NWR, which led to the successful establishment of RBR populations on the refuge (USFWS 2020b). Due to the success of this reintroduction, reintroductions of RBRs to other areas on the Complex have been suggested as an avenue to ensure resiliency for this species. Understanding the amount of high-quality RBR habitat is crucial to understanding where reintroductions could be successful. High-quality RBR habitat includes a healthy, diverse understory with dense, brushy vegetation; grasses and herbs; ecotonal edges; scaffolding shrubs and trees; and connectivity around open areas (USFWS 2020b).

Riparian Brush Rabbit Habitat Quality Strategies:

Riparian restoration and enhancement projects will focus on planting shrubs that provide both food and shelter during winter flood events, such as wild rose and native blackberry.

Objective 2.4: Special Status Species Management

Protect, conserve, enhance and/or restore wildlife habitat on the San Luis and Merced NWRs for the benefit of Special Status species (Federal Candidate 1 and Candidate 2; California Species of Concern).

Rationale 2.4:

Many Special Status species have been documented to occur on the San Luis and/or Merced NWRs. The Federal Candidate 1 and 2 Species include the southwestern otter, ferruginous hawk, white-faced ibis, mountain plover, black tern, long-billed curlew, tricolored blackbird, western least bittern, burrowing owl, California horned lizard, silvery legless lizard, western spadefoot, western pond turtle, Sacramento perch, hispid bird's-beak, delta button celery, Merced phacelia, heartscale and valley spearscale. Additionally, Special Status species historically documented on refuge lands with only the California Species of Concern status include badger, western yellow-billed cuckoo, greater sandhill crane, Swainson's hawk, Cooper's hawk, sharp-shinned hawk, golden eagle, northern harrier, osprey, prairie falcon, merlin, short-eared owl, long-eared owl, white pelican, double-crested cormorant and yellow warbler. Furthermore, there are several other Special Status species that have not been documented on Complex lands, but the Complex is within their historic range and potentially has appropriate habitat. The Complex provides critical year-round or stopover habitat for many Special Status species.

Special Status Species Management Strategies:

Sandhill Cranes. Photo: Rick Lewis

2.4.1. Document the occurrence and location of any California Special Status species, their abundance and/or nest or den location within Complex lands.

2.4.2. Identify Complex management activities that may benefit or detract from the occurrence of Special Status Species.

2.4.3. Monitor the Complex management activities occurring near the last known occurrence of a Special Status species.

2.4.4. Support collaborative research and field surveys on Special Status species to thoroughly understand life history patterns and habitat preferences at the Complex.

2.4.5. Monitor Complex population trends and distributions of Special Status species when possible.

2.4.6. Continue to monitor and document known nesting colonies of double-crested cormorants and white-faced ibis.

2.4.7. Participate in the flyway-wide long-billed curlew, greater sandhill crane and tricolored blackbird population surveys.

2.4.8. Provide foraging habitat for greater sandhill crane by maintaining 10,000 acres of annual/ perennial grasslands in a short-cropped condition through grazing and prescribed fire. Continue growing corn and winter wheat for winter forage for cranes on the Merced NWR.

2.4.9. Limit disturbance in crane roosts and foraging areas by maintaining sanctuaries.

2.4.10. Support the ongoing efforts by university researchers investigating populations of California horned lizards and silvery legless lizard.

2.4.11. Document the presence and habitat use of monarch butterflies on San Luis and Merced NWRs.

Objective 2.5: CA Endemic Species Management

Manage Complex wetland, upland, riparian and aquatic habitats to meet the breeding and non-breeding life history needs of California endemic species.

Rationale 2.5:

The San Luis NWR Complex provides critically important habitat for many taxa endemic to California and the Great Central Valley. Preserving required habitat is especially important for these endemic species because extirpation from refuge lands could lead to significant species population declines and even extinction. The habitats used by California endemic species are threatened by continued conversion of native habitats to agriculture, urban development, road construction, pollution and invasion by exotic species. Faced with these challenges, California endemic species' reliance on available habitats becomes crucial to their persistence and population growth.

CA Endemic Species Management Strategies:

2.5.1. Develop a list of California endemic species, both wildlife and plants that occur or historically occurred on Complex lands.

2.5.2. Preserve, manage and where appropriate, restore Complex lands to benefit breeding and non-breeding habitats of California endemic species. These include tricolored blackbird, yellow-billed magpie, tule elk, San Joaquin kit fox, Heermann's kangaroo rat, Fresno kangaroo rat, blunt-nosed leopard lizard, Sacramento splittail and Sacramento blackfish.

2.5.3. Preserve, manage and where appropriate, restore Complex lands to benefit California endemic vernal pool species, including California tiger salamander, California fairy shrimp (or California Linderiella), conservancy fairy shrimp, longhorn fairy shrimp, vernal pool fairy shrimp, midvalley fairy shrimp and vernal pool tadpole shrimp.

2.5.4. Monitor California endemic species abundance, distribution and habitat use on Complex lands.

2.5.5. Implement or support research programs to more thoroughly understand life history needs of endemic species found on the Complex.

2.5.6. Preserve and enhance active breeding colonies and foraging areas of tricolored blackbirds on Complex lands.

2.5.7. Implement management practices to attract silage-nesting tricolored blackbirds away from private agricultural lands and onto Complex lands to nest.

2.5.8. Determine annual breeding, foraging and wintering distributions of tricolor blackbirds throughout the Refuge Complex and surrounding Grasslands WMA.

2.5.9. Provide annual and periodic Complex monitoring survey information on California endemic species to appropriate state (i.e., CDFW) and Federal (i.e., USFWS-Sacramento Fish and Wildlife Office) agencies.

2.5.10. Implement public outreach and education to enhance private landowner awareness and build public support for conservation of endemic species.

2.5.11. Participate in state- and region-wide annual survey efforts for focal endemic species with partnering organizations.

2.5.12. Participate with partners to support endemic species action plans.

Objective 2.6: Rare Species Monitoring

Monitor threatened and endangered species and Special Status species to assess whether management activities are protecting and conserving endangered and Special Status species' populations and habitat and to ensure recovery objectives are being met at the Complex.

Rationale 2.6:

Federal and state threatened and endangered species and other Special Status species are a high priority for Complex management. The Complex will aid in the protection and recovery of these species by maintaining and managing the habitats on which they depend and participating in species recovery efforts. The outcomes of monitoring programs involving threatened and endangered species and their habitats serve as the foundation for decision-making in all facets of conservation planning and are critical to evaluating the effectiveness of management prescriptions and the success of habitat restoration. Decisions to implement techniques such as water management, grazing, integrated pest management, prescribed fire and habitat restoration, as well as to manage Complex wetlands and uplands, need to be based on data generated through monitoring efforts.

Rare Species Monitoring Strategies:

Conduct surveys for focal threatened and endangered species to document presence, determine abundance and describe habitat affinities. Incorporate the species and habitat inventories into the Complex's GIS database

Utilize monitoring programs to evaluate the effectiveness of grazing, prescribed fire, water management, integrated pest management and other management of wetlands and uplands in meeting recovery objectives for listed species.

Use a science-based adaptive management system to incorporate the results of listed species monitoring efforts into Complex management decisions geared toward these species.

Conduct periodic monitoring of vernal pool habitats to document the presence and distribution of listed fairy and tadpole shrimp species and California tiger salamanders.

Conduct baseline surveys for threatened, endangered and Special Status species on newly acquired or restored lands.

Conduct periodic monitoring for San Joaquin kit fox using spotlight surveys, remote cameras and trained, scat-sniffing dogs to document their presence and persistence on refuge lands.

Conduct periodic point count surveys of riparian habitats to document the presence of threatened, endangered and Special Status songbird species (least Bell's vireo, southwest willow flycatcher, yellow warbler, western yellow-billed cuckoo) breeding and wintering on the Complex.

Cooperate with the Service Fisheries personnel to monitor for listed fish species using Complex waterways.

Cooperate with university researchers to conduct monitoring for Fresno kangaroo rats and other rare kangaroo rat species to document their presence on Complex units, describe their distribution and determine the impacts of upland management techniques on populations.

Work with research partners to conduct giant garter snake surveys in permanent wetlands and Complex waterways.

Evaluate riparian habitat conditions to determine the feasibility of RBR reintroduction to areas of San Luis NWR.

Determine the level of occurrence of the San Joaquin Valley woodrat on the Complex.

Conduct periodic surveys and mapping of listed vegetative species (Colusa grass, palmate bracted bird's beak, delta button celery, etc.).

Encourage and support research and monitoring projects at the Complex by university, nonprofit and government agencies on listed and Special Status fish and wildlife populations, habitats and ecosystem processes.

Objective 2.7: Rare Species Research

Contribute to a better understanding of the ecology and life-requirements of Federal and state listed threatened and endangered and Special Status species so that knowledge can be used to direct management activities that lead to species recovery and enhanced populations.

Rationale 2.7:

Effective recovery of threatened and endangered species and conservation of Special Status species require that management actions be undertaken with a solid knowledge base of the species life history, distribution, genetics, habitat requirements and threats to its survival. Resource agencies often lack much of this information on individual species. Refuges with existing populations or appropriate habitat for those species can provide an opportunity to conduct research in support of species conservation and recovery.

Rare Species Research Strategies:

Secure grant funding through the Central Valley Project Conservation Program or other sources to conduct population surveys for Fresno kangaroo rats on refuge fee-title and easement lands.

