

San Luis National Wildlife Refuge Complex Feral Pig Monitoring and Management Plan

Prepared by:

Anna Prowant, Conservation Planner

Concurred:

Chris Harper, Project Leader

Concurred:

Jenny Ketterlin, Refuge Invasive Species Coordinator

Concurred:

Mark Pelz, Chief, Natural Resources Division, Refuges

Approved:

Curt McCasland, Assistant Regional Director, Refuges

Chapter 1: Summary/Introduction

Location

This San Luis National Wildlife Refuge (NWR or Refuge) Complex Feral Pig Monitoring and Management Plan (Plan) is for the United States (U.S.) Fish and Wildlife Service (Service), U.S. Department of Agriculture Wildlife Services (USDA WS), or other cooperator to monitor and manage feral pigs within the approximately 128,747-acre San Luis NWR Complex. The San Luis NWR Complex is comprised of the San Joaquin NWR, San Luis NWR, Merced NWR, and Grasslands Wildlife Management Area (WMA). The Complex is surrounded by Interstate 5 to the west and California Highway 99 to the east, and is located in Merced, Stanislaus, and San Joaquin counties. The NWR Complex is enclosed by the Sierra Nevada Mountains to the east and the Coast Range to the west in the northern San Joaquin Valley. The City of Los Banos separates the West and South units of the Grasslands WMA, and the acquisition boundary of the Grasslands WMA extends to six miles from the City of Merced (see **Figure 1**, *San Luis NWR Complex Location Map*). The San Joaquin River NWR is approximately 35 miles north of the San Luis NWR and is located within western Stanislaus and San Joaquin counties, nine miles west of the City of Modesto, California. The San Luis NWR, Merced NWR, and Grasslands WMA are located wholly in Merced County, California.

The approved acquisition boundary for San Luis NWR, Merced NWR, and Grasslands WMA is over 200,000 acres in size, with approximately half of the lands being either fee-title and owned by the Service or privately owned land in perpetual conservation easements (see **Figure 2**, *Land Status Map - San Luis NWR, Merced NWR, and Grasslands WMA*). The Service has the land-use rights to protect or enhance the habitats on the conservation easements within the Complex. The San Luis NWR, Merced NWR, Grasslands WMA, and San Joaquin River NWR currently total approximately 128,747 acres, of which approximately 44,158 acres are fee-title and 84,589 acres are conservation easements to protect native plants and wildlife. The Grasslands WMA, which has the largest concentrated easement program for wildlife in California, contains approximately 80,335 acres of land in conservation easements. The Grasslands WMA “East Unit” contains approximately 14,412 acres of fee-title land, while the “West Unit” contains approximately 691 acres of fee-title land. Merced NWR contains approximately 3,822 acres of fee-title land, while San Luis NWR is approximately 17,817 acres of fee-title land. Meanwhile, San Joaquin River NWR is approximately 7,416 acres of fee-title land and approximately 4,254 acres of conservation easement land (see **Figure 3**, *Land Status Map - San Joaquin River NWR*).

Figure 1. San Luis NWR Complex Location Map

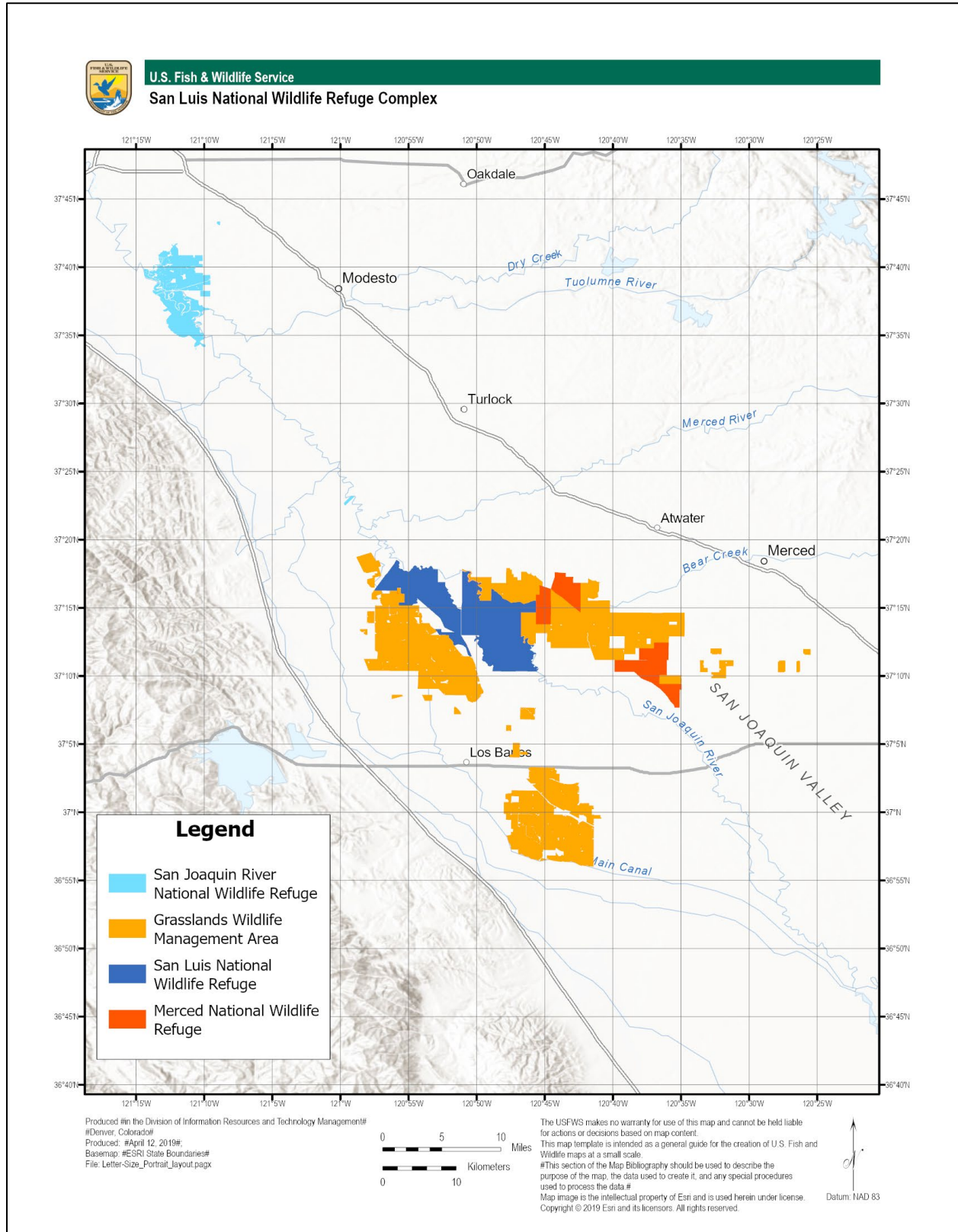


Figure 2. Land Status Map - San Luis NWR, Merced NWR, and Grasslands WMA

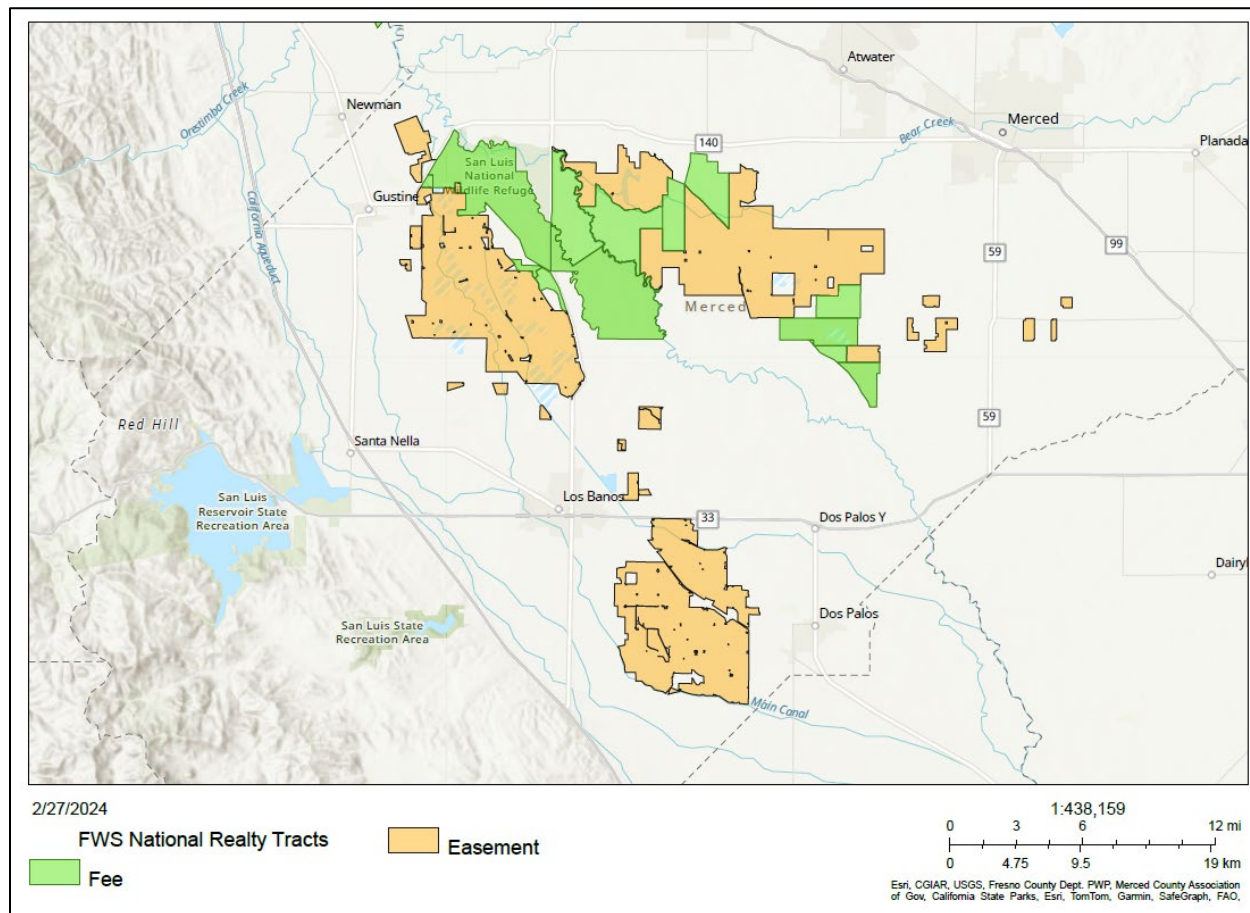
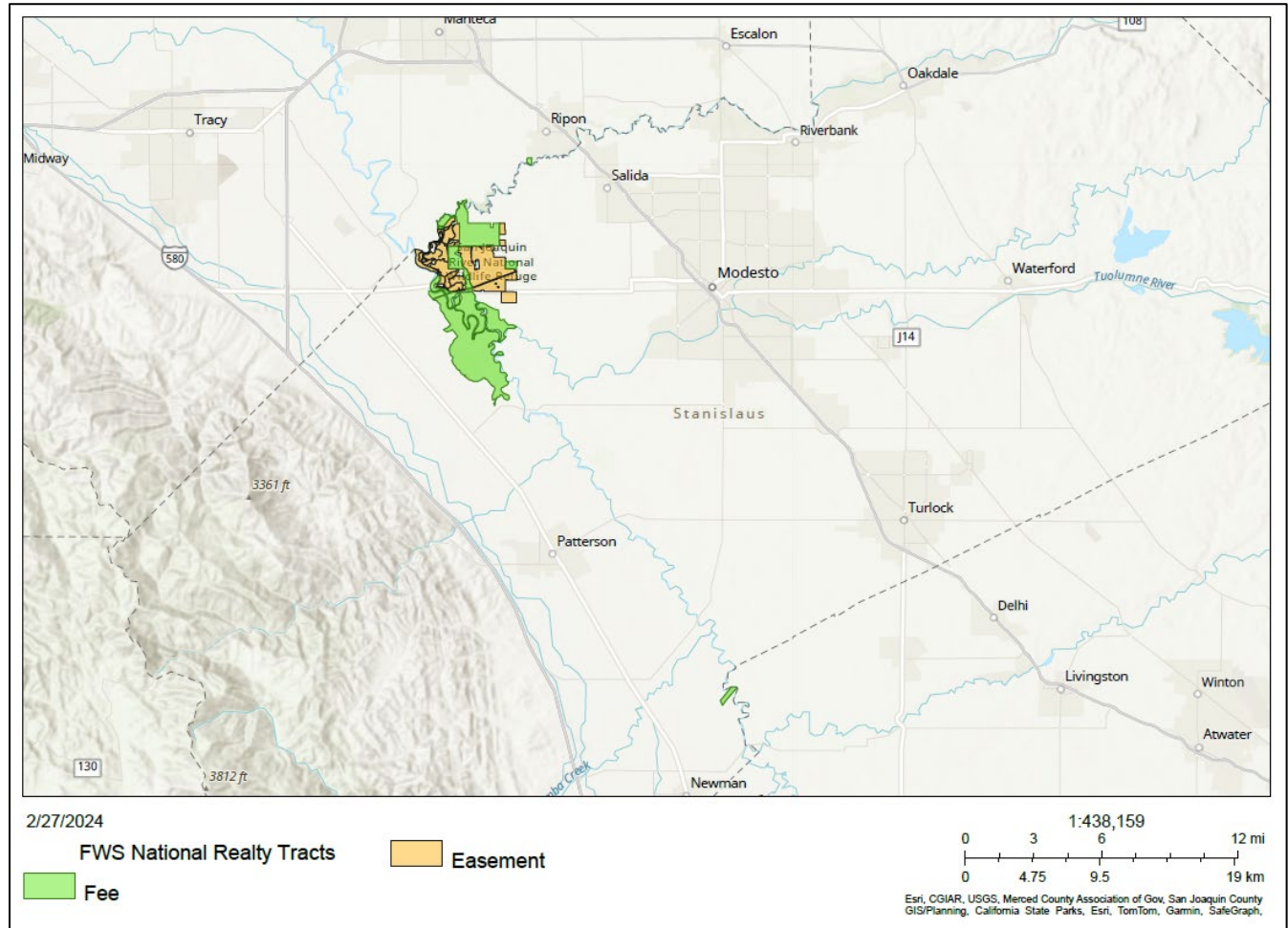


Figure 3. Land Status Map - San Joaquin River NWR



The San Joaquin River NWR occurs along the main stem of the San Joaquin River, from near the confluence of the Merced River, north to the Stanislaus River. While most of the San Joaquin NWR is within Stanislaus County, California, this Refuge contains two noncontiguous parcels, the Mohler tract, which is located approximately three miles east of the main portion of the Refuge, along the north bank of the Stanislaus River in San Joaquin County, California, as well as the Eplin tract, which is south of the Refuge. The landscape of the San Joaquin River NWR, in addition to the San Luis NWR, Merced NWR, and Grasslands WMA, represents a locally and regionally significant remnant of what was once a broad floodplain of major rivers in California's Central Valley. The entire Complex occurs within the San Joaquin River watershed (see **Figure 4, Watershed Map**).

The San Luis NWR is the largest contiguous Refuge occurring in California's Central Valley and consists of seven management units, while the Merced NWR consists of four discrete parcels: Merced Unit, Snobird Unit, Arena Plains Unit, and Lone Tree Unit. The Grasslands WMA consists principally of private lands protected by conservation easements and serves as a critical east-west corridor for wildlife between the Sierra Nevada and Coastal Range. Active wetland management occurs at nearly all of the regularly flooded wetlands located within the San Luis NWR Complex, with the goal of producing high-quality

habitats for wetland-dependent wildlife, especially migratory birds (U.S. Fish and Wildlife Service [Service] 2023).

Figure 4. Watershed Map



Background

Executive Order (EO) 13751, *Safeguarding the Nation from the Impacts of Invasive Species*, was established in 2016 and, “directs actions to continue coordinated Federal prevention and control efforts

related to invasive species.” This EO defines invasive species as, “a non-native organism whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health” (81 Fed. Reg. 88609 [2016]). Within this EO, it states:

“It is the policy of the United States to prevent the introduction, establishment, and spread of invasive species, as well as to eradicate and control populations of invasive species that are established. Invasive species pose threats to prosperity, security, and quality of life. They have negative impacts on the environment and natural resources, agriculture and food production systems, water resources, human, animal, and plant health, infrastructure, the economy, energy, cultural resources, and military readiness. Every year, invasive species cost the United States billions of dollars in economic losses and other damages.

Of substantial growing concern are invasive species that are or may be vectors, reservoirs, and causative agents of disease, which threaten human, animal, and plant health. The introduction, establishment, and spread of invasive species create the potential for serious public health impacts, especially when considered in the context of changing climate conditions. Climate change influences the establishment, spread, and impacts of invasive species.”

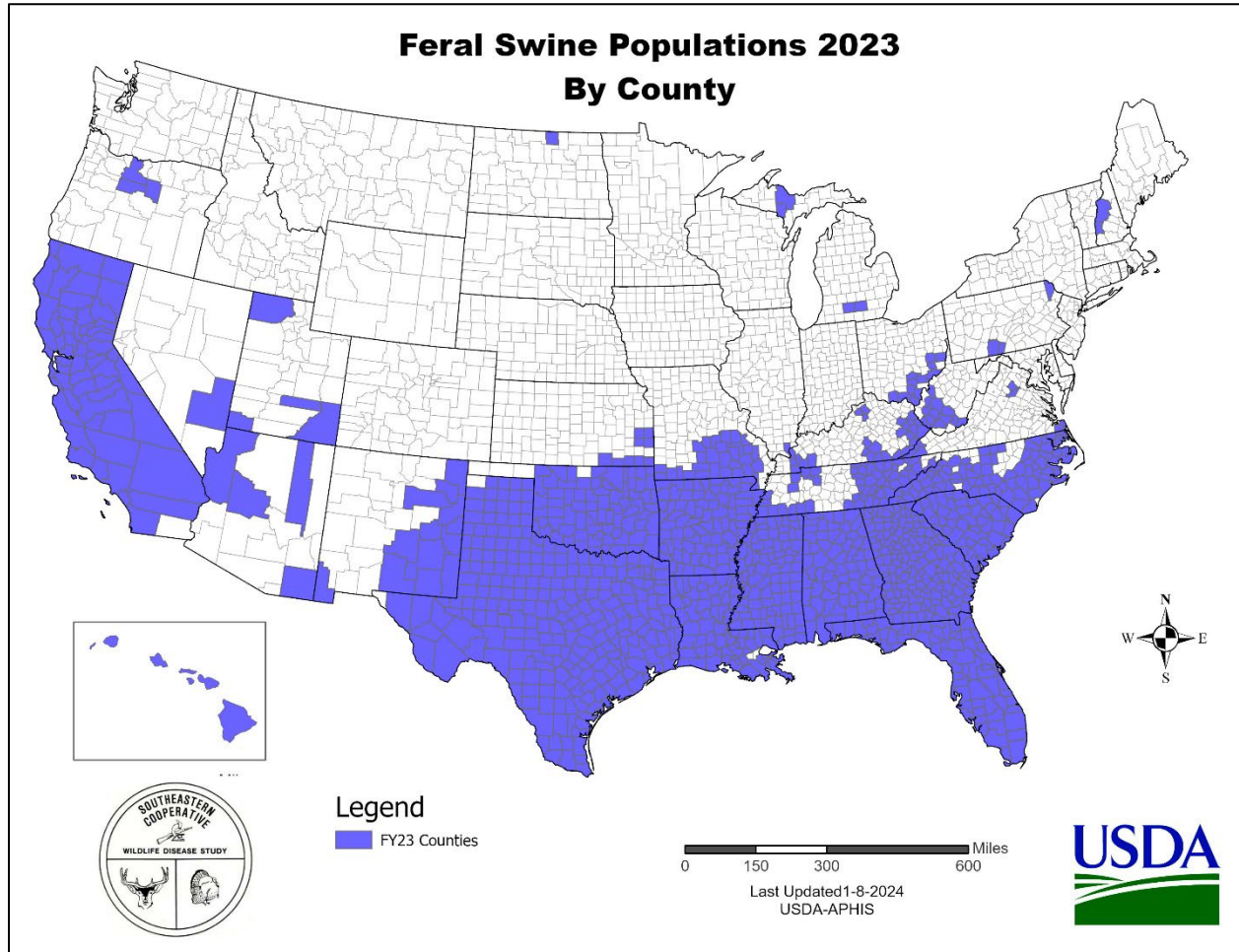
Domestic pigs were brought to California by Spanish and Russian settlers in the early 1700s as livestock; however, many became feral and in the 1920s the European wild boar was introduced and bred with the domestic pigs. These introductions created wild boar/feral domestic pig hybrids, which ravage native landscapes (California Department of Fish and Wildlife [CDFW] 2023).

Feral pig (*Sus scrofa*) has been documented in 56 of California’s 58 counties, which has raised concerns regarding adverse effects this invasive species can have on native flora and fauna, sensitive habitats, and agriculture (CDFW 2023). This invasive species can carry at least 30 diseases and almost 40 parasites that may affect humans, in addition to transmitting foodborne illnesses with the ability to cause elevated waterborne bacteria levels in water sources. Feral pigs can also become aggressive toward humans, as well as pets. In addition, as omnivores, they will feed upon vegetation, reptiles, amphibians, and small mammals, as well as the nests, eggs, and young of ground-nesting birds (USDA 2020a).

This invasive species is known for having a voracious appetite and one study reported 49 spadefoot toads (*Scaphiopus holbrookii*) in the stomach of a single feral pig. They have an affinity for acorns, thus reducing the regeneration of oak trees in California and causing damage to their root systems. Damage can include reducing habitat suitability for native and listed species (candidate, threatened or endangered) through rooting (uprooting plants and exposing bare soil for invasive species to invade), wallowing (disturbing riparian areas), foraging (reducing food sources for native species), and hunting behaviors (Finzel and Baldwin 2015).

Damage caused by this invasive species and methods to control the further spread within the U.S. is estimated to cost 1.5 billion each year, but ongoing research indicates it could be considerably higher (USDA 2020b and **Figure 5, Feral Pig Distribution Map**).

Figure 5. Feral Pig Distribution Map



Due to the destructive nature of feral pigs, an effective monitoring and management plan is necessary, to avoid negative impacts from this species and protect natural and cultural resources conserved within the San Luis NWR Complex. Managing feral pig populations on the San Luis NWR Complex will help with the management of feral pigs on adjacent privately owned land.

Feral pigs have been observed on the San Joaquin River NWR and San Luis NWR, and on neighboring agricultural lands. This invasive species is actively being managed by a property owner with land adjacent to the San Joaquin River NWR, who began trapping on their privately owned land in fall of 2022. Coordination efforts with adjacent landowners is proposed as part of the management and monitoring activities for the San Luis NWR Complex and will assist in achieving widespread monitoring and control efforts of feral pigs on Complex lands and adjacent privately owned land.

Due to the current lack of feral pig management on the San Luis NWR Complex, Complex lands could be harboring pigs, thus reducing the effectiveness of control efforts conducted by adjacent landowners. In addition, this leads to further negative impacts to the sensitive flora, fauna, and habitats within the San Luis NWR Complex caused by this destructive species. The most effective and efficient means to control for feral pig requires large-scale action, where the Service works collaboratively with adjacent landowners.

This Plan has been prepared to describe the details of future actions to monitor for and control, when deemed necessary, the presence of feral pig within the San Luis NWR Complex on fee-title and easement land. The potential effects to the human environment of implementing this proposal were analyzed in the Environmental Assessment (EA) for the San Luis NWR Complex Feral Pig Monitoring and Management Plan.

Chapter 2: Refuge Overview and Purpose

Every NWR is guided by the mission and goals of the NWR System (Refuge System), the purposes of each individual Refuge, Federal laws, EOs, Service Policy, and international treaties. Relevant guidance includes, but are not limited to, the National Wildlife Refuge System Administration Act (Administration Act) of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 United States Code [U.S.C.] 668dd et seq.), the Refuge Recreation Act of 1962, selected portions of the Code of Federal Regulations, and the Service Manual.

The mission of the Refuge System 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 the United States for the benefit of present and future generations of Americans.” (U.S.C. 668dd(a)(2))

The Administration Act directs the Secretary of the Department of the Interior (DOI) to manage each Refuge to fulfill the mission of the Refuge System and individual Refuge purposes (16 U.S.C. 668dd(a)(3)(A)). Additionally, the Administration Act mandates the Secretary of the Interior in administering the Refuge System (16 U.S.C. 668dd(a)(4)) to:

- Provide for the conservation of fish, wildlife, and plants, and their habitats within the Refuge System;
- 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;
- Ensure that the mission of the Refuge System described at 16 U.S.C. 668dd(a)(2) and the purposes of each Refuge are carried out;
- Ensure effective coordination, interaction, and cooperation with owners of land adjoining Refuges and the fish and wildlife agency of the states in which the units of the Refuge System are located;
- Assist in the maintenance of adequate water quantity and water quality to fulfill the mission of the Refuge System and the purposes of each Refuge;
- Recognize compatible wildlife-dependent recreational uses as the priority general public uses of the Refuge System through which the American public can develop an appreciation for fish and wildlife;
- Ensure that opportunities are provided within the Refuge System for compatible wildlife-dependent recreational uses; and
- Monitor the status and trends of fish, wildlife, and plants in each Refuge.