Support agency and university research efforts on the ecology of listed vernal pool fauna, and the ecology of and threats to vernal pools and associated plant communities that support those listed species.

Support agency and university research efforts on the distribution and ecology of giant garter snakes on Complex and private lands within the GEA of Merced County.

Support agency and university research efforts on the distribution and population ecology of tricolored blackbirds as part of the Tricolored Blackbird Cooperative Management Agreement.

Support research for actions identified in recovery plans that promote the recovery of threatened and endangered species, such as cooperative range-wide and directed population status and habitat condition surveys, seed/cyst collections/banking, genetics and demography for conservation and reintroduction/introduction and effects of habitat management.

Support research for actions identified in California Partners in Flight species conservation plans and the CVJV Implementation Plan that promote the conservation of Special Status species.

Support management-oriented research focused on identifying new populations of threatened and endangered and Special Status species previously undetected on Complex lands.

Objective 2.8: Rare Species Partnership

Maintain existing partnerships and develop new relationships with agencies, nonprofit organizations, landowners and other entities that contribute to the recovery of threatened and endangered species and conservation of Special Status species on the Complex.

Rationale 2.8:

Although the Service has legal responsibility over threatened and endangered species, effective conservation and species recovery are part of a group effort that requires multiple partners from the public, academic and private sectors. A similar partnership approach is necessary to pursue management actions that conserve or increase populations of species of concern or Special Status species.

Rare Species Partners Strategies:

2.8.1. Maintain a close working relationship with the Service's endangered species office, CDFW endangered species staff, the CSU Stanislaus Endangered Species Recovery Program and other agencies/groups working on endangered species recovery or conservation of Special Status species.

2.8.2. Continue staff participation in recovery teams and working groups for listed species such as the San Joaquin kit fox, giant garter snake, RBR, San Joaquin woodrat and other species as assigned.

2.8.3. Continue staff participation in the TBWG, and coordinate/provide logistical support for tricolored blackbird researchers under contract with the Service.

2.8.4. Contribute to collaborative efforts to conserve and protect species of concern and other Special Status species through staff participation in the shorebird and riparian bird working groups of the CVJV Technical Committee.

2.8.5. Provide support for and collaborate in grant and other funding requests by the CSU Stanislaus Endangered Species Recovery Program and other entities conducting recovery actions for listed species or conservation actions for species of concern or other Special Status species.

2.8.6. Provide lodging and other logistical support as available for researchers conducting recovery tasks such as surveys or reintroductions for listed species or other conservation actions for species of concern or other Special Status species.

Objective 2.9: Law Enforcement—Rare Species

Ensure adequate enforcement of all laws and regulations to provide optimal protection for threatened, endangered and Special Status species on the Refuge Complex.

Rationale 2.9:

A major goal of the NWR System is to protect and conserve threatened and endangered species on national wildlife refuges. Existing programs at the San Luis NWR Complex are designed to provide law enforcement protection to listed and rare species including providing law enforcement patrols to detect and deter Endangered Species Act violations and provide educational contacts.

Rare Species Law Enforcement Strategies

Black-necked stilts. Photo: Lee Eastman

Conduct regular patrols of Complex lands on an ongoing basis to detect possible Endangered Species Act violations and provide deterrence against such violations.

Conduct law enforcement of the hunting programs on San Luis and Merced NWRs to ensure that rare species are not adversely affected by the hunting programs.

Protect active breeding colonies of tricolored blackbirds on Complex lands from outside disturbances by patrolling areas around active colonies.

Protect tule elk and black-tailed deer on Complex lands through regular law enforcement patrols.

Goal 3 Objectives and Strategies

Goal 3: Ecological Processes, Ecosystem Management and Partnerships (Merced and San Luis NWRs)

Maintain and/or restore natural ecological processes to promote healthy, functioning ecosystems for wildlife on Complex lands. Coordinate the natural resource management of the Complex's natural resources within the larger context of the Central Valley/San Francisco Ecoregion and Pacific Flyway.

Objective 3.1: Land Acquisition

To increase the ability of the refuge to promote functioning ecosystems for wildlife species of concern, seek the acquisition of lands for the San Luis and Merced NWRs and Grasslands WMA from within the approved refuge acquisition boundary from willing landowners. Review the current land acquisition boundary for both Merced and San Luis NWRs and seek to increase the acquisition boundary if deemed needed for the benefit of natural resources.

Rationale 3.1:

Any remaining lands not yet purchased or acquired are in private or public ownership. These lands previously have been identified as having suitable or potentially significant wildlife values. Acquisition of lands within the approved refuge boundary will enhance existing wildlife resources on present Complex lands and enhance wildlife resources by increasing the landbase; it also will provide for increased flexibility in the management of wildlife resources and offer greater opportunities for wildlife-dependent public use at the San Luis and Merced NWRs. Planning documents establishing and expanding the Grasslands WMA included specific acreage objectives for easement and fee title acquisition. Currently 37,905 acres of easement acquisition authority remain in Grasslands WMA with potential for converting some of those acres to fee-title acquisition acres within the acquisition boundary. Additional opportunities for fee-title acquisition adjacent to San Luis and Merced NWRs. See Chapter 2—Land Ownership and Acquisition History for additional context.

Land Acquisition Strategies:

Maintain a database of acquired lands within the approved land acquisition boundary for the Merced and San Luis NWRs.

Both Merced and San Luis NWRs have achieved their authorized land acquisition goals. However, refuge lands are still being acquired under acquisition authority for the Grasslands WMA.

Convert 7,580 current and future acres of Grasslands WMA easement acquisition authority to fee-title acquisition authority. Work with the Service's realty office on the acquisition of lands from willing sellers adjacent to Merced and San Luis NWR if justified by key natural resource features on land parcels.

Work with the Service's realty office to review the current land acquisition boundaries for the Merced and San Luis NWRs and seek to expand the acquisition boundaries, if justified by key natural resource features on land parcels appropriate for inclusion into the Complex.

Expand the San Luis NWR Complex's GIS capabilities over the next 10 years to include lands outside the boundary of the Complex, particularly regarding riparian corridors and undisturbed lands.

Objective 3.2: Natural Processes and Ecosystem Functions

Maintain, manage and restore natural ecological processes to meet Complex's conservation goals and maximize the efficiency and cost effectiveness of management interventions.

Rationale 3.2:

Ecosystems consist of biotic communities and their associated abiotic environments functioning together as a unit. Ecosystem health depends not only on ecosystem components but also the natural processes that drive ecosystem functions. Although the San Luis NWR, Merced NWR and Grassland WMA form a relatively large, contiguous protected area, natural ecological processes (such as fire, flooding, wildlife migration corridors, intact food webs and biogeochemical cycling) are impacted by human-induced alteration and, in some cases, complete truncation. The Refuge Complex must deal with the dual challenge of restoring some natural ecological processes while reducing other human-induced or human-intensified processes (such as salinization, bioaccumulation of selenium and methylmercury, accumulation of pesticide and herbicide residues and the colonization of invasive species). Additionally, the ecosystem services historically provided by the natural hydrology and periodic flooding of the San Joaquin River and the creeks and sloughs that are part of its watershed were halted in the 1940s by the building of the Friant Dam, which diverted 95 percent of its annual flow for irrigation. Consequently, the annual conveyance of water to allow for moist soil management of seasonal wetlands is the single most labor-intensive and costly habitat management technique implemented by Complex personnel. Selenium contamination, the accumulation of boron and salts and methylmercury present further challenges to Complex management in the GEA. In 1994, in recognition that all components of an ecosystem are interrelated, the Service recommended an ecosystem approach to wildlife conservation through the protection or restoration of the function, structure, and species composition of an ecosystem (USFWS 1994). An ecosystem approach to conservation involves the management of natural resources using system-wide concepts to maintain viable populations of plants and wildlife in native habitats while restoring or maintaining basic ecosystem processes (Clark and Zaunbrecher 1987). Resources of the Complex that can be addressed at this larger scale include migratory birds, water issues, endangered and threatened species, contaminants, habitat patch size and riparian corridors. The Service has divided the nation into ecoregions to coordinate natural resource management. The San Luis NWR Complex is situated in the Central Valley/San Francisco ecoregion, which includes the San Joaquin and Sacramento valleys and their drainages.

Natural Processes and Ecosystem Functions Strategies:

Identify key ecological processes (hydrology, fire, trophic functions, pollination, seed dispersal, nutrient cycling, etc.) at the Complex and identify those that are impaired or no longer function effectively. Prioritize impaired processes that must be restored or performed by other means to sustain wildlife populations.

Manage seasonal wetlands by maintaining prescribed water depths via delivered water or groundwater from September to April in wetland basins.

Disk wetland basins to increase the availability of organic matter and nutrients for plant growth and to reduce the dominance of emergent wetland plants such as hardstem bulrush (*Scirpus* spp.) and cattails (*Typha* spp.) relative to earlier successional grasses and herbs that are highly used waterfowl food plants. This ecological function once was provided by the natural scouring and deposition of silt by floodwaters.

Mow, burn and monitor wetland plant communities at the Complex to meet waterbird forage, thermal and spatial requirements.

Develop memorandums of understanding between the Service and key partners, including the CDFW, California State Parks, the Lower San Joaquin Levee District and private landowners, to adopt managed levee opening along the San Joaquin River during flood events to increase riparian habitat and benefit wetland-dependent plant and wildlife species.