The San Luis NWR complex supports significant waterfowl and waterbird resources, and provides habitat for populations of other sensitive species (including candidate, threatened, and endangered). This NWR

Complex protects and restores many of the unique, native upland and wetland habitats of the Central Valley, as well as the wildlife and plants that they support.

San Joaquin River NWR Establishment and Purpose

The San Joaquin River NWR was established in 1987 for the purpose of preserving wetland, grassland, pasture, and riparian habitats for use by the previously endangered Aleutian Canada geese (*Branta canadensis leucopareia*), as well as four other endangered wildlife and plant species, and a great variety of Pacific Flyway geese, ducks, cranes and other birds (Service 1987).

The initial acquisition that established the San Joaquin River NWR was made under the authorities of:

- The Endangered Species Act (ESA) of 1973 (16 U.S. Code 1531-1543; 87 Statute 884), as amended;
- Migratory Bird Conservation Act of 1929; and
- Fish and Wildlife Act of 1956, using funds made available through the Land and Water Conservation Fund Act of 1965 (U.S. Code 4601-4-4601011; 78 Statute 897)

The San Joaquin River NWR purposes, as stated in the law, are:

"To conserve (A) fish or wildlife which are listed as endangered species or threatened species or (B) plants..." 16 U.S.C. § 1534 (ESA of 1973)

"...For use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. § 715d (Migratory Bird Conservation Act)

"...For the development, advancement, management, conservation, and protection of fish and wildlife resources." 16 U.S.C. § 742f(a)(4)

"...For the benefit of the United States Fish and Wildlife Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant, or condition and servitude." 16 U.S.C. § 742f(b)(1) (Fish and Wildlife Act of 1956)

Goals of the San Joaquin River NWR include:

"Conserve and protect the natural diversity of migratory birds, resident wildlife, fish and plants through restoration and management of riparian, upland and wetland habitats on Refuge lands."

"Contribute to the recovery of threatened/ endangered species, as well as the protection of populations of special status wildlife and plant species and their habitats."

"Provide optimum wintering habitat for Aleutian Canada geese to ensure the continued recovery from threatened and endangered species status."

"Coordinate the natural resource management of the San Joaquin River National Wildlife Refuge within the context of the larger Central Valley/San Francisco Ecoregion."

"Provide the public with opportunities for compatible, wildlife-dependent visitor services to enhance understanding, appreciation and enjoyment of natural resources at the San Joaquin River NWR."

San Joaquin River NWR is managed to conserve, protect, and enhance native habitats of the San Joaquin Valley, focusing on wildlife and the ecological processes on which they depend. Due to intensive land

use and development, a large portion of native habitats and species have been reduced within the valley. The Refuge maintains the land as an important riparian corridor within the state's Central Valley by conserving and restoring the native habitats (Service 2006).

The San Joaquin River NWR expanded their focus in 1999 to include protecting floodplain lands through acquisition and restoration of floodplain habitats, as well as function of those lands. The goal for the San Joaquin River NWR is to restore and enhance habitat for threatened, endangered, and sensitive wildlife species, while increasing connectivity to existing riparian habitat, and creating self-sustaining native habitats (Service 2011). The Service purchased over 3,000 acres of land between 1998 and 2000 to contribute to the San Joaquin River NWR and have garnered \$24.5 million in grant funding for both riparian and floodplain restoration since 2002. Approximately 2,700 acres of riparian woodland habitat and 700 acres of wetland habitat, as well as eight miles of flood refugia on levee slopes, has been restored within this Refuge (Service 2021a). In addition, re-establishment of the Federally endangered riparian brush rabbit (*Sylvilagus bachmani riparius*) was initiated in 2002 at the San Joaquin River NWR as part of the species' recovery program.

The San Joaquin River NWR's focus has expanded over time to include other threatened and endangered species, migratory birds, wildlife dependent on wetlands and riparian floodplain habitat, as well as restoration of habitat and ecological processes. However, providing wintering habitat for Aleutian Canada geese and protecting this species remains a primary objective of this Refuge. The San Joaquin River NWR and its management have assisted in the recovery of the Aleutian Canada goose and its removal from the Threatened and Endangered Species List. This species was delisted in 2001 and the population expanded to approximately 215,000 in 2022 (Service 2022). The San Joaquin River NWR and adjacent lands still provide important wintering habitat for Aleutian Canada geese even as the wintering population size has increased and expanded to other areas, including northern California counties (Pacific Flyway Council 2023).

San Luis NWR Establishment and Purpose

The San Luis NWR was established in 1967 to provide habitat for migratory birds. The initial acquisition that established the San Luis NWR was made under the authority of the Migratory Bird Conservation Act of 1929.

The San Luis NWR purposes, as stated in the law, are:

"...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds."
16 U.S.C. § 715d (Migratory Bird Conservation Act)

"... shall be administered by him [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 U.S.C. § 664 (Fish and Wildlife Coordination Act)

"... for the development, advancement, management, conservation, and protection of fish and wildlife resources ..." 16 U.S.C. § 742f(a)(4)

"... for the benefit of the United States Fish and Wildlife Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant, or condition of servitude ..." 16 U.S.C. § 742f(b)(1) (Fish and Wildlife Act of 1956)

Goals of the San Luis NWR include:

“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.”

“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.”

“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.”

“Maintain and/or restore natural ecological processes to promote healthy, functioning ecosystems for wildlife on Complex lands by developing strong partnerships 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” (Service 2023).

The San Luis NWR is the largest contiguous Refuge of the Refuge System in California’s Central Valley and includes sensitive habitats, such as annual grassland, vernal pool, wetland, and riparian corridors (Service 2023).

Merced NWR Establishment and Purpose

In 1951, the Merced NWR was established and was the first acquisition of the San Luis NWR Complex. This NWR was acquired under the Lea Act for the purpose of protecting surrounding agricultural land from waterfowl depredation by attracting these birds to the Merced NWR. The initial acquisition that established the Merced NWR was made under the authorities of the Lea Act of 1948 (16 U.S.C. 695-695c; 62 Stat. 238).

Additional acquisitions occurred under the authorities of:

- The ESA of 1973 (16 U.S. Code 1531-1543; 87 Statute 884), as amended;
- Migratory Bird Conservation Act of 1929;
- Fish and Wildlife Act of 1956, as amended; and
- Refuge Recreation Act of 1962

The Merced NWR purposes, as stated in the law, are:

“...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds.”
16 U.S.C. § 715d (Migratory Bird Conservation Act)

“...for the management and control of migratory waterfowl and other wildlife ...” 16 U.S.C. § 695 (Lea Act)

“...to conserve (A) fish or wildlife which are listed as endangered species or threatened species or (B) plants ...” 16 U.S.C. Sec 1534 (ESA of 1973)

Goals of the Merced NWR include:

“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.”

“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.”

“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.”

“Maintain and/or restore natural ecological processes to promote healthy, functioning ecosystems for wildlife on Complex lands by developing strong partnerships 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” (Service 2023).

Since the original acquisition, no additional land was acquired for this Refuge until the 1990s, which included adding the Arena Plains unit in 1992, and supports at least nine natural communities, including vernal pool, freshwater marsh, native grassland, and a remnant of the Merced River alluvial dune ecosystem. This area has not been cultivated or irrigated and thus supports a wide diversity of endemic, rare, and endangered flora and fauna that were once abundant throughout California’s Central Valley (Service 2023). Additional land has been added to the Merced NWR since that time and the Refuge is split into four discrete parcels, which are the Merced unit, Snobird unit, Lone Tree unit, and Arena Plains unit.

Grasslands WMA Establishment and Purpose

The Grasslands WMA was officially established in 1979, with the requirement of the lands within the easement program benefiting migratory birds, and specifically waterfowl. The purpose of the conservation easements is to provide waterfowl habitat, in addition to protecting land from urban and agricultural encroachment (Service 2023).

The initial approval of the acquisition boundaries occurred in 1978 and was approved by the Migratory Bird Conservation Commission for the West Grasslands WMA, which allowed for the establishment of conservation easements on privately owned land.

The Grasslands WMA purposes, as stated in the law, are:

“...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds.”
16 U.S.C. § 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 U.S.C. § 3901(b) (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 U.S.C. § 1534 (ESA of 1973)

The goal of the Grasslands WMA is to:

“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” (Service 2023).

Chapter 3: Refuge Resources of Concern

Service Policy 620 Fish and Wildlife (FW) 1, Habitat Management Plans, defines Resources of Concern as:

“...all plant and/or animal species, species groups, or communities specifically identified in Refuge purpose(s), System mission, or international, national, regional, state or ecosystem conservation plans or acts.”

The Central Valley is known for having a rich Native American history, as Native Americans resided in villages on the elevated locations above the floodplain. Due to the abundance of natural resources along the San Joaquin River, the Yokuts lived along the river and its tributaries (Service 2006, 2023). Therefore, there are cultural resources within the San Luis NWR Complex.

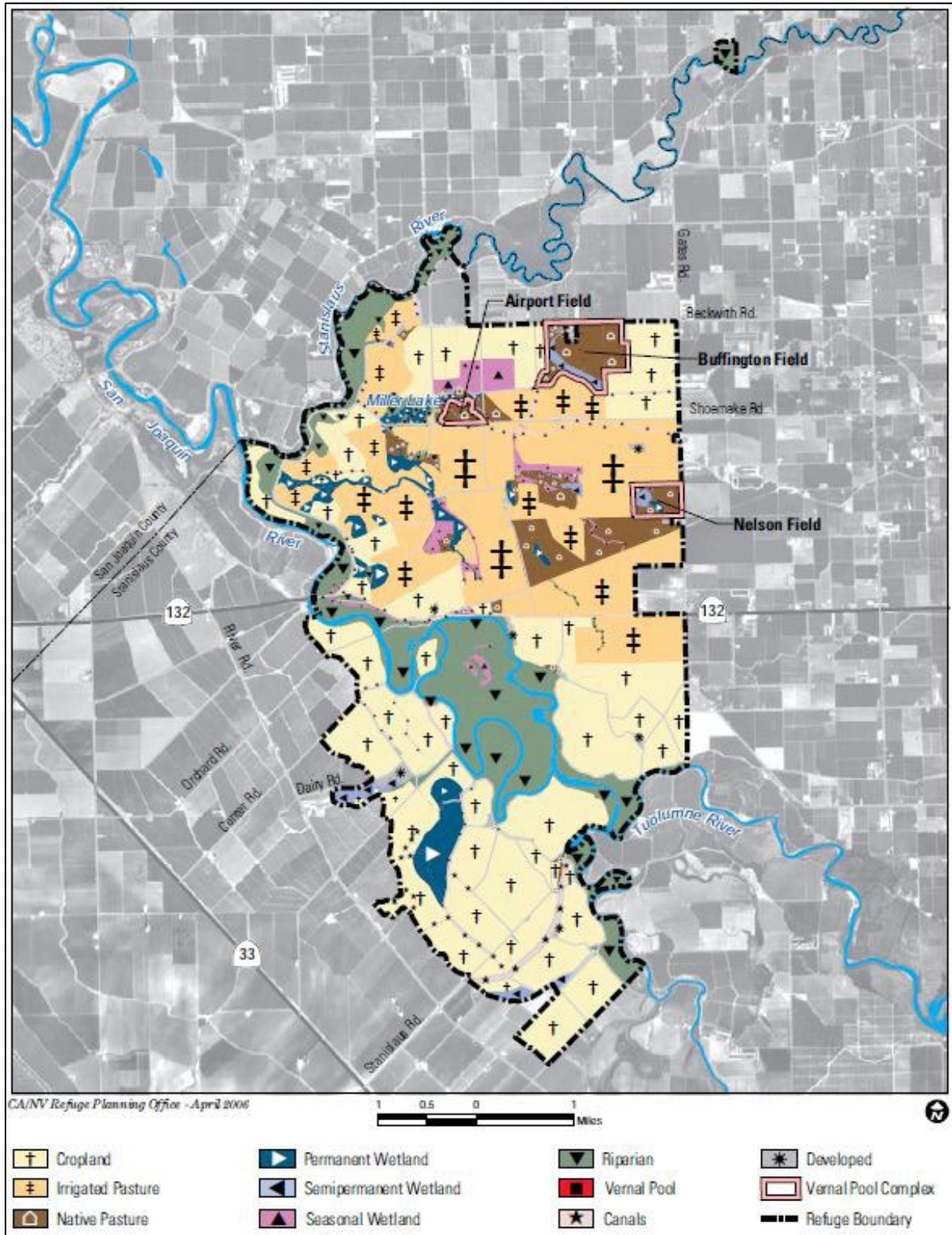
The San Luis NWR Complex is located on the northern boundary of the Grasslands area, which contains the largest remaining acreage of freshwater wetlands in California. The importance of this critical area for waterfowl and other waterbirds has been recognized by the Central Valley Joint Venture and the North American Waterfowl Management Plan. It is considered of international importance for migratory waterfowl and shorebirds of the Pacific Flyway (Service 2006).

Sensitive Habitat

San Joaquin River NWR

Within the Central Valley where the San Joaquin River NWR occurs, there are three major vegetation communities, which include riparian, wetland, and grassland habitats. This Refuge supports a variety of native habitats, ranging from valley oak gallery and mixed riparian forests/woodlands to seasonal and permanent wetlands, and native grasslands. These habitats support a diversity of native fish, wildlife, and plants (see **Figure 6, Land Cover Map – San Joaquin River NWR**, Service 2006).

Figure 6. Land Cover Map - San Joaquin River NWR



San Luis NWR

The San Luis NWR consists of wetland, riparian, and grassland habitats. This Refuge contains the largest acreage of mature riparian woodland habitats within the Complex, with the majority associated with the San Joaquin River, as well as its tributaries and sloughs (see **Figure 7**, *Land Cover Map – San Luis NWR, Merced NWR, and Grasslands WMA*; Service 2023).

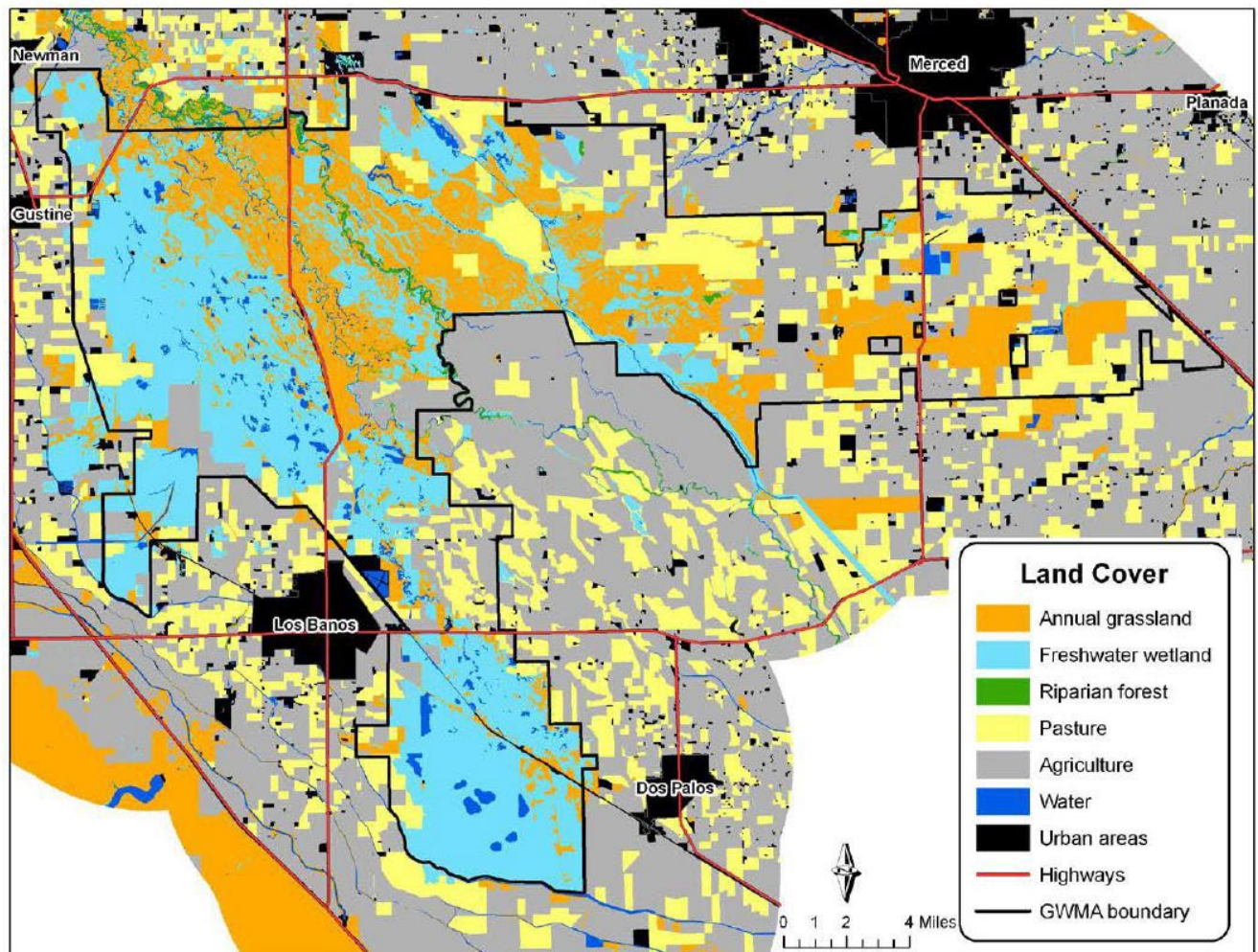
Merced NWR

Habitats within the Merced NWR include wetland, riparian, grassland, and cropland. While much of cropland habitat within this Refuge has been restored to other habitat types, some remains, such as irrigated pastures, to provide shortgrass winter foraging habitat for waterfowl and other migratory birds. Riparian woodlands are restricted to narrow strips along some of the waterways within this Refuge (see **Figure 7**, *Land Cover Map – San Luis NWR, Merced NWR, and Grasslands WMA*; Service 2023).

Grasslands WMA

Within the Grasslands WMA, the habitat types are classified as wetland, riparian, grassland, and cropland. In addition, some of the conservation easements within the Grasslands WMA contain irrigated pastures, which provide upland habitat for waterfowl and various migratory birds (see **Figure 7**, *Land Cover Map – San Luis NWR, Merced NWR, and Grasslands WMA*; Service 2023).

Figure 7. Land Cover Map - San Luis NWR, Merced NWR, and Grasslands WMA



Special-Status Species

The entire San Luis NWR Complex is a major migration and wintering area for waterfowl in the Pacific Flyway. The San Luis NWR, Merced NWR, and Grasslands WMA alone provide wintering habitat for 25 percent of waterfowl that winter in the Central Valley of California. The San Luis NWR Complex occurs in what is known as the Grasslands (or Grasslands Ecological Area) of the San Joaquin Valley. The Grasslands is one of the most important shorebird areas on the west coast of the U.S., as it contains approximately one-third of California's remaining wetland habitat. The Grasslands has been designated as one of 22 international shorebird reserves in the entire world (Service 2023).

Several native species listed as threatened or endangered under the Federal ESA; threatened or endangered under the California ESA; proposed, candidate, or protected under other environmental laws and regulations occur on the San Luis NWR Complex for at least a part of their life cycle. These species are protected and managed in accordance with the following sources of law:

- Bald and Golden Eagle Protection Act of 1940, as amended, 16 U.S.C. 668-668c, 50 Code of Federal Regulations (CFR) 22;

- ESA of 1973, as amended, 16 U.S.C. 1531-1544; 36 CFR Part 13; 50 CFR Parts 10, 17, 23, 81, 217, 222, 225, 402, and 450;
- Fish and Wildlife Coordination Act of 1934, 16 U.S.C. 661-666(e);
- Fish and Wildlife Act of 1956, 16 U.S.C. 742 a-m;
- Lacey Act of 1900, as amended, 16 U.S.C. 3371 et seq.; 15 CFR Parts 10, 11, 12, 14, 300, and 904;
- Migratory Bird Treaty Act of 1918, as amended, 16 U.S.C. 703-712; 50 CFR Parts 10, 12, 20, and 21; and
- EO 13186 – Responsibilities of Federal Agencies to Protect Migratory Birds, 66 Fed. Reg. 3853 (2001).

Within the San Luis NWR Complex, the species that are known to occur or have potential to occur include nine Federally listed endangered species, one Federally proposed endangered species, eight Federally listed threatened species, two Federally proposed threatened species, six State listed endangered species, six State listed threatened species, 23 California species of special concern, seven State watch list species, and one State fully protected species.

Portions of the San Luis NWR Complex are designated as critical habitat for Conservancy fairy shrimp (*Branchinecta conservatio*), longhorn fairy shrimp (*Branchinecta longiantenna*), vernal pool fairy shrimp (*Branchinecta lynchi*), vernal pool tadpole shrimp (*Lepidurus packardii*), delta smelt (*Hypomesus transpacificus*), steelhead (California Central Valley DPS) (*Oncorhynchus* [=Salmo] *mykiss*), colusa grass (*Neostapfia colusana*), and Hoover's spurge (*Chamaesyce hooveri*). As part of the Complex's conservation efforts, re-establishment of the riparian brush rabbit was initiated in 2002 at the San Joaquin River NWR as part of the species' recovery program, which currently only exists in a few isolated populations.

Chapter 4: Background and Need for the Plan

Management goals within the San Luis NWR Complex on Service land include conserving, protecting, managing, restoring, and enhancing native habitats, plants, and wildlife species of the San Joaquin Valley, with an added emphasis on supporting the abundance of migratory birds. Maintaining and ideally improving water quality is critical to maintaining the health and productivity of the fish and other native wildlife within the San Luis NWR Complex and is an essential part of Service operations (Service 2023). As part of the Complex's management and operations, the Service has a goal of contributing to the recovery of threatened and endangered species, and protecting Central Valley endemic species and their habitats.

To assist in maintaining, enhancing, and restoring natural ecological processes throughout the Complex to have healthy and functioning ecosystems for native wildlife, the Service has a management goal of developing strong relationships with other entities, such as research institutions, partners, as well as local, State, and Federal agencies. Coordination with these entities could assist with natural resource management within the larger context of the Central Valley and Pacific Flyway (Service 2006, 2023). In addition, maintaining and enhancing communication with adjacent landowners to identify issues or concerns at an early state and resolve any issues that arise to mutually assist one another on projects addressing those concerns is an objective for the Service (Service 2023).

Goals for the Complex on Service land also include providing the public with opportunities for compatible, wildlife-dependent recreation and other uses to enhance visitor's understanding,

appreciation, and enjoyment of the native plants, animals, and habitats within the Complex. For the Grasslands WMA, the Service has a goal to manage the Service's easement program to benefit native wildlife on the privately owned land (Service 2023).

Status of the Feral Pig

Feral pigs did not occur in California prior to the early 1700s when domestic pigs were introduced by settlers as livestock, with many becoming feral (CDFW 2023). Feral pigs can weigh between 75 and 250 pounds and due to their large size, they have few predators (USDA 2020a). They sexually mature at six to nine months of age and can have up to two litters per year of three to 18 piglets per litter (with an average of five or six piglets), thus making population management pertinent to avoid further negative impacts from this invasive species (Finzel and Baldwin 2015).

Feral pigs are known to prey on the eggs and young of threatened and endangered ground-nesting birds and reptiles, as well as hunt mammals, reptiles, and amphibians. In addition to carrying diseases and parasites that could spread to native wildlife, feral pigs compete with native species for food, water, and habitat, as well as have the potential to displace sensitive wildlife species and contaminate the water resources (USDA 2020c).

The USDA has stated that feral pigs are "ecosystem engineers" that have the ability to change their environment by altering water quality and runoff in sensitive wetland habitats, shifting plant composition and distribution of grasslands, as well as decreasing tree diversity in forests (USDA 2020c). This invasive species can transport non-native, invasive seeds in hair and feces, while trampling native plants. Their rooting and wallowing behavior degrades riparian and other sensitive habitat types utilized by native and listed wildlife and can create habitat-type conversion by providing the opportunity for non-native plants to invade (Glow et al. 2020). This invasive species also reduces the regeneration of oak trees in oak woodlands by cratering underneath the trees, due to their affinity for acorns (Finzel and Baldwin 2015).

Although the agricultural lands adjacent to the San Luis NWR Complex are generally fenced, feral pigs move from the Complex to the agricultural fields, thus making coordination with adjacent landowners an important part of this Plan. Although the population size is unknown within the San Luis NWR Complex, as well as the adjacent privately owned agricultural lands, the occurrence of observing adult pigs, piglets, and vegetation damage has increased within the Complex (see **Appendix B, Photographs of Feral Pig Observations and Habitat Damage**).

Feral pig management is often challenging because of the prolific nature of the species. Efficient and effective population "management" is necessary for protection of sensitive resources within the San Luis NWR Complex. Control effort administration will be under the jurisdiction of Service personnel, USDA WS, or other cooperator pursuant to EO 13751, which directs Federal agencies whose actions may affect the status of invasive species to reduce invasion of exotic species and associated damages to the extent practicable and permitted by law.