Investigate potential challenges and opportunities posed by the SJRRP.

Secure high quality delivered water supplies to meet the selenium water quality objective and continue to monitor selenium levels in aquatic birds.

Monitor water quality reports in waters at or adjacent to the Complex from the CVRWQCB.

Monitor water quality reports on methylmercury concentrations in managed wetland water, invertebrate and vertebrate species and research investigating the role managed wetlands play in sequestering, amplifying or reducing methylmercury loads conducted by the U.S. Geological Service and the State of California Regional Water Quality Control Board.

Maintain the ecological role of fire on Complex lands through the prescribed fire program.

Coordinate the natural resource management of the Refuge Complex within the context of the larger Central Valley/San Francisco ecoregion to minimize the effects of surrounding land use and its management impacts by working cooperatively with both public and private entities on a landscape or ecoregion level.

Identify lands outside of the approved acquisition boundary for the San Luis NWR Complex that have key or the potential for key natural resources and/or would protect or enhance existing Complex resources.

Provide natural resource information collected at the San Luis NWR Complex to other interested agencies, groups and researchers to foster collaborative efforts and support ecoregion-wide natural resource databases.

Participate in joint natural resource projects at the ecoregion level involving partners on issues pertaining to the management and protection of resources at the San Luis NWR Complex.

Objective 3.3: Climate Change

Develop and implement strategies at the Complex for assisting wildlife and plants in adapting to climate change.

Rationale 3.3:

It will be difficult to predict how climate change will impact existing issues and how those impacts will affect the plant and wildlife species of the Complex, but Complex staff must make the best assessments of what is likely to occur. Impacts of climate change may include difficulty in accessing an adequate and reliable water supply, rising water costs, erosion, increased demands for electricity, changes in land use, shifts in species distributions, effects on species' reproductive capabilities, changes in arrival and departure times of migratory birds, decreased air quality, an increase in wildfires and the spread of non-native species and pathogens.

Climate Change Strategies:

Identify and monitor wildlife resources that are critically vulnerable to climate change.

Set strategic priorities and guide tactical efforts to achieve resilience, representation and redundancy of wildlife and plant populations and habitats.

Identify and prioritize key ecological processes (including pollination, seed dispersal and nutrient cycling) that must be protected or restored to sustain wildlife populations over this century.

Identify reactive and anticipatory approaches to facilitate adaptations by wildlife.

Use landscape conservation approaches that identify key areas that must be conserved to account for climate change impacts.

Identify water management capabilities and needs for wildlife conservation; work with partners, including water management agencies and other water entities, to ensure water resources of adequate quantity and quality to support biological objectives for wildlife.

Reduce non-climate stressors (e.g., invasive species, wildfires, agriculture conversion, energy development, urbanization, contaminants and wildlife crime) and address interactions among climate and non-climate stressors in priority landscapes.

Participate in regional climate science partnerships between employees and partners to acquire the necessary regional expertise to accomplish the designed goals and objectives.

Reduce habitat fragmentation and build connectivity by means such as habitat corridors to facilitate the movement of wildlife and plant species in response to climate change.

Acquire key water rights and flows.

Manage populations according to genetic resource needs.

Reduce susceptibilities to disease, pathogens and contaminants through improved surveillance and response capabilities and identification and implementation of management measures to reduce wildlife vulnerabilities.

Adjust harvest models of game species to incorporate climate change effects.

Participate in monitoring and research partnerships to conduct biological inventory and monitoring to understand the status and trends of wildlife and plant populations and their habitats and to help determine large-scale patterns of ecosystem health.

Enhance existing and develop new collaborative partnerships to conduct research related to wildlife adaptation to climate change.

Reduce carbon footprint through fleet replacement with comparable electric-type vehicles, increase solar power footprint and utilize best energy conservation practices for facilities.

Objective 3.4: Exotic and Invasive Species Management (Landscape Level)

Coordinate the Complex's invasive species management program to reduce the area coverage of non-native invasive plants/animals at the Complex that adversely impact native plant and wildlife communities, meet Complex habitat management objectives and reduce the opportunities for invasive species to colonize the Complex and surrounding lands.

Rationale 3.4:

Invasive non-indigenous (exotic) species have become the single greatest threat to the Refuge System and the Service's wildlife conservation mission. The Central Valley is occupied by a diversity and abundance of exotic, invasive species that are harmful because they crowd out or replace native species that are important to wildlife natural diversity and ecosystem function. These species often dominate old agricultural fields and early successional stages of restoration sites.

Exotic and Invasive Species Strategies (Landscape Level):

Black Phoebe. Photo: Rick Lewis

Cooperate with adjacent landowners in controlling and monitoring invasive species on Complex and adjacent lands within the greater GEA.

Participate in invasive species working/management groups at the Regional and National levels.

Participate in regional control and monitoring programs of invasive species, particularly along major corridors such as waterways and roads.

Participate and support research efforts into invasive species and control techniques on the landscape level.

Objective 3.5: Partnerships (Landscape Level)

Create and cultivate partnerships, whenever possible, with other entities including agencies, organizations, businesses, universities, landowners and private individuals, to coordinate and foster natural resource protection and management in the ecoregion. Maintain and enhance at least 15 partnerships among Federal, state, local agencies, organizations, schools, corporations and private landowners to promote natural resource management, with an emphasis on wildlife in the San Joaquin Valley and Central Valley.

Rationale 3.5:

The Service recognizes that forming partnerships with other entities, including agencies, organizations, businesses, universities, landowners and private individuals, provides significant benefits to wildlife, natural resources and the Refuge System. Partners support refuge activities and programs, raise funds for projects, advocate on behalf of wildlife and the Refuge System, provide support on important wildlife and natural resource issues and help coordinate wildlife management between refuge and non-refuge lands. In *Fulfilling the Promise* (USFWS 1999c), the Service identified the need to forge new and non-traditional alliances and strengthen existing partnerships with states, Tribes, nonprofit organizations and academia to broaden citizen and community understanding and support for the Refuge System. In addition to management at the San Luis NWR Complex, other ecosystem management efforts are being undertaken in the San Joaquin Valley. The USACE's Comprehensive Study, the San Joaquin River Management Program, NRCS's Wetlands Reserve Program and others are seeking to connect natural lands and foster natural resource management along the San Joaquin River. Refuge Complex involvement with these initiatives will provide greater benefits for wildlife.

Partnerships Strategies (Landscape Level):

Maintain and seek partnerships with local and regional conservation groups, academic institutions, organizations, and other local, state and Federal agencies to protect and enhance wildlife and natural resources in the San Joaquin and Central Valleys.

Pursue opportunities to cost share mutually beneficial wildlife projects with other organizations in the San Joaquin and Central Valleys.

Continue and expand involvement in Federal, state and local planning processes to protect the Refuge Complex's resources and foster cooperative management of those resources.

Maintain active participation by the Refuge Complex with the CVJV.

Participate in regional planning and management for migratory birds.

Participate in regional planning for the conservation of the California tiger salamander, vernal pool species and communities, San Joaquin kit fox and other listed species and species of special concern in the Central Valley.

Continue and foster partnerships with the Rocky Mountain Elk Foundation, Ducks Unlimited, California Waterfowl Association, California Deer Association, River Partners, the Nature Conservancy, local chapters of the Audubon Society and other conservation non-governmental organizations to protect and enhance wildlife in the Central Valley.

Continue to work closely with the USBR, local water districts and others on water supplies for the Refuge Complex and water issues.

Maintain and expand efforts with the USGS and others to conduct management-oriented research and monitoring efforts at the Refuge Complex and adjacent lands.

Provide natural resource information collected at the San Luis and Merced NWRs to other interested agencies, groups and researchers to foster collaborative efforts and support ecoregion-wide natural resource databases.

Participate in joint natural resource projects at the ecoregion level involving partners on issues pertaining to the management and protection of resources on the San Luis and Merced NWRs.

Partner with local and state fire services to provide fire suppression services for wildlands in the Central Valley and foster the use of prescribed fire on wildlands for fuels and wildlife management.

Partner with local schools and universities to maintain and expand environmental educational programs for students at the San Luis NWR Complex.

Expand opportunities with local chambers of commerce, schools and communities to participate in local events and improve dissemination of public recreation literature about the Refuge Complex.

Objective 3.6: Water Quantity (Landscape Level)

Maintain and use current Level 2 and Level 4 water allocations as designated under the CVPIA (See Goal 1.4) for the Merced NWR and San Luis NWR. Continue to foster and expand partnerships while coordinating with the responsible irrigation districts, the California State Water Board, the USBR, and other affiliated water management agencies (private and public) to maintain and improve water use efficiencies on a regional level.

Rationale 3.6:

Adequate water supplies are in high demand and short supply in the San Joaquin Valley of California. During years where refuge water supplies are reduced below their full Level 2 allocations, Merced and San Luis NWRs are unable to flood existing wetlands and some must be left unmanaged. Another challenge the Complex faces is the period during which water is available. For much of the area, surface water deliveries are tied to the agricultural irrigation cycles, which begin in April and end in September or October; most of the managed wetlands are flooded during the autumn when the irrigation season is ending, hold water throughout the winter and are drained during the spring. Additionally, many of the privately owned wetlands do not have the conveyance infrastructure and water rights necessary to secure surface water. As a result, surface water is not sufficiently available to manage the wetlands when water is most needed. Often groundwater pumping is the only option, but it is more expensive and less efficient, and provides water of lower quality. Other options for water are often cost prohibitive.