Status of Feral Pig on the San Luis NWR Complex

Feral pigs have been incidentally observed on the San Joaquin NWR and San Luis NWR, although the exact population size is unknown, and no management activities have occurred to-date within the San Luis NWR Complex. Service staff coordination with adjacent landowners has assisted in documenting feral pig observations on the San Joaquin River NWR. Known locations of feral pigs within this Refuge

are shown in **Figure 8**, *Northern Portion of San Joaquin River NWR – Feral Pig Distribution Map*, **Figure 9**, *Southern Portion of San Joaquin River NWR – Feral Pig Distribution Map*, and **Figure 10**, *Initial Feral Pig Survey Results for the San Joaquin River NWR*.

In addition, one feral pig sow and seven juvenile pigs were observed feeding in a wetland at the San Luis NWR in November 2023. While no feral pigs have been shot or killed within the San Luis NWR Complex, they have wandered onto the San Joaquin River NWR from adjacent privately owned land and become deceased on this Refuge. See **Table 1** for incidental observations of feral pigs by Service staff, volunteers, and private landowners.

Figure 8. Northern Portion of San Joaquin River NWR - Feral Pig Distribution Map

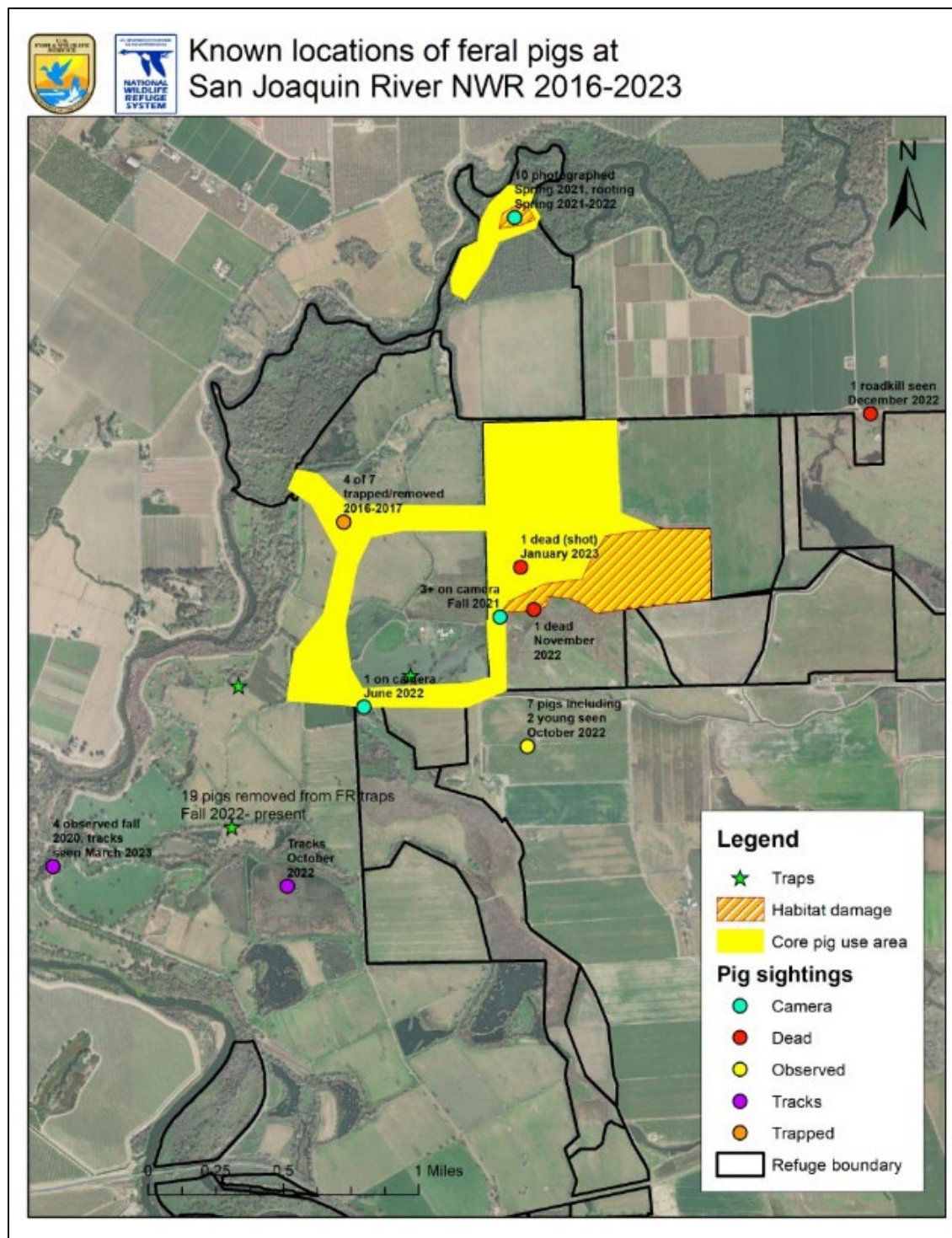


Figure 9. Southern Portion of San Joaquin River NWR – Feral Pig Distribution Map

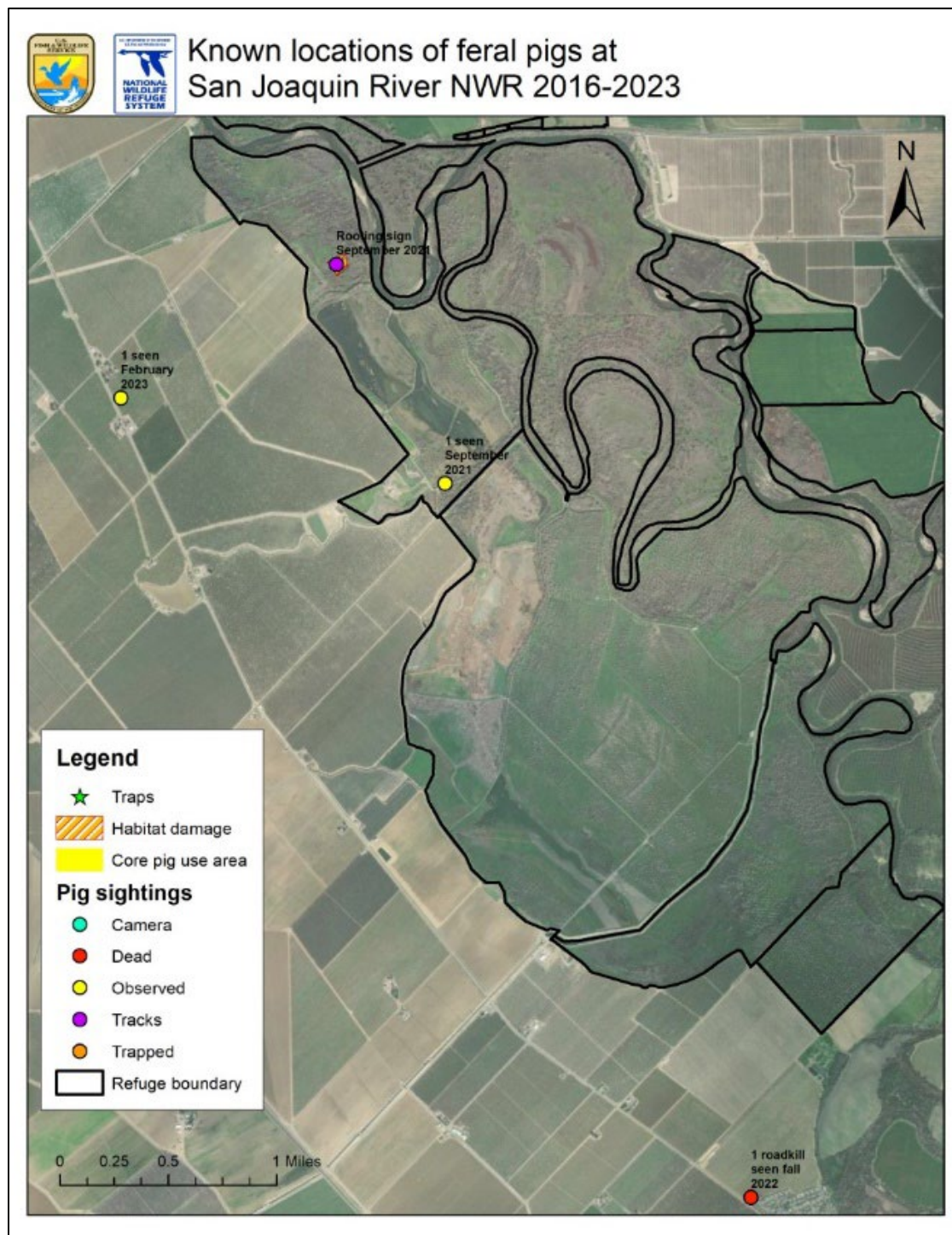


Figure 10. Initial Feral Pig Survey Results for the San Joaquin River NWR

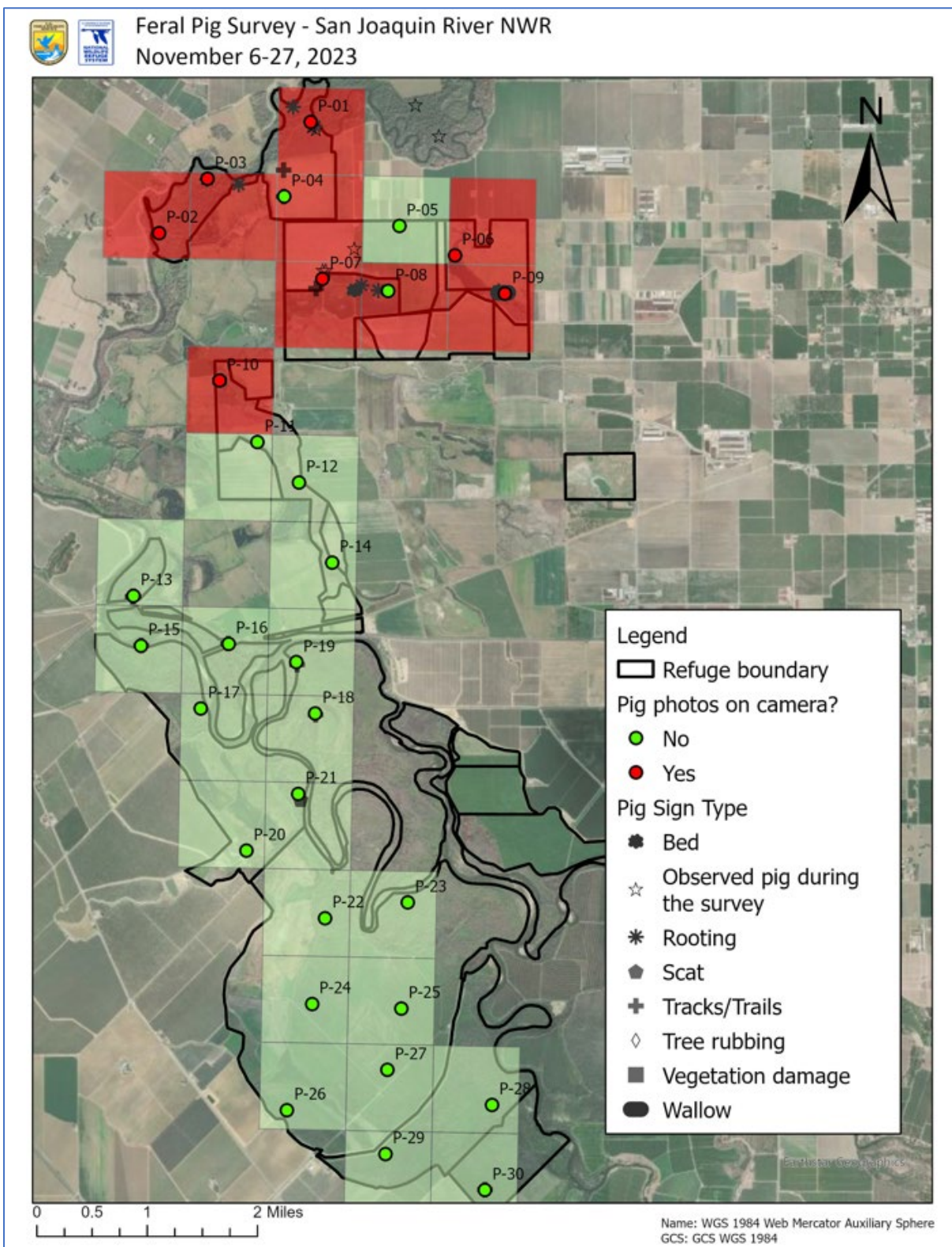


Table 1. Feral Pigs Documented on and off the San Luis NWR Complex

Date(s)	Observer(s)	Location(s)	Amount Observed	Additional Information
2011 - 2017	Service	San Luis NWR Elk enclosure	1	One boar was observed occasionally between 2011 and 2017, but has not been observed since 2017.
2016-2017	Private landowner	San Joaquin River NWR Faith Ranch	7	Observation of approximately 7 feral pigs; trapped 4.
Oct 29 th , 2019	Service	San Joaquin River NWR Page Field	3+	Trail camera photograph of feral pigs entering Page Field corn at night.
Fall, 2020	Private landowner	San Joaquin River NWR Faith Ranch	4+	Observation off of Levee road, south of Stanislaus River.
Spring, 2021	Service	San Joaquin River NWR Buffington Riparian area	10	Photographed (on night-time trail camera).
September, 2021	Service	San Joaquin River NWR North Vierra	1+	Observation of likely boar rooting activity near RBR trail camera.
September, 2021	Refuge visitor	San Joaquin River NWR South Vierra	1+	Visitor sighting of at least one feral pig in dense riparian vegetation near Public Nature Trail, along Hospital Creek.
Fall, 2021	Service	San Joaquin River NWR Watergrass wetland, near Page Road	2-3	Trail camera photograph.
June 20 th , 2022	Service	San Joaquin River NWR Lower Miller Lake wetland	1	Nutria camera detection.
October 5 th , 2022	Private landowner	San Joaquin River NWR Mapes Ranch, Field M1	7 (including 2 young)	Cell phone video provided.
Dec 30 th , 2022	Service	San Joaquin River NWR Beckwith Road	1	Small boar road killed 1.2 miles west of Gates Road.
Fall & Winter, 2022/2023	Numerous Service staff and volunteers	San Joaquin River NWR Page Corn field and wetlands south of Beckwith Road	Up to 10 (per sighting)	Numerous direct sightings of feral pigs, as well as observations of rooting and habitat destruction around edge of seasonal wetlands.
February 2023	Service	San Joaquin River NWR Road near Grayson	1	1 road killed feral pig observed off River Road, near the town of Grayson.
March 4 th , 2023	Service	San Joaquin River NWR Buffington Riparian area, near river	1+	Observation of rooting under oak trees. Ground disturbance and destruction of native vegetation.
February, 2023	Service	San Joaquin River NWR Center/River Roads	1	Lone boar observed along almond orchards near Center/River Roads.
November 2023	Service	San Luis NWR East Bear Creek Unit, Channel 3	1 sow and 7 young	1 sow and 7 young feral pigs observed feeding in a wetland adjacent to a thick patch of milk thistle, with lots of feral pig sign.
November 2023	Service	San Joaquin River NWR	See Figure 10	During November 2023 pilot camera trapping study, feral pigs and sign of the invasive species were observed in the San Joaquin River NWR. See Figure 10 for locations.

Feral Pig Impacts to Refuge Resources of Concern

Damage from feral pigs can include reducing habitat suitability for native and listed species and other special-status species through rooting (uprooting plants and exposing bare soil for invasive species to invade), wallowing (disturbing riparian areas), foraging (reducing food sources for native species), and hunting behaviors (Finzel and Baldwin 2015).

Feral pigs can spread diseases to native wildlife, as well as humans, as this invasive species is a known carrier for pig fever, pig brucellosis, pseudorabies, trichinosis, and leptospirosis. While impacts of these diseases would primarily be to domestic pigs, some are also transmittable to humans and the diseases they carry could be transferred to sensitive native species, as they are known to carry at least 30 diseases and almost 40 types of parasites. This invasive species also causes elevated waterborne

bacteria levels in streams and irrigation canals, posing additional risks to human health and native wildlife (USDA 2020a).

Overall, this invasive species is known to cause erosion issues through uprooting native plants, disturbing riparian areas, and exposing bare soil for weeds to invade, due to their rooting habits; disturb native habitats, thus lowering habitat quality and food sources for native species; prey on native species; and compete with native wildlife for food sources, such as mule deer (*Odocoileus hemionus*), which depend on the hard mast crops that feral pigs prefer (Finzel and Baldwin 2015). Feral pigs have contributed toward the decline of almost 300 native flora and fauna, over 250 of which are listed as threatened or endangered in the United States (USDA 2020c). Through their rooting, trampling, wallowing, and feeding behaviors, feral pigs are known to damage and reduce crop yield by destroying fields. This species degrades agricultural land, while eating, contaminating, and destroying livestock feed, in addition to damaging fences, water systems, irrigation ditches, troughs, and levees (USDA 2020a).

To control this invasive and destructive species, the Service is proposing trapping and shooting feral pigs within the San Luis NWR Complex by Service staff, USDA WS, or other cooperator. The full extent of feral pig damage within the San Luis NWR Complex would be determined as part of the monitoring portion of this Plan. However, feral pigs have been documented damaging riparian habitat near the Stanislaus River, as well as damaging and degrading the wetland shoreline at Goose Lake within the San Joaquin River NWR. This invasive species has also been observed causing damage at Page Lake and Watergrass wetland of the San Joaquin River NWR. See **Appendix B**, *Photographs of Feral Pig Observations and Habitat Damage*.

Chapter 5: Project Purposes

The goal of the Feral Pig Monitoring and Management Plan for the San Luis NWR Complex on fee-title and easement land is to minimize and reduce the spread of feral pigs and their negative impacts to sensitive habitats, predation on native wildlife and competition for food sources, spread of invasive plants, potential impacts to cultural resources, water quality and erosion issues, and human and wildlife health threats from diseases and parasites. Complete removal of feral pigs from the San Luis NWR Complex is unlikely given the wet landscape, lack of fences, and proximity to private agricultural lands.

Therefore, the goal would be achieved by preventing the establishment of a feral pig population on the Complex. Service staff may coordinate with adjacent landowners managing for feral pigs, to maximize the reduction in the feral pig population. As part of this action, the location(s) and level of infestation would be initially determined by following the Feral Pig Camera Survey Protocol (**Appendix C**), while documenting the extent of resource damage (e.g. biological, cultural, and watershed) within the San Luis NWR Complex.

The Service would be implementing the Plan, with the following objectives for the proposed project:

1. Within three years of implementation of initial control efforts, achieve a 50 percent or greater decline in feral pig detections compared to baseline camera survey results.
2. Within five years of implementation of control methods, achieve 80 percent or great decline in feral pig detections compared to baseline camera survey results.

3. Reinitiate control efforts within one year of determining that a resident population is forming on the Complex or if negative impacts to sensitive environmental resources from this invasive species are observed.

Carrying out these objectives is dependent on availability of funding and resources. Monitoring methods may change to better suit the conditions and/or needs.

The proposed action would meet the Refuge purposes by:

Conserving fish or wildlife which are listed as endangered or threatened species or plants; protecting habitat from destruction that acts as an inviolate sanctuary for migratory birds; managing, conserving, and protecting fish and wildlife resources; and for the benefit of the Service in performing its activities and services.

The selected action to monitor and manage feral pigs within the San Luis NWR Complex is an integrated feral pig management approach wherein the most effective, selective, and environmentally desirable method or combination of methods would be tailored to site-specific field conditions. Based on variables encountered in the field, such as location, topography, land uses, vegetation type, and amount of feral pigs, the Service, USDA WS, or other cooperator would decide which of the allowable control methods would be most suitable for implementation. Project activities and control methods are described in *Section 7* below.

Chapter 6: Regulatory Compliance

Pest Management Regulations

In accordance with Service Policy, 569 FW 1 (Integrated Pest Management) of the Service Manual, plant, invertebrate, and vertebrate pests on units of the Refuge System can be controlled to assure balanced wildlife and fish populations in support of Refuge-specific wildlife and habitat management objectives.

This Plan is the Service's Integrated Pest Management Plan for feral pig monitoring and management within the San Luis NWR Complex. This Plan is meant to make decisions regarding invasive species control and to ensure a science-based process that minimizes risk to environmental health. This Plan includes current information about feral pig's biology and life cycle, as well as the most appropriate suite of integrated pest management tools to effectively prevent, eradicate, and control this invasive species, while protecting native fish, wildlife, plants, and human health.

Applicable elements of the Service's Integrated Pest Management Policy (569 FW 1) include:

"Promote and adopt pest prevention as the first line of defense by using a pathway management strategy...to prevent unintended spread of species and biological contamination. Focus on conserving more pristine habitats, monitor these areas, and protect them from invaders."

Service Policy 569 FW 1 also states that the Service will manage pests if:

"A. The pest causes a threat to human or wildlife health or private property; action thresholds for the pest are exceeded; or Federal, State, or local governments designate the pest as noxious; B. The pest is detrimental to site management goals and objectives; and C. The planned pest management actions will not interfere with achieving site management goals and objectives."

Control of animal species identified as damaging or destroying Federal property and/or considered detrimental to the management program of a Refuge is also permitted, as described in 50 CFR 31.14 (Official Animal Control Operations).

The specific justifications for this Integrated Pest Management Plan for feral pig monitoring and management for the San Luis NWR Complex, in accordance with Service Policy 569 FW 1, include:

- Feral pigs are causing a threat to human, wildlife health, habitats, and private property.
- Action thresholds for feral pigs are exceeded.
- This invasive species is designated as noxious by the government.
- The pest is detrimental to San Luis NWR Complex goals and objectives.
- The planned pest management actions will not interfere with achieving San Luis NWR Complex management goals and objectives.

For the purposes of this Plan, the threshold for treatment is a threat of a resident population forming on the Complex or if negative impacts to sensitive environmental resources from this invasive species are observed.

In addition, this Integrated Pest Management Plan will be in accordance with the Biological Integrity, Diversity, and Environmental Health (BIDEH) Service Policy 601 FW 3, as amended, as it states:

“Invasive species pose a variety of threats to native species, ecosystems, and human health and safety. Facing little if any natural controls, invasive species can spread quickly into refuge habitats, causing extensive and costly damage to refuge ecosystems, reducing biodiversity, altering natural processes, and compromising our conservation mission. Therefore, we actively pursue actions to control invasive species when necessary to meet statutory requirements, fulfill refuge purposes, and ensure BIDEH.”

“(1) Actions to control invasive species include preventing their introduction; engaging in detection, eradication, and control of invasive populations; and restoring native species and habitats in invaded ecosystems.”

“(2) Refuge Managers must produce an integrated pest management plan to make decisions regarding invasive species control and to ensure a science-based process that minimizes risk to environmental health. An integrated pest management plan entails using current information about an invasive species’ biology and life cycle, in combination with the most appropriate suite of mechanical, chemical, biological, and cultural tools to effectively prevent, eradicate, and control invasive species while protecting native fish, wildlife, plants, and human health.”

Vertebrate pest control on Federal (Refuge) lands is also authorized under the following legal mandates:

Control of Feral Animals (50 CFR 30.11):

“Feral animals, including horses, burros, cattle, pig, sheep, goats, reindeer, dogs, and cats, without ownership that have reverted to the wild from a domestic state may be taken by authorized Federal or State personnel or by private persons operating under permit in accordance with applicable provisions of Federal or State law or regulation.”

Disposition of Feral Animals (50 CFR 30.12):

“Feral animals taken on wildlife refuge areas may be disposed of by sale on the open market, gift or loan to public or private institutions for specific purposes, and as otherwise provided in section 401 of the act of June 15, 1935.” (49 Stat. 383, 16 USC 715c)

EO 13751 of 2016, Safeguarding Nation from Impacts of Invasive Species:

“Federal agencies shall consider the potential public health and safety impacts of invasive species, especially those species that are vectors, reservoirs, and causative agents of disease.”

Integrated Pest Management Policy (DOI Policy, 517 Department Manual [DM 1]):

“Federal agencies shall use Integrated Pest Management techniques in carrying out pest management activities and shall promote Integrated Pest Management through procurement and regulatory policies and other activities.” (FIFRA, 7 U.S.C. 136r-1)

Official Animal Control Operations (CFR 31.14):

“Animal species which are surplus or detrimental to the management program of a wildlife refuge area may be taken in accordance with Federal and State laws and regulations by Federal or State personnel or by permit issued to private individuals.”

“Animal species which are damaging or destroying Federal property within a wildlife refuge area may be taken or destroyed by Federal personnel.”

The DOI policy 517 DM 1 (Integrated Pest Management Policy) defines pests as:

“...living organisms that may interfere with the site-specific purposes, operations, or management objectives or that jeopardize human health or safety,” and defines an invasive species as, “a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.”

Similarly, Service policy 569 FW 1 defines pests as:

“...invasive plants and introduced or native organisms that may interfere with achieving our management goals and objectives on or off our lands, or that jeopardize human health or safety.”

Additional Applicable Regulations

ESA of 1973 (16 U.S.C. 1531-1543; 87 Statute 884, as amended):

“...provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found.”

Migratory Bird Conservation Act of 1929 (16 U.S.C. 715-715d):

“The North American Wetlands Conservation Act authorizes grants to public-private partnerships in Canada, Mexico and the U.S. to protect, enhance, restore, and manage waterfowl, other migratory birds and other fish and wildlife, and the wetland ecosystems and other habitats upon which they depend...”

National Wildlife Refuge System Administration Act of 1966, as amended (16 USC 668dd et seq.):

“...provides authority, guidelines and directives for the Service to improve the National Wildlife Refuge System; administers a national network of lands and waters for the conservation, management, and restoration of fish, wildlife and plant resources and habitat; ensures the biological integrity, diversity, and environmental health of refuges is maintained...”

North American Wetlands Conservation Act (16 U.S.C. 4401):

“...to protect, enhance, restore, and manage waterfowl, other migratory birds and other fish and wildlife, and the wetland ecosystems and other habitats upon which they depend...”

Use of Non-Lead Ammunition for Management and Research Activities on Refuges (Service Policy, 601 FW 8):

“Use only non-lead ammunition (i.e., shot, slugs, bullets) for lethal control of wildlife for management purposes (e.g., feral pig, beaver, and deer).”

Wilderness Act of 1964 and National Wilderness Preservation System:

“...National Wilderness Preservation System to be composed of federally owned areas designated by Congress as “wilderness areas”, and these shall be administered...so as to provide for the protection of these areas, the preservation of their wilderness character, and for the gathering and dissemination of information regarding their use and enjoyment as wilderness...”

State of California Regulations

Feral pigs were first regulated by the State of California in 1992, and any pig that is not branded or confined is considered a “wild pig” (CDFW 2001). Wild pig is regulated by State of California Fish and Game Commission, California Code of Regulations, Division 1, Subdivision 2, Chapter 3, Big Game - Section 368. Wild pigs may be taken all year and there is no bag or possession limit. A California hunting license with a wild pig tag is required. Wild pigs may also be taken by a depredation permit under Fish and Wildlife Code section 4181 and California Code of Regulations Title 14 section 401. A state permit may be required for the Federal government to lethally remove feral pigs from the San Luis NWR Complex land. However, any feral pig management activities on privately owned land would require applicable permits. The State will offer an annual depredation permit. The Service will seek an open permit for feral pig trapping at the San Luis NWR Complex. Any cooperating private landowners will need to seek state depredation permits for their properties individually. State depredation tags are required prior to removing the carcass from the property in which it was taken per California Fish and Wildlife Code Title 14 §401(g) for reporting requirements and §401(h) for tagging requirements prior to transporting carcass.

Chapter 7: Proposed Action

Inventory Feral Pig Population and Monitoring

Monitoring and trapping may initially occur within the San Joaquin River NWR, north of Highway 132, where habitat types include wetlands, grasslands, and riparian woodlands. The results of the initial feral pig survey would assist in determining where trapping may initially occur within the San Joaquin River NWR (see **Figure 10**, *Initial Feral Pig Survey Results for the San Joaquin River NWR*). However, monitoring and management activities could occur throughout the San Luis NWR Complex, depending

on where feral pig or their damage are observed. The Service would conduct pre-trapping population surveys following the *Feral Pig Camera Survey Protocol*, which is **Appendix C** of this Plan, and may be updated in the future as adaptive management occurs. The pre-trapping population survey assists trapping and dispatching efforts by detailing locations of high feral pig use. Annual and post trapping population surveys would be completed in subsequent years to inform population trends and future trapping efforts, as necessary.

Cameras with or without Bait

Feral pigs have poor eyesight and rely primarily on their sense of smell, which makes them sensitive to human presence. Use of remote cameras minimizes human presence and provides the ability to monitor large tracts of land (USDA 2015). Cameras may be utilized to identify the locations of feral pig within the San Luis NWR Complex, which can be used to track size and habits of sounders (i.e., feral pigs that travel in family groups). This information may help concentrate trapping and ground shooting efforts by Service personnel or USDA WS in key areas and make those efforts as effective as possible. Service contact with other landowners would be maintained to track feral pig sightings on adjacent privately owned lands. When pig activity is identified, Service staff or USDA WS would respond immediately to initiate control methods. Monitoring data would be used to adaptively manage where search, trapping, and dispatch activities should occur.

Cellular-enabled game cameras may be used for monitoring, which allows personnel to minimize travel expenses and monitor feral pig activity without disturbing bait and trap sites. Camera systems may be used with remote-activated cage traps to maximize the chance that an entire sounder is captured and minimize risks to non-target species. Some of the traps proposed may utilize remote trigger, while others may not and may be visually inspected daily when set, instead.

Telemetered Animal

A telemetered pig is generally an adult female that has been trapped and released by personnel after attaching a radio-collar, as females tend to be part of a sounder (Parkes et al. 2010). The telemetered animal may then be monitored and located through telemetry. Once the sounder's location is discovered, the Service, USDA WS, or other cooperator would lethally remove the feral pig (USDA 2015).

Spotlighting and Driving/Walking Surveys

Surveyors may spotlight by vehicle in the early morning or evening to aid in detecting feral pigs. Surveys may also be conducted during the daytime and travel by vehicle along roads, via utility task vehicles (UTVs), or on foot to search for feral pig sign. Any observations of pig sign (tracks/trails, scat, wallows, rooting, beds, and tree rubbings) may be uploaded as point locations with an attached photo or staff may utilize other methods of documenting feral pig, as feasible. The survey area searched would be tracked. The survey tracks may be uploaded following the survey to detect areas that were not searched.

Uncrewed Aerial System (Drone) Flights

Drones may be utilized by the Service or USDA WS, according to current Service and/or DOI Policy, to find the locations of feral pig within the San Luis NWR Complex where the canopy is open, as necessary. This monitoring action could assist in locating remaining feral pigs within the San Luis NWR Complex.

Detector Dogs

Tracking feral pig with dogs that are managed by Service personnel or USDA WS may be utilized to locate feral pig. Staff would be present whenever dogs are utilized and dogs would be trained to locate feral pigs specifically.

Removal of Feral Pig from San Luis NWR Complex

Two methods may be employed to remove feral pigs from the San Luis NWR Complex: 1) trapping and shooting, and 2) pursuit and shooting of individuals. The methods would be used strategically, and the Service would coordinate with USDA WS and adjacent landowners in order maximize the reduction in feral pig numbers. It is anticipated that most feral pigs would be removed by trapping, with professional ground-based marksmen from USDA WS, Service personnel, or other cooperator used to pursue and shoot (dispatch) “trap-averse” feral pigs after trapping efforts have taken place. All feral pigs captured in traps located on the San Luis NWR Complex would be euthanized in situ and disposed of on-site by dragging away from the trap to facilitate recapture in the same trap, as well as to minimize possible spread of zoonotic diseases associated with feral pigs. Feral pig may also be transported off Complex for disposal or donation for animals, following general disease testing.

Trapping

Traps may be baited to attract feral pigs and types of traps may vary and include pig brig (a drop net), corral traps, box traps, or other types of cage traps. Traps may be baited with whole kernel corn or other types of bait, and the Service or USDA WS may install cellular-enabled game cameras adjacent to the traps. Trapping is anticipated to be the largest part of feral pig control efforts. The trapping efforts may focus on utilizing corral style traps large enough to hold multiple feral pigs in areas documented to be frequented by this invasive species. Open corral-style traps allow large non-target wildlife, such as deer, to escape. The number of traps utilized would be based on available and qualified personnel and the population of feral pigs in a treatment area.

Determinations as to where traps would be located would be based on the results of on-going efforts to monitor feral pig populations and their impacts. They may be set near water sources where pigs are likely to congregate and forage, as well as travel corridors and any other areas where feral pigs may occur. Traps would be placed to avoid resource damage and trapping in areas easily accessible by or visible to the public would be avoided as much as possible. Installation of traps by hand may involve minor ground disturbance associated with minor vegetation removal, and trap installation, including rebar stakes, driving t-posts and other earth anchors and cables to secure the trap to the ground, as necessary, to contain captured feral pig. The activity of the feral pigs themselves while they are inside the traps may also cause minor ground disturbance. Traps may be baited with corn, grain, or other food attractive to feral pigs.

All proposed trapping locations on the San Luis NWR Complex may be flagged on the ground and global positioning system (GPS) locations provided to Service archaeological and biological staff to avoid or minimize impacts to biological and cultural resources.

Humane treatment of captured feral pigs would be emphasized throughout the control program and traps would be checked daily. Traps would be placed in locations with at least partial shade to the greatest extent practicable. Traps set to capture feral pigs would be monitored in person or via cell phone cameras daily and captured pigs would be dispatched before noon to the greatest extent

practicable. Dispatching would consist of careful yet quick and humane rifle shots to the head. Non-target animals like deer would be released by opening the traps to allow escape.

Trapping may take place year-round, as needed. Traps doors are locked open and pre-baited prior to being set to capture feral pigs. Successive pre-baiting and capture periods may continue for the duration of the trapping session. All trap sites would be preapproved by Refuge Manager. Technicians may move traps to new locations when no additional captures occur. At the end of the first session of intensive trapping, traps may be removed from trapping locations, cleaned, repaired, and stored until the next trapping session. If traps are not removed, they would be left open to ensure no impacts to native or non-native species while the trap is not in use. Periodic surveys for fresh rooting and wallowing disturbance may be used to assist trackers in locating areas with active groups of feral pig. Trapping efforts would be utilized throughout the year, as feral pig and associated soil/vegetation damage are observed.

Dispatching Feral Pig

Captured pigs would be dispatched quickly with a gunshot to the head using non-lead ammunition. Firearms may be equipped with noise suppressors. For scientific purposes and for evaluating the progress of the control effort for changes in population age structure, basic biological and wildlife disease, data or samples may be collected. After dispatching the pig, the carcass may remain on-site to decompose or transported off Complex for disposal or donation for animals, following general disease testing, consistent with CDFW codes and regulations and any other applicable laws and regulations.

Shooting of individual feral pigs may also be conducted without the use of traps, by shooting over bait piles, or ground hunting by Service staff, USDA WS, or another cooperator. Shooting feral pigs at night may occur, possibly with the use of night vision and suppressors.

Adaptive Management

Following five years of intensive feral pig monitoring and management efforts, if resource impacts from feral pigs have not been eliminated or drastically reduced within the San Luis NWR Complex, then the project goals would be re-evaluated. If it is determined through this evaluation that feral pig elimination or drastic reduction in population is not a practical objective, efforts would be re-evaluated to determine what amount of feral pig reduction and overall management is feasible to protect the resources.

Public Safety and Risk Management

Public and worker safety would be a top priority during all feral pig management activities. Service staff would be trained in safe firearm and trap operation prior to the first trapping efforts and refreshed the beginning of each year thereafter, in addition to trained USDA WS or other cooperator.

Mitigation Measures

The following Mitigation Measures would be implemented to minimize and avoid negative effects to the environment:

1. Surveys for Feral Pig Damage and Focused Removals: Prior to initiation of feral pig removal activities, surveys would be carried out to identify specific locations being impacted by feral pigs. Pig removal efforts may be highly focused to such areas.

2. **Trap Placement and Vegetation Trimming:** When feasible, traps would be placed in locations that require minimal to no vegetation trimming and minimal ground disturbance. Traps would be placed in such a manner as to avoid water quality impacts.
3. **Active Traps:** All active traps, regardless of the type, would be checked daily.
4. **Lead Free Ammunition:** Lead-free ammunition would be used to dispatch all pigs to avoid lead contamination and associated non-target effects.
5. **Cultural Resources:** Where ground disturbance is necessary for minor vegetation removal prior to fence and trap installation, minor digging for fence and trap installation, as well as the potential for feral pigs to disturb soil while temporarily in the traps, the Complex staff would coordinate with the Service's Regional Archaeologist to comply with Federal laws relating to cultural resources. These activities would be coordinated with the Service's Regional Archaeologist to avoid any potential adverse effects to cultural resources and to comply with Federal laws related to cultural resources.
6. **Discovery of Unknown Cultural Resources:** In the event that unanticipated cultural or tribal resources are encountered during the course of the project, the Service would cease any ground-disturbing activities within 50 feet of the resource. The Service's Regional Archaeologist would evaluate the resource and recommend treatment measures, as appropriate.
7. **Documented Cultural Resources:** If ground disturbance is proposed in the vicinity of a documented cultural or tribal resource, coordination with the Service's Regional Archaeologist would occur to put a buffer in place and not disturb the ground within that buffer.
8. **Closures:** Efforts would be made for feral pig trapping to take place in locations away from publicly accessible areas within the Complex. If trapping is necessary near publicly accessible areas, temporary closures may occur.
9. **Disposal Sites and Sanitary Landfills:** After dispatching the pig, they may remain on-site or transported off-site for disposal or donation for animals, following general disease testing, consistent with California Department of Fish and Wildlife codes and regulations and any other applicable laws and regulations.