The potential impacts of climate change on water availability are of serious concern to both Merced NWR and San Luis NWR. Temperature increases will cause less precipitation to fall as snow, resulting in a reduction in the amount and reliability of water available in Central Valley reservoirs, which would lead to increased demands and rising water costs, thereby increasing competition between a growing urban population, the agriculture industry and wildlife needs. Increases in demands for electricity will make it more costly for the land managers to operate lift pumps and deep wells making it more difficult to manage wetland habitat and the wildlife beneficial agricultural program. In addition, limited sources of high-quality water could negatively influence the willingness of private landowners, who otherwise would have enrolled their lands into conservation easements, to consider other options that could eventually result in the conversion of habitat valuable to wildlife to and housing and commercial developments, which provide no value to wildlife. It is imperative that the NWRs, landowners within the Grasslands Management Area, CDFW, appropriate water districts, the California State Water Board and the USBR continue to work together, coordinate water needs and deliveries and search for the best available options to meet current water needs.

Greater Yellowlegs. Photo: Rick Lewis

Water Quantity Strategies (Landscape Level):

Continue to work with water districts, the California State Water Board and the USBR to maintain existing and secure additional water allotments for the Complex.

Continue to have regularly scheduled coordination meetings between the NWRs, CDFW, water districts, the California State Water Board and the USBR regarding all aspects of the use of water for land management.

Continue to document water delivery and use records at the Complex.

Continue to provide water use records from the Complex to the USBR.

Coordinate with neighboring landowners regarding flood runoff on the Complex and adjacent lands when appropriate.

Identify strategies and funding to maintain existing water supplies for the Complex while securing additional sources of water to effectively counter the effects of climate change.

Objective 3.7: Water Quality (Landscape Level)

Continue working with others to improve the quality of Complex water supplies for their use on wetlands and ensure Complex discharges from managed wetlands meet quality discharge standards.

Rationale 3.7:

Maintaining and ideally improving water quality is an essential part of Complex operations and is critical to maintaining the health and productivity of fish and wildlife communities. Both upstream and downstream issues regarding water quality directly impact or heavily influence Complex operations. Strong partnerships are needed to achieve ecosystem-level objectives and to insure that Complex-managed resources receive optimal water quality.

Landscape Water Quality Strategies:

Work with local water districts and other agencies to conduct assessments of the quality of water delivered to the Complex.

Work with academic partners (e.g., University of the Pacific, CSU Stanislaus and UC Merced) to encourage research and conduct assessments of the quality of water (i.e., salt, carbon, methylmercury and selenium flux) flowing into and out of Complex wetlands.

Work with the USBR to monitor and improve water quality being delivered to and draining off Complex lands.

Communicate with other NWRs to share lessons and best practices regarding monitoring and improving water quality on refuge lands.

Objective 3.8: Research (Landscape Level)

Contribute to a better understanding of the landscape-level ecology associated with the Northern San Joaquin Valley so that knowledge can be used to promote and direct natural processes that increase biodiversity and desired habitat conditions in a highly altered landscape.

Rationale 3.8:

Loggerhead Shrike. Photo: Paul Prado

Public agencies, private organizations and individual citizens have long shared a commitment of conserving the natural environment of their state. Laws, policies and programs already are in place to protect many elements of California's natural heritage. That experience, and a growing body of scientific research, demonstrates the need to move beyond existing efforts focused on the conservation of individual sites, species and resources. The need to protect and manage ecosystems and biological communities at the landscape level is now recognized; however, effective management approaches that address natural communities and ecosystems at a landscape level require a solid knowledge base of the species life history, biological communities, geomorphology and hydrologic processes on a bio-regional basis.

Research Strategies (Landscape Level):

Encourage and support applied research efforts that address major biodiversity conservation issues such as identifying natural ecological processes and habitat response to human-induced change.

Support research efforts to develop tools and guidelines for regional biodiversity planning.

Support research for actions identified in endangered species recovery plans and other species conservation/management plans that promote the recovery/conservation of species on a range-wide population level.

Support applied research to develop effective techniques to restore natural communities in the San Joaquin Valley.

Make Complex lands available, where compatible, as research sites to be used as part of large-scale, long-term ecological studies.

Support efforts of the California Natural Heritage Program by entering data collected from on-refuge surveys and research studies of threatened, endangered and Special Status species into the California Natural Diversity Database as well as other appropriate databases.

Objective 3.9: Monitoring (Landscape Level)

Contribute to local, landscape, regional and flyway-wide monitoring efforts for the benefit of fish and wildlife and the habitats on which they depend.

Rationale 3.9:

The exchange of biological data, from various landscape scales, between the Service and its partners contributes to the efficiency of Complex management, facilitates progress towards local, regional and national NWRS goals and helps to achieve landscape-scale conservation. Management and monitoring of species and their habitat at the landscape and regional level are critical to the stability and growth of their populations.

Monitoring Strategies (Landscape Level):

Implement monitoring programs that are compatible with Complex objectives, in partnership with state fish and wildlife agencies, universities, nonprofit groups, government agencies and volunteers to assist with landscape and regional ecological issues.

Coordinate with public and private partners at the local, landscape and regional level to monitor threatened and endangered species to facilitate their recovery.

Participate with other agencies and researchers in conducting flyway-wide population surveys, banding efforts and other research to benefit waterfowl and other migratory birds.

Contribute data gathered on the Complex to flyway and regional dataset for landscape level analyses of migratory birds, water quality and threatened and endangered species initiatives.

Work with the Service's National and Region 8 Refuge Inventory and Monitoring Programs to participate in landscape level monitoring efforts for trust resources.

Objective 3.10: Migratory Birds Management (Landscape Level)

Within local, landscape and regional frameworks, work with a diversity of landowners and partners to conserve migratory bird populations though habitat protection, restoration and management.

Rationale 3.10:

At the landscape level, migratory birds in the San Joaquin Valley are adversely impacted by the loss of wetlands and open space due to population growth and the change from wildlife-compatible agriculture to dairies, orchards and vineyards (USFWS 2009a and 2009b). To further fish and wildlife conservation outside of refuge fee-title boundaries, the Service engages willing partners, through non-regulatory incentives, by providing TA and funding support to protect agricultural lands and river floodplains, restore wetlands and riparian habitats and support wildlife-friendly farming and ranching. Privately owned lands within the GEA, on which 65,000 acres of conservation easements have been established since 1979, are managed to conserve their wetland and upland habitats for migratory birds. At a regional and flyway scale, the GEA is interconnected with other refuges and easements lands to form a network of suitable habitat areas for a host of migratory bird species. These areas provide migrants with stopover sites throughout the flyway on their way between breeding and wintering grounds. Taking a wider view of conservation issues and planning is paramount in successfully managing for migratory bird species.

Migratory Birds Strategies (Landscape Level):

Develop, enhance, support and implement collaborative conservation efforts to ensure long-term survival and growth of migratory bird populations in the GEA.

Coordinate with Pacific Flyway entities including DMBM, CDFW, USGS National Wildlife Health Lab and other organizations to conduct survey and monitoring efforts.

Work with private land managers to conserve, enhance or restore habitat for migratory birds across the landscape.

Include local, regional and flyway objectives when managing and restoring upland, wetland and riparian habitats through restoration of native vegetation.

Monitor the response of migratory birds to management and restoration efforts at the landscape level.

Support, through cooperation and management, conservation plans such as the Grassland Bird Conservation Plan (California Partners in Flight), Central Valley Habitat Joint Venture, California RHJV Conservation Plan, International Crane Foundation and National Mourning Dove Management Plan.

Objective 3.11: Ungulate Management (Landscape Level)

The San Luis NWR Complex will protect and conserve healthy, ecologically viable populations of California tule elk (*Cervus elaphus nannodes*) and black-tailed deer (*Odocoileus hemionus*). The Refuge Complex also will consider the future reintroduction of the native species pronghorn antelope (*Antilocapra americana*).

Rationale 3.11:

Large numbers of tule elk, pronghorn antelope and black-tailed deer once characterized the faunal assemblage of the Central Valley. Continued persistence and possible growth of the remaining ungulate populations found here today will require efforts through strong partnerships to achieve landscape level conservation.

Ungulate Management Strategies (Landscape Level):

Manage the San Luis NWR elk population in cooperation with the State of California to conserve the subspecies and meet the state's tule elk metapopulation management goals. Work with CDFW to continue to make improvements related to the captive herd's animal welfare.

Maintain and update elk management documents, such as the Johnne's Disease Management Plan and the MOU (1974) with the CDFW regarding California's Tule Elk Management Plan.

Evaluate proceeding with the third phase of the GEA Tule Elk Reintroduction Feasibility Study to examine potential alternatives for expanding the habitat available for tule elk on the

Refuge Complex and throughout the Grasslands WMA and propose strategies for addressing any issues related to a possible free-roaming elk herd.

Utilize Complex law enforcement resources—coordinating with CDFW and state parks—to protect the existing black-tailed deer population from poaching and other harassment.

Work with California Department of Transportation to implement the installation of "deer warning" signs along state highway 165 in the interest of black-tailed deer conservation and public safety.

Maintain and update the Deer Herd Management Plan Implementation Program (2003), a cooperative effort between the Service and CDFW to reestablish black-tailed deer in Merced County.

Conduct a pronghorn antelope reintroduction feasibility study with partners to investigate the potential for reintroducing this species to the GEA.

Examine the potential of including ungulate hunting on the Complex through revisions to the Complex Hunt Plan, and in careful coordination with CDFW and neighboring landowners, to manage healthy ungulate populations.

Objective 3.12: Fisheries Management (Landscape Level)

Coordinate with USFWS Anadromous Fisheries Recovery Program staff and other fisheries professionals to ensure that wetland and riparian habitats at the Complex and surrounding aquatic habitats provide and support rearing, migration and spawning habitat for native fish species.

Rationale 3.12:

The native and unique fish communities of the Central Valley have been severely impacted and depleted by habitat destruction and the introduction of exotic fish species. Most fish at the Complex and neighboring aquatic habitats are non-native species. Restoration of part or all the native assemblage of Central Valley fish species is a diversity priority for the Complex and surrounding lands.

Fisheries Strategies (Landscape Level):

Investigate the potential impacts of the restoration of the San Joaquin River for the Complex's natural resources, including fisheries.

Seek funding sources and establish partnerships to implement additional riparian floodplain restoration and fisheries projects along the San Joaquin River and adjacent natural waterways.

Support efforts and assist in the restoration of Chinook salmon to the San Joaquin River as well as other native fish species.

Investigate the potential impact of the reintroduction of Chinook salmon to the San Joaquin River on the vegetation, invertebrates, fish, birds and mammals of the streams and riparian habitats of the Complex.

Work with partners to evaluate floodplain rearing potential for fish, support and conduct monitoring to document actual use by and benefits to fish species and resolve any fisheries issues on Complex and adjacent lands.

Objective 3.13: Law Enforcement (Landscape Level)

Protect the Complex's wildlife, habitat and ecosystem resources, and ensure compliance with regulations through effective law enforcement on Complex lands and adjacent lands.

Rationale 3.13:

The Refuge Complex's wildlife, habitat and ecosystem resources are enhanced by and dependent on the adjacent landscapes within the greater GEA. Effective law enforcement is required on all lands to ensure compliance with regulations pertaining to the management of trust resources.

Law Enforcement Strategies (Landscape Level):

3.13.1. Conduct periodic easement compliance checks on the Grasslands WMA to ensure that the activities on easement lands remain in compliance with USFWS regulations regarding conservation easement lands.

3.13.2. Cooperate and participate with regional natural resource law enforcement initiatives to protect and conserve natural resources in the GEA.

Long-billed Curlew and Greater Yellowlegs. Photo: Rick Lewis

Objective 3.14: Fire Management (Landscape Level)

The Complex's fire program will provide support to other land management agencies in suppressing wildfires and conducting prescribed burns for the benefit of natural resources in the Central Valley.

Rationale 3.14:

To conduct a Complex fire program, the Complex must coordinate with other fire and land management agencies for support of wildfire suppression and prescribed burning. The San Luis NWR Complex fire management program coordinates with other NWRs within its Fire Management Zone on wildfire suppression, fuels treatments, prescribed fire projects and preventive cover assignments. The Complex program works with these other Refuges to help them meet their management and fire protection goals. At the local, landscape, regional and national levels, the Complex fire management program cooperates with county, state, and Federal resources within the National Wildfire Coordination Group on numerous wildfire suppression assignments per year.

Fire Management Strategies (Landscape Level):

Ensure firefighter and public safety.

Maintain a suppression response capability appropriate for meeting expected wildland fire complexity to include assisting with initial attack on off-refuge wildfires and provide resources to project wildfires in the central valley and adjacent lands.

Use prescribed fire, where appropriate, to reduce hazardous fuels by implementing prescribed burns as needed in support of lands managed by other natural resource agencies.

Employ prescribed fire to allow a natural phenomenon to continue to be a vital ecological process on lands managed by other natural resource agencies.

Use prescribed fire as a management technique to improve habitat for native wildlife on lands managed by other natural resource agencies.

Use prescribed fire to enhance and maintain native plant species composition in wetland, upland/grassland and vernal pool/alkali meadow habitats on lands managed by other natural resource agencies.

Use appropriate suppression tactics and strategies to minimize long-term impacts of wildfire suppression actions.

Educate the public regarding the role of fire concerning natural resources within the Central Valley.

Objective 3.15: Cooperate and Communicate with Adjacent Landowners

Maintain and enhance cooperation and communication with adjacent landowners to the Merced and San Luis NWRs to address mutual issues and concerns.

Rationale 3.15:

It is important to communicate with our neighbors to help identify any issues/concerns at an early stage and attempt to resolve any conflicts that may exist and to mutually assist one another on projects benefitting all concerns.

Cooperate and Communicate with Adjacent Landowners Strategies:

Maintain contact with adjacent neighbors at the Merced and San Luis NWRs to discuss mutual concerns and opportunities.

Implement improvements and operational revisions to resolve issues with adjacent landowners that are compatible with the mission of the Service and purpose of the refuges, as well as consistent with the funding available to the refuges.

Design habitat restoration and management projects to address considerations of adjoining landowners, including but not limited to provision of access controls and access for emergency and utility services, consideration of appropriate fire access and breaks, consideration of law enforcement issues, consideration of appropriate buffers where new planting directly adjoins agricultural crops and other issues/concerns.

Continue to consult with adjoining landowners as part of the development of plans for proposed restoration projects and other physical changes to the Complex.

Commission field surveys as needed to identify specific property boundaries where uncertainty has contributed to unresolved issues at the Complex.

Objective 3.16: Mosquito Control

The Complex strives to responsibly address the risks to public health and safety and protect trust resources from mosquito-borne diseases and the impacts of mosquito control pesticides on wildlife and the ecosystem. Several mosquito species found in the Central Valley include important vectors of potentially lethal diseases, including encephalitis, malaria and West Nile Virus.

Rationale 3.16:

Issues concerning mosquitoes and their associated problems (i.e., nuisance biting and vector-borne diseases) are frequently encountered with aquatic habitats, particularly when they are in proximity to human habitations. Aquatic habitats and wetlands, as well as irrigated pasture, provide conditions for breeding mosquitoes on the refuges. The San Luis and Merced NWRs are located within the Merced County Mosquito District. The district conducts mosquito monitoring programs (both larvae and adults), as well as disease monitoring programs (i.e., encephalitis, malaria and West Nile Fever). The district also conducts programs to control mosquito larvae and adults in Merced County. Both the San Luis and Merced NWRs are located far enough away from population centers in Merced County that the district mosquito control programs have not been conducted at either refuge. If the mosquito control program expands in Merced County to include the NWRs, the Complex will follow Service national guidance regarding mosquito control. Control programs on either of these refuges will require the approval of the refuge manager. Control efforts will focus on spraying larvicide as the preferred control method and adulticides will only be used on NWRs when there is a declared public health emergency. Any mosquito abatement efforts on Complex lands will require they do not negatively impact natural resources and addresses legitimate mosquito nuisance and disease issues in neighboring communities.

Mosquito Control Strategies:

Cooperate with local mosquito control districts to determine the presence of potentially dangerous mosquito-transmitted diseases on the Complex and take steps to restrict public access if needed.

Disseminate information to the public via printed material or local media regarding the presence of mosquitoes or potentially dangerous mosquito-transmitted diseases on the Complex.

Inform and educate the public regarding the important role mosquitoes fill in the ecosystem.

Follow NWR System policy regarding any requests for mosquito control programs on the Merced and San Luis NWRs.

Goal 4 Objectives

Strategies for this goal can be found in the Visitor Services Plan (Appendix G), which is incorporated by reference into this document.

Goal 4: Visitor Services and Public Use (Merced and San Luis NWRs)

Provide the public with opportunities for compatible, wildlife-dependent recreation and other uses to enhance understanding, appreciation and enjoyment of natural resources on the Merced and San Luis NWRs.

Objective 4.1: Wildlife Observation and Photography

The Complex will provide high quality and a variety of opportunities for wildlife observation and wildlife photography on its lands.

Rationale 4.1:

Wildlife observation is identified in the Refuge Improvement Act as a priority public use that can be allowed when compatible with other refuge purposes. As a result, the refuges encourage first-hand opportunities to observe wildlife in their habitats. This activity will be managed to ensure that people have opportunities to observe wildlife in ways that minimize wildlife disturbance and damage to refuge habitats. Wildlife viewing will be managed to foster a connection between visitors and natural resources. The wildlife observation program will be managed in accordance with Service Manual 605 FW 4, Wildlife Observation.

Wildlife photography is identified in the Refuge Improvement Act as a priority public use that can be allowed when compatible with other refuge purposes. As a result, the refuges encourage first-hand opportunities to observe and photograph wildlife in their habitats. This activity will be managed to ensure that people have opportunities to photograph wildlife in ways that minimize wildlife disturbance and damage to the refuges' habitats. Wildlife photography will be managed to foster a connection between visitors and natural resources. The wildlife photography program will be managed in accordance with Service Manual 605 FW 5, Wildlife Photography.

Objective 4.2: Hunting Program

The Service will provide the public a high quality and diverse hunting program, including opportunities for hunting of waterfowl and other waterbirds, at the San Luis and Merced NWRs.