Monitoring and Reporting

Initial monitoring will be to identify feral pig activity and locate feral pigs within the San Joaquin River NWR, but monitoring and reporting may occur throughout the San Luis NWR Complex. Feral pig locations, as well as the amount lethally removed from the San Luis NWR Complex will be monitored and recorded during implementation of this Plan. Locations where feral pigs have been removed would be surveyed to determine if feral pigs are no longer utilizing that portion of the land. Continuous surveys would occur, as needed, to determine if traps need to be relocated or added to best control feral pig activities from causing negative impacts.

An annual report would be developed that would include:

- Monitoring activity types and locations where feral pig activity is documented.
- Recording gender and approximate weight of feral pig.
- Locations feral pig are observed and habitat types, as well as amount lethally removed.
- Evaluation of current year's monitoring and control methods to ensure they are achieving plan objectives.
- Recommendations for how feral pig control and surveillance may be improved or expanded, as necessary.

Justification

Feral pig management is often challenging because of the prolific nature of the species. Efficient and effective population “management” is necessary for protection of sensitive resources within the San Luis NWR Complex. Control effort administration will be under the jurisdiction of Service personnel and USDA WS pursuant to EO 13751, which directs Federal agencies whose actions may affect the status of invasive species to reduce invasion of exotic species and associated damages to the extent practicable and permitted by law.

Feral pigs represent a serious threat to the diversity of habitats and species protected in and around the San Luis NWR Complex, including Federal and State threatened and endangered species supported on the San Luis NWR Complex, as well as other special-status species. This invasive species threatens to disturb sensitive cultural resources, as well as damage sensitive habitats and water quality, and potentially human health.

Chapter 8: Literature Cited

[California Department of Fish and Wildlife \(CDFW\). 2001. *Guide to Hunting Wild Pigs in California*.](#)

[2023. *Wild Pig Management Program*.](#)

[Finzel, J.A. and R.A. Baldwin. 2015. *Wild Pigs*. University of California Cooperative Extension, University of California Davis.](#)

Gilsdorf, J. M., S. E. Hygnstrom, and K. C. VerCauteren. 2003. *Use of Frightening Devices in Wildlife Damage Management*. Integrated Pest Management Reviews. 7:29-45.

[Glow, M.P., K.C. VerCauteren, and N.P. Snow. 2020. *Feral Swine*. Wildlife Damage Management Technical Series. U.S. Department of Agriculture Animal and Plant Health Inspection Service, Wildlife Services National Wildlife Research Center. Fort Collins, Colorado.](#)

[Massei, Giovanna; Roy, Sugoto; and Bunting, Richard. 2011. *Too Many Hogs? A Review of Methods to Mitigate Impact by Wild Boar and Feral Hogs*, Human–Wildlife Interactions: Vol. 5: Iss. 1, Article 10.](#)

[Missouri Department of Conservation. 2021. *Feral Hogs in Missouri*.](#)

Parkes, J. P., D. S. I. Ramsey, N. Macdonald, K. Walker, S. McKnight, B.S. Cohen, and S.A. Morrison. 2010. *Rapid Eradication of Feral Pigs (Sus scrofa) from Santa Cruz Island, California*. Biological Conservation. 143:634-641.

[U.S. Department of Agriculture \(USDA\). 2015. *Final Environmental Impact Statement Feral Swine Damage Management: A National Approach*. U.S. Department of Agriculture Animal and Plant Health Inspection Service.](#)

[2020a. *Feral Swine: Damages, Disease Threats, and Other Risks*.](#)

[2020b. *Feral Swine Damage*.](#)

[2020c. *Feral Swine: Impacts on Threatened and Endangered Species*.](#)

[2020d. *Feral Swine Damage*.](#)

U.S. Fish and Wildlife Service (Service). 1987. *Finding of No Significant Impact Proposed Land Acquisition to Establish the San Joaquin River National Wildlife Refuge*. Portland, OR: U.S. Department of the Interior, Fish and Wildlife Service.

[2006. *San Joaquin River National Wildlife Refuge Final Comprehensive Conservation Plan*. Sacramento, CA: U.S. Department of the Interior, Fish and Wildlife Service.](#)

[2011. *Riparian Restoration Plan for the Hagemann 3 Project: Hagemann and Arambel Tracts of the SJRNWR*. Department of Water Resources Flood Protection Corridor Program, Modesto, CA.](#)

[2021. *Conservation Summary of the Priority Resources of Concern and Riparian and Floodplain Ecosystems at San Luis National Wildlife Refuge Complex*. National Wildlife Refuge System, Pacific Southwest Region, Inventory and Monitoring Initiative, Sacramento, CA.](#)

[2022. *Waterfowl Population Status*. Laurel, MD: U.S. Department of the Interior, Fish and Wildlife Service Division of Migratory Bird Management.](#)

[2023. *San Luis National Wildlife Refuge Complex Draft Comprehensive Conservation Plan and Environmental Assessment*. Sacramento, CA: U.S. Department of the Interior, Fish and Wildlife Service.](#)

Appendix A: Acronyms

Biological Integrity, Diversity, and Environmental Health	BIDEH
Code of Federal Regulations	CFR
Department of Interior	DOI
Department Manual	DM
Environmental Assessment	EA
Endangered Species Act	ESA
Executive Order	EO
Fish and Wildlife	FW
Global positioning system	GPS
National Wildlife Refuge	NWR or Refuge
National Wildlife Refuge System Administration Act	Administration Act
NWR System	Refuge System
United States	U.S.
United States Code	U.S.C.
U.S. Department of Agriculture Wildlife Services	USDA WS
U.S. Fish and Wildlife Service	Service
Utility Task Vehicle	UTV
Wildlife Management Area	WMA

Appendix B: Photographs of Feral Pig Observations and Habitat Damage within the San Luis NWR Complex



Feral pigs observed at Page Lake in San Joaquin River NWR on December 8th, 2022



Feral pigs observed at watergrass wetland in San Joaquin River NWR on February 17th, 2023



Wetland shoreline damaged by feral pigs at Goose Lake in San Joaquin River NWR on November 26th, 2022



Riparian habitat damaged by feral pigs near Stanislaus River in San Joaquin River NWR on March 4th, 2023



Feral pig observed in San Joaquin River NWR in November 2023



Feral pigs observed in San Joaquin River NWR in November 2023



Feral pig observed during November 2023 Feral Pig Survey in San Joaquin River NWR



Feral pig tracks observed during November 2023 Feral Pig Survey in San Joaquin River NWR



Feral pig rooting and tracks observed during November 2023 Feral Pig Survey in San Joaquin River NWR



Feral pigs observed at San Luis NWR in November 2023

APPENDIX C: Feral Pig Survey Protocol for San Luis National Wildlife Refuge Complex

Background

Feral pigs (*Sus scrofa*) are an invasive species that have been recurrently detected on San Joaquin River National Wildlife Refuge (NWR; Refuge) from 2016 to present. Feral pigs cause damage to native habitats through rooting, wallowing, spreading invasive species, as well as trampling and foraging on native vegetation and wildlife. Habitat damage caused by the increasing population of feral pigs at the San Joaquin River NWR has been observed in wetlands, crop fields, and riparian areas throughout the northern section of this Refuge (**Figures 11 and 12**). In addition, this invasive species was observed at the San Luis NWR in November 2023.

Therefore, there is a need within the San Luis NWR Complex to document areas of feral pig activity and feral pig damage, to increase the success of the trapping and removal efforts. Camera surveys would help to inform management decisions regarding feral pig trapping and to measure trapping success across the San Luis NWR Complex, starting at the San Joaquin River NWR, where the majority of feral pigs have been observed.

The Service would be implementing the Plan, with the following objectives for the proposed project:

1. Within three years of implementation of initial control efforts, achieve a 50 percent or greater decline in feral pig detections compared to baseline camera survey results.
2. Within five years of implementation of control methods, achieve 80 percent or great decline in feral pig detections compared to baseline camera survey results.
3. Reinitiate control efforts within one year of determining that a resident population is forming on the Complex or if negative impacts to sensitive environmental resources from this invasive species are observed.

Carrying out these objectives is dependent on availability of funding and resources. Monitoring methods may change to better suit the conditions and/or needs.”

Goals of the camera survey:

1. Thoroughly search the San Luis NWR Complex for feral pig sign and document areas that are inhabited by feral pigs to assist with trapping and removal, starting with the San Joaquin River NWR.
2. Create an index of feral pig activity that can be used to monitor the success of the Plan over time.

Figure 11. Northern Portion of San Joaquin River NWR - Feral Pig Distribution Map

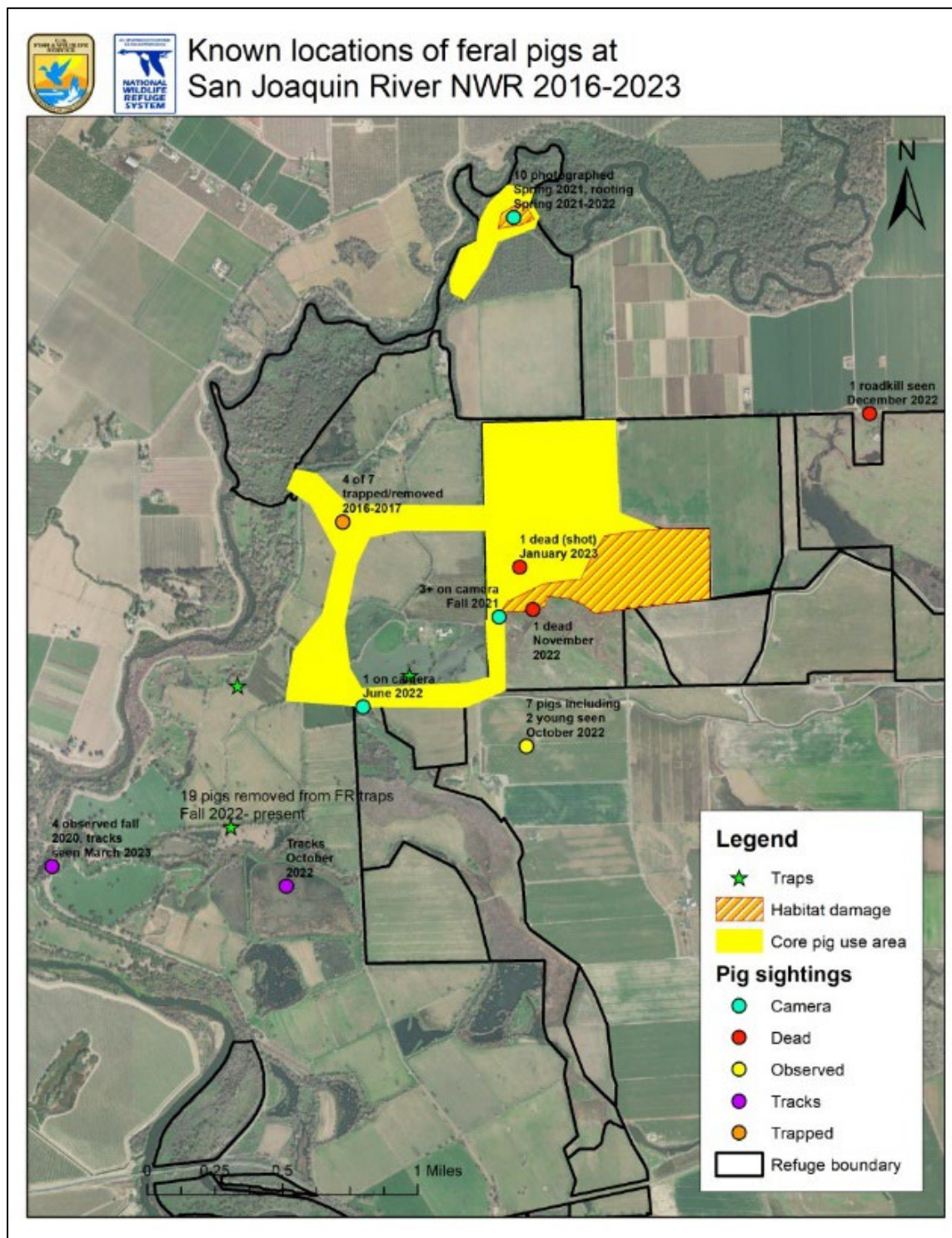