Rationale 4.2:

Hunting is identified in the Refuge Improvement Act as a priority public use that can be allowed when compatible with other refuge purposes. As a result, the refuges allow hunting of waterfowl, coot, common moorhen, ring-necked pheasant and snipe. The hunting program may be expanded in the future, if found to be compatible, to include ungulate hunting through revisions to the Complex Hunt Plan, in careful coordination with CDFW and neighboring landowners. The hunting program will be conducted in a safe and cost-effective manner, consistent with State regulations, to provide safe hunting opportunities and minimize conflicts with other priority wildlife-dependent recreational uses. Other visitor uses occur on different areas on the refuges, thereby minimizing potential conflicts with hunters. The Complex hunting program complies with the Code of Federal Regulations Title 50[16], 32.1 and is managed in accordance with Service Manual 605 FW 2, Hunting.

Objective 4.3: Fishing

The Complex will implement a quality fishing program for visitors at the San Luis unit of the San Luis NWR by providing and maintaining fishing access locations along Salt Slough.

Rationale 4.3:

Fishing is identified in the Refuge Improvement Act as a priority public use that can be allowed when compatible with other refuge purposes The San Luis NWR will continue to allow fishing at designated locations in the Salt Slough channel. The fishing program will be conducted in a safe and cost-effective manner, consistent with state regulations to provide fishing opportunities, while minimizing conflicts with other priority wildlife-dependent recreational uses. Other visitor uses that could conflict with fishing occur on different areas of the refuge, thereby minimizing potential conflicts with anglers. The refuge fishing program complies with the Code of Federal Regulations Title 50, 32.1 and is managed in accordance with Service Manual 605 FW 2, Hunting (for fishing).

Objective 4.4: Environmental Education

The Complex will promote and conduct environmental education that is aligned to the current Federal, state and local curriculum standards; meets the goals and needs of local school districts; and provides interdisciplinary opportunities that link the natural world with all subject areas.

[16] Available online at https://www.ecfr.gov/current/title-50/chapter-I/subchapter-C/part-32

Rationale 4.4:

Environmental education is identified in the Refuge Improvement Act as a priority public use that can be allowed when compatible with individual refuge purposes. As a result, the refuges encourage environmental education as a process of building knowledge in students. The Complex staff will work with schools (K-12) to integrate environmental concepts and concerns into structured educational activities. These Complex-led or educator-conducted activities are intended to actively involve students or others in first-hand activities that promote discovery and fact-finding, develop problem-solving skills and lead to personal involvement and action. The environmental education program will be managed in accordance with Service Manual 605 FW 6, Environmental Education.

Objective 4.5: Interpretation

The Refuge Complex will provide quality opportunities for wildlife interpretation on its lands.

Rationale 4.5:

Interpretation is identified in the Refuge Improvement Act as a priority public use that can be allowed when compatible with other refuge purposes. As a result, the Complex encourages interpretation as both an educational and recreational opportunity that is aimed at revealing relationships, examining systems and exploring how the natural world and human activities are interconnected. Participants of all ages can voluntarily engage in stimulating and enjoyable activities as they learn about the issues confronting fish and wildlife resource management on the refuges. First-hand experiences with the environment will be emphasized, although presentations, audiovisual media and exhibits will be necessary components of the refuges' interpretive program. The interpretive program will be managed in accordance with Service Manual 605 FW 7, Interpretation.

Environmental Ed School Visit Presentation. Photo: USFWS

Environmental Ed School Visit at Amphitheatre. Photo: USFWS

Objective 4.6: Visitor Center Operation

The San Luis NWR Complex Visitor Center serves as a welcoming and launching point for visitors to learn about the wildlife and habitats of the Complex before embarking outdoors on the refuges. The visitor center is a contact point for visitors to interact with staff and have questions and concerns addressed.

Rationale 4.6:

Visitor centers serve an important function to welcome and orient visitors on a refuge. The information contained in exhibits conveys key messages about the Complex and provides background information to complement the visit.

Objective 4.7: Volunteer Program

The Complex will maintain and increase the number of participants in the volunteer program to assist with visitor services, wildlife and natural resources projects at the San Luis NWR Complex.

Rationale 4.7:

The National Wildlife Refuge System Volunteer and Partnership Enhancement Act of 1998 (P.L. 105–242) strengthens the Refuge System's role in developing relationships with volunteers. Volunteers possess knowledge, skills and abilities that can enhance the scope of refuge operations. Complex staff will initiate, support and nurture relationships with volunteers so they may continue to be an integral part of refuge programs and management. The volunteer program will be managed in accordance with part 150 of the FWSM; chapters 1–3 of *Volunteer Services Program*; and part 240, chapter 9, of *Occupational Safety and Health, Volunteer and Youth Program*.

Objective 4.8: Friends Group

The Complex will explore developing a partnership with a Refuge Friends nonprofit support and advocacy group.

Rationale 4.8:

Friends groups can be instrumental in assisting refuges with building support from the public and funding refuge projects.

Objective 4.9: Public Outreach

The Complex will reach out to surrounding communities using a variety of media and venues to raise awareness and inform residents about the importance of the Complex, its mission and the availability of public use activities.

Rationale 4.9:

Public support is vital for refuge operations. To give support, the public needs to have a clear understanding of why refuges exist, what refuge management entails, how the public can use and enjoy the refuge and what wildlife-dependent activities occur for the public to take part in throughout the year.

Objective 4.10: Monitoring (Visitor Services)

The Complex will monitor public visitation to determine when and where visitation occurs, in which activities visitors are engaging and the number of visitors that are participating, as well as monitor and inspect public use infrastructure for needed repair or replacement.

Rationale 4.10:

For the public use program to be successful, the Complex must understand visitation trends at each refuge, including which public uses take place, visitor numbers and visitation seasons.

Monitoring Strategies (Visitor Services):

Maintain automobile traffic counters at suitable access and egress locations on auto tour routes and foot traffic counters on nature trails at the San Luis NWR and Merced NWR to estimate annual public use.

Maintain records on visitation at public events and environmental education events to track visitation trends annually.

Regularly inspect public use infrastructure (i.e., kiosks, observation platforms, wayside exhibits, auto tour routes, nature trails) for necessary repair or replacement.

Track hunter use and harvest information for all hunt units and blinds.

Objective 4.11: Research (Visitor Services)

The Complex will promote conducting research of public use activities to answer questions regarding how public uses impact wildlife and habitats as well as on the quality of visitor services programs.

Rationale 4.11:

To better understand the impacts that public uses have on wildlife, the Complex must conduct research of public visitation and wildlife interactions.

Visitor Services Research Strategies:

The Complex will partner with local universities to conduct research on human dimensions and wildlife interactions on the Complex as well as on the quality of visitor services programs at the Complex.

Goal 5: Objectives and Strategies

Goal 5: Wildlife Conservation Easement Management (Grasslands WMA)

Manage the Service's easement program (Grasslands WMA) on private lands for the benefit of wildlife and explore the potential for additional wildlife easements from willing sellers within the approved easement acquisition boundary.

Objective 5.1: Easement Acquisition

Continue to acquire wildlife habitat conservation easements from willing landowners within the Grasslands WMA's approved acquisition boundary.

Rationale 5.1:

Since the inception of the Complex private lands program in 1979, the Service has been acquiring conservation easements. The Service has acquired approximately 80,000 acres of conservation easements on private lands (Grasslands WMA). These easements perpetually protect habitat for a variety of wildlife, with emphasis on benefits to migratory birds.

Easement Acquisition Strategies:

Acquire conservation easements in the refuge acquisition boundary to include the Grasslands WMA approved boundary.

Identify lands within the acquisition boundary that will meet the habitat needs of migratory birds and other wildlife and prioritize by habitat type (e.g., native wetlands, native uplands, managed wetlands and wildlife-friendly agricultural uses) and wildlife use.

Special consideration will be given to lands threatened by habitat destruction or conversion to non-wildlife friendly uses and that have willing sellers.

Develop and maintain cordial relationships with landowners, with emphasis on those that are within the acquisition boundary and have land with habitat values that are consistent with the conservation easement program.

Develop specific easement language for each parcel of land to maximize the value to wildlife while meeting the needs of the interested landowner.

Work with the Service's realty office on the acquisition of easement lands from willing sellers within the approved land acquisition boundary for the Grasslands WMA. Act as liaison between realty and landowner.

Objective 5.2: Easement Management and Compliance

Maintain wildlife habitat values on easement lands of the Grasslands WMA through easement monitoring, PFW project monitoring, coordination with landowners and, where needed, enforcement provisions of the conservation easement.

Rationale 5.2:

Daily management of easement lands is solely a landowner responsibility. However, the Service, through the easement program manager, has the responsibility to monitor the easement lands, ensuring that the wildlife habitat values that were purchased through the easement are retained in perpetuity.

Easement Management and Compliance Strategies:

Further landowners' understanding of the importance of easement compliance within the Grasslands WMA and the benefits to maintaining their land as wildlife habitat.

Further develop geographic database to include easement status, restoration/enhancement status, updated property name, contact information and compliance issues for the Grasslands WMA.

Conduct easement compliance site visits on at least 45 properties per year of the Grasslands WMA.

Conduct annual aerial compliance flights over 100 percent of the Grasslands WMA.

Identify and document issues of easement non-compliance within the Grasslands WMA.

Strive to work cooperatively with landowners that are non-compliant to rectify matters in a positive and reinforcing matter to resolve issues.

Objective 5.3: Habitat Enhancement and Restoration

Conduct projects to restore, enhance and protect habitat for migratory birds and other wildlife on the easement lands making up the Grasslands WMA.

Rationale 5.3:

Continue to enter into short-term (10–30 years) habitat restoration or enhancement partnerships with interested willing landowners within the Grasslands WMA, San Joaquin Valley and surrounding foothills. Employ the Service's PFW and other habitat programs to implement habitat restoration/enhancement projects on lands within the Grasslands WMA.

Habitat Enhancement/Restoration Strategies:

Strive to extend habitat enhancement and restoration projects to the full extent of the Northern San Joaquin Valley and Foothill Ring Partners for Fish and Wildlife focus areas.

Map existing Complex fee-title lands, easements and partnerships to identify wildlife habitats in need of improvement and prioritize potential projects.

Prioritize efforts to develop new habitat restoration and enhancement partnerships based on trust species' use of unprotected habitat for the Grasslands WMA.

Develop contact lists of landowners and land managers of unprotected habitats who might be willing to enter into partnerships within the Grasslands WMA.

Maintain positive relationships with existing partners. Identify when partnerships are due to expire and ensure the opportunity to enter into new partnerships as appropriate.

Implement habitat projects through the Service's PFW and other habitat programs on the easement lands making up the Grasslands WMA.

Develop TA documents to assist private landowners in the management of wildlife habitat on their lands within the Grasslands WMA.

Objective 5.4: Partnerships and Coordination (Easements)

Develop and maintain partnerships and coordinate habitat improvement and protection activities with a diverse group of private landowners and managers, conservation groups and government agencies.

Rationale 5.4:

Network with private landowners and managers, conservation organizations and local, state, Native American and Federal government agencies to perpetuate the conservation of wildlife habitat values in the San Joaquin Valley, with emphasis on the Grasslands WMA.

Partnerships/Coordination Strategies:

Identify, meet with and open discussions with as many private landowners and managers, conservation organization representatives and members, and local, state, Native American, and Federal government employees as practicable regarding wildlife and habitat programs. Seek to leverage funding with other organizations and agencies to implement larger projects.

Actively maintain professional relationships and develop new ones with local landowners, land managers, conservation organization members and conservation agency contacts to promote and enhance wildlife conservation.

Maintain and update contact information about conservation programs for landowners in the Grasslands WMA.

Assist private landowners with advice and funding to achieve their partnering habitat improvement goals wherever and whenever possible.

Develop a public outreach program targeted at new landowners and partners within the Grasslands WMA acquisition boundary.

Develop an environmental education program for school-aged children and one for adults with the help of the PFW.

Utilize various media (e.g., newsprint, brochures, local radio and television, internet) to expand knowledge and awareness of the Partners for Fish and Wildlife and Conservation Easement programs and provide information on beneficial habitat management practices for wildlife.

Objective 5.5: Wildfire Management (Easements)

The Complex's Fire Program will respond to CA Department of Forestry and Fire Protection (CAL FIRE) requests to assist with fighting wildfires on easement lands of the Grasslands WMA. The Fire Program also will respond to landowner requests and work through the Complex project leader to plan and implement prescribed fires on easement lands conducted for the benefit of wildlife.

Prescribed Burn. Photo: USFWS

Rationale 5.5:

Easement lands are protected by Merced County in the event of a vegetation fire or structure fire. However, the Complex's FMP is written to provide guidelines for preparedness, prevention and suppression of fires on neighboring properties, including the Grasslands WMA as well as the protection of Complex resources.

Easement Wildfire Strategies:

At the request of CAL FIRE/county, Complex firefighting personnel will assist with suppressing wildfires on easement lands and other lands.

By special request only, and through coordination with private landowners and the Complex's project leader, Complex firefighting personnel will assist with prescribed fires on easement lands.

The Complex's Fire Program will ensure firefighter and public safety through good decision-making and compliance with Service policy as identified in the Fish and Wildlife Service Manual (621 FW 1) and Fire Management Handbook.

Objective 5.6: Law Enforcement (Easements)

In cases of easement non-compliance, when all other methods of persuasion have failed, involve the Service's law enforcement program to correct issues/concerns.

Rationale:

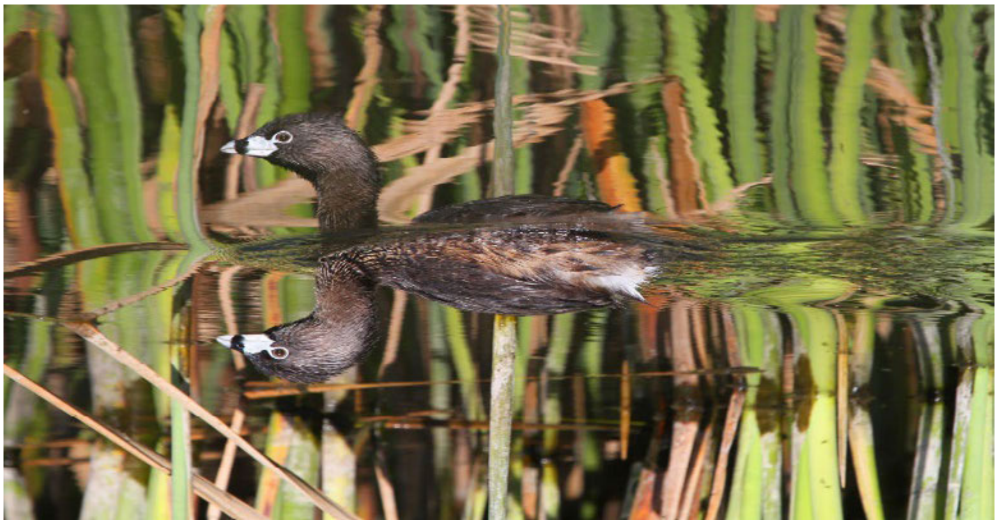
Throughout the more than 40 years this easement program has been in existence, there have been very few instances where the easement program manager for the Grasslands WMA has had to involve law enforcement to enforce the terms and conditions of the easement language. Nonetheless, law enforcement involvement is available as a final step to ensure easement compliance.

Easement Law Enforcement Strategies:

Investigate and exhaust all avenues prior to involving the law enforcement program in easement compliance.

Determine severity and importance of easement violation to determine the level of law enforcement involvement needed (e.g., mediator, solicitor or Federal agent).

Involve the law enforcement program, determine what input they need and follow through until the easement non-compliance issue is resolved.



Pied-billed Grebe. Photo: Rick Lewis

Chapter 5: Implementation

Introduction

This CCP will serve as the primary reference document for San Luis NWR Complex planning, operations and management for the next 15 years or until it is formally revised or otherwise amended within that time period. The Service will implement the CCP with assistance from existing and new partner agencies and organizations and the public. The timing and achievement of the management strategies proposed in this document are contingent upon a variety of factors, including:

- Funding and staffing
- Step down plans
- Compliance requirements
- Compatibility determinations
- Adaptive management
- Monitoring
- Plan amendment and revision

CCPs provide long-term guidance for management decisions and set forth goals, objectives and strategies needed to accomplish refuge purposes and identify the Service's best estimate of future needs. These plans detail program planning levels that are sometimes substantially above current budget allocations and, as such, are primarily for Service strategic planning and program prioritization purposes. Accordingly, the plans do not constitute a commitment for staffing increases, operational and maintenance increases or funding for future land acquisition.

Funding & Staffing

The funding required to operate any NWR includes initial capital outlay for equipment, facilities, labor and other expenditures, as well as annual, ongoing costs for staff, contracts, supplies, management, maintenance and other recurring expenses. Initial expenditures for the Complex as described in the CCP would cost approximately 16 million dollars. Not all these capital expenditures would accrue during the first year of implementation or even during the full 15 years of this plan. For example, habitat development and research would be implemented over the entire length of the plan and select equipment, vehicles and staff may be borrowed or shared from other refuge units of the San Luis NWR Complex. The largest costs for this initial outlay are for habitat restoration and maintenance, implementation of a public use program and maintaining infrastructure. Funding for many of these individual projects will be sought through grants and cooperative partnerships.

At full staffing, personnel dedicated to the Complex would include a project leader, deputy project leader, a conservation easements manager, three assistant refuge managers, a patrol captain and two refuge law enforcement officers, three administrative personnel, four visitor services staff, a private lands biologist, three wildlife biologists, seven maintenance staff and ten fire management program staff. At full staffing, the Complex would also employ several term, temporary and part-time positions and interns. Most of these staff are shared among the different refuges of the Complex. The recurring CCP implementation total approximately $5–7 million at full staffing and implementation.

Step-Down Management Plans

Some projects or types of projects require more in-depth planning than the CCP process is designed to provide. For these projects, the Service prepares step-down management plans. In essence, step-down management plans provide the additional details necessary to implement management strategies identified in a CCP.

The Refuge System Manual lists more than 25 step-down management plans that might be needed at a refuge. These step-down management plans typically are revised at a more frequent interval than a CCP.

Current or anticipated step-down plans for the San Luis NWR Complex include:

- Plans that are current and up to date:
- Visitor Services Plan (2022)
- Hunt Plan (2020)
- A Conservation Summary/Inventory and Monitoring Plan (2021)

Plans that need to be initiated:

- Integrated Pest Management Plan
- Fire Management Plan
- Compliance Requirements

This CCP was developed to comply with all applicable Federal laws, executive orders and legislative acts. Some activities, particularly those that involve revising an existing step-down management plan or preparing a new one, will need to comply with additional laws or regulations besides NEPA and the Refuge Improvement Act. In addition to these acts, full implementation of all components of this CCP requires compliance with other laws and mandates (Appendix I: Relevant Federal Laws and Mandates).

Adaptive Management & Monitoring

Adaptive management acknowledges there is uncertainty in decision making and seeks to reduce that uncertainty through comparison of predicted outcomes. The NWRS is a vast, complex management program that requires making natural resource management decisions often under considerable uncertainty and operational constraints. The NWRS presents many opportunities for applying the adaptive management process.

Williams, Szaro and Shapiro (2007) defined adaptive management as an adjustable, learning-based, decision-making process that utilizes scientific monitoring of management actions and ecological variability to make effective decisions to meet the environmental, social and economic goals of resource stakeholders. Specific, measurable and achievable, result-oriented objectives with specified time frames are developed followed by a range of potential management actions. Testable models and monitoring methods are designed to allow for adaptive decision-making regarding management actions. This process is followed by further monitoring, evaluation, assessment and revisiting of alternatives.

Evaluation.

Adaptive management is the process of implementing policy decisions as scientifically driven experiments that test predictions and assumptions about management plans, using the resulting information to improve the plans. Management direction is periodically evaluated via a system of applying several options, monitoring the objectives and adapting original strategies to reach desired objectives. Habitat, wildlife and public use management techniques and specific objectives will be regularly evaluated as results of a monitoring program and other new technology and information become available. These periodic evaluations would be used over time to adapt both the management objectives and strategies to better achieve management goals. Such a system embraces uncertainty, reduces option foreclosure and provides new information for future decision-making while allowing resource use.

Monitoring.

The outcomes of monitoring programs involving wildlife populations and their habitats and ecosystem processes serve as the foundation for decision-making in all facets of refuge management. Monitoring programs guide conservation planning and are critical to evaluating the effectiveness of management prescriptions and the success of habitat restoration. Decisions to implement techniques—such as water management, grazing, integrated pest management, prescribed fire and habitat restoration—to manage refuge wetlands and uplands are based on data generated through monitoring efforts.

Monitoring is integrated directly into the iterative process of adaptive management. Complex personnel will continue to use a science-based, adaptive management system to pursue the Refuge System mission of conserving, managing and restoring fish, wildlife and plant resources and their habitat.

Monitoring varies in intensity and complexity based on the level of detail needed, funding, available personnel and time constraints. To gather the appropriate level of information, monitoring programs ranging from qualitative observational efforts to rigorous experiments are employed. At the refuge level, studies include individual species surveys (threatened and endangered species, baseline inventories), long-term population-level surveys (indices to track changes over time), wildlife response to habitat management (comparison of diversity and abundance under different management regimes), and controlled, replicated experiments (block designs to isolate treatment effectiveness). Complex staff also contribute to landscape, flyway, regional and national monitoring initiatives in which they are one of many participants working toward a common goal. These projects include Aleutian cackling goose banding and collar reading, mid-winter waterfowl surveys, snow and Ross's goose counts and mourning dove banding.

Historically, monitoring on the Complex focused on describing population trends in threatened and endangered species, migratory birds, vernal pool fauna and flora, colonial nesting waterbirds and the captive tule elk herd. Stemming from the issue of selenium poisoning at Kesterson NWR in the 1980s, much research and monitoring have been conducted with partners on contaminant levels in wildlife and their aquatic and terrestrial habitats. In more recent years, there has been an increased emphasis on water quality monitoring to assess levels of salt, boron, methylmercury, organic carbon and nutrients in water supplies entering and leaving Complex wetlands. In addition to population trends and contaminants/water quality monitoring, more detailed research has been conducted by universities and nonprofit groups to answer specific questions of interest. Generally, these projects are focused on a particular management or ecological question (for example, impacts of power line diverters on birds) rather than broader scale, population-level trends.

Through an internal review of the biological monitoring program, improvements to its scientific rigor, data storage and retrieval, level of analysis and overall focus have been made. Written proposals for new monitoring programs include literature reviews to ensure that the latest peer-reviewed techniques are employed, methods are scientifically valid and study designs will adequately answer the questions posed. Proposals are reviewed by internal biologists and managers and, when possible, external experts to ensure they are scientifically sound. For example, the process of counting individuals of a species and entering data into Complex records without a clear objective for why the data are being collected is being replaced by posing specific questions of ecological and management concern, designing monitoring to collect meaningful data and analysis to test competing hypotheses. To aid this process, both monitoring and management databases have been developed to efficiently manage and query the numerous sources of monitoring data and conduct analyses to assess the impacts of management prescriptions on wildlife and their habitats.

A shift from general population monitoring toward the establishment of science-based objectives and questions has begun and will continue to occur in the future. This is the most efficient use of data within the adaptive management framework. Large-scale monitoring programs have been integrated with management on the Complex to complete the adaptive management feedback loop. For example, data on wetland plant composition, structure and productivity and the use of seasonal wetlands by waterbirds have been coupled with wetland management databases. This allows Complex staff to assess the effectiveness of management techniques in growing moist soil plants and the subsequent use of wetlands by migratory waterbirds. The findings of these analyses have been used to change management prescriptions to better serve Complex resources. As databases continue to develop, future queries and analyses will allow Complex staff to adjust water management, rehabilitation schedules and restoration plans to more efficiently meet the needs of wetland-dependent wildlife species.

A similar program is being initiated within refuge upland habitats to track the effectiveness of grazing, integrated pest management, prescribed fire and mechanical treatment on migratory and resident birds, small mammals, reptiles, amphibians and vernal pool invertebrates. The same database, GIS and analysis models already developed for wetland habitats will be used for the upland monitoring program. With some modifications to the existing systems, the integration of this program into current upland monitoring and management will occur smoothly.

An effort also has been made to describe the relationships between monitored wildlife species and the habitats they make use of during various life stages. Assessing this link provides us with a much more detailed description of what drives wildlife use of particular areas. To accomplish this, we have expanded many monitoring programs—which in the past focused solely on wildlife counts—to include measures of habitat characteristics. Information on vegetation composition, structure and spatial juxtaposition is collected in addition to data on wildlife abundance, diversity and density. With these data, more complex analyses can be conducted to ascertain species habitat preferences and fine-tune habitat management. In short, the San Luis National Wildlife Refuge Complex is attempting to answer not only how many individuals there are in an area, but why they are there.

The flexibility that is built into the biological monitoring program can accommodate future projects as they come online. Databases can be expanded, GIS can be updated easily and new monitoring programs can be tracked as future challenges present themselves. The established adaptive management program and science-based decision-making process will allow us to efficiently monitor wildlife and their habitats on the Complex in the years to come, regardless of the challenges faced.

Monitoring is an essential component of the CCP. Monitoring strategies have been integrated into many of this plan's goals and objectives. Specific details, including monitoring strategies, methods, techniques and locations, are or will be outlined in a step-down Habitat Management Plan and Wildlife Inventory and Monitoring Plan, respectively. In this CCP, habitat monitoring receives an important emphasis.

All habitat management activities will be monitored to assess whether the desired effects on wildlife and habitat components have been achieved. Baseline surveys will be conducted for wildlife species for which existing or historical numbers and occurrences are not well known. Studies will also monitor wildlife responses to increased public use of the Complex for fishing, hunting, wildlife observation and environmental education.

Monitoring will be designed and developed in cooperation with universities and non-governmental organizations to the greatest extent possible. Applied research can provide insight into ecological questions concerning habitat, wildlife and public use management. Complex staff would work with researchers to ensure that investigations are applicable and compatible with Complex objectives.

Maintaining and restoring habitat quality and quantity are a major means of accomplishing Complex goals and objectives. Monitoring would focus on measuring vegetative diversity and abundance, water quality and quantity and wildlife response to management practices. Baseline surveys would be established for other species for which existing or historical numbers are not established.

Progress toward Complex goals and objectives will be evaluated based on the results of this station's monitoring activities. Refuge goals outline the desired future conditions of a refuge in clear and succinct statements. The Refuge System defines goals as a "descriptive, open-ended, and often broad statement of desired future conditions that conveys a purpose but does not define measurable units" (602 FW 1). SMART objectives are then developed in subsequent CCP step-down plans in more detail. CCP goals reflect working toward the refuge's vision and purpose.

Plan Amendment and Revision

This CCP is intended to evolve as the Complex changes, and the Refuge Improvement Act specifically requires formal revision and updating of CCPs at least every 15 years. The formal revision process would follow the same steps as the CCP creation process. In the meantime, the Service would be reviewing and updating this CCP periodically based on the results of its adaptive management program. This CCP would also be informally reviewed by Complex staff while preparing annual work plans and updating Complex databases. It may also be reviewed during routine inspections or programmatic evaluations. Results of any of these reviews may indicate a need to modify the plan.

The goals described in this CCP would not change until they are reevaluated as part of the formal CCP revision process. However, the objectives and strategies may be revised to better address changing circumstances or to take advantage of increased knowledge of the resources at the Refuge Complex. If changes are required, the level of public involvement and associated NEPA documentation would be determined by the refuge manager.

Complex objectives and strategies are intended to be attained over the next 15 years. Management activities would be phased in over time and implementation is contingent upon and subject to results of monitoring and evaluation, funding levels and staffing.

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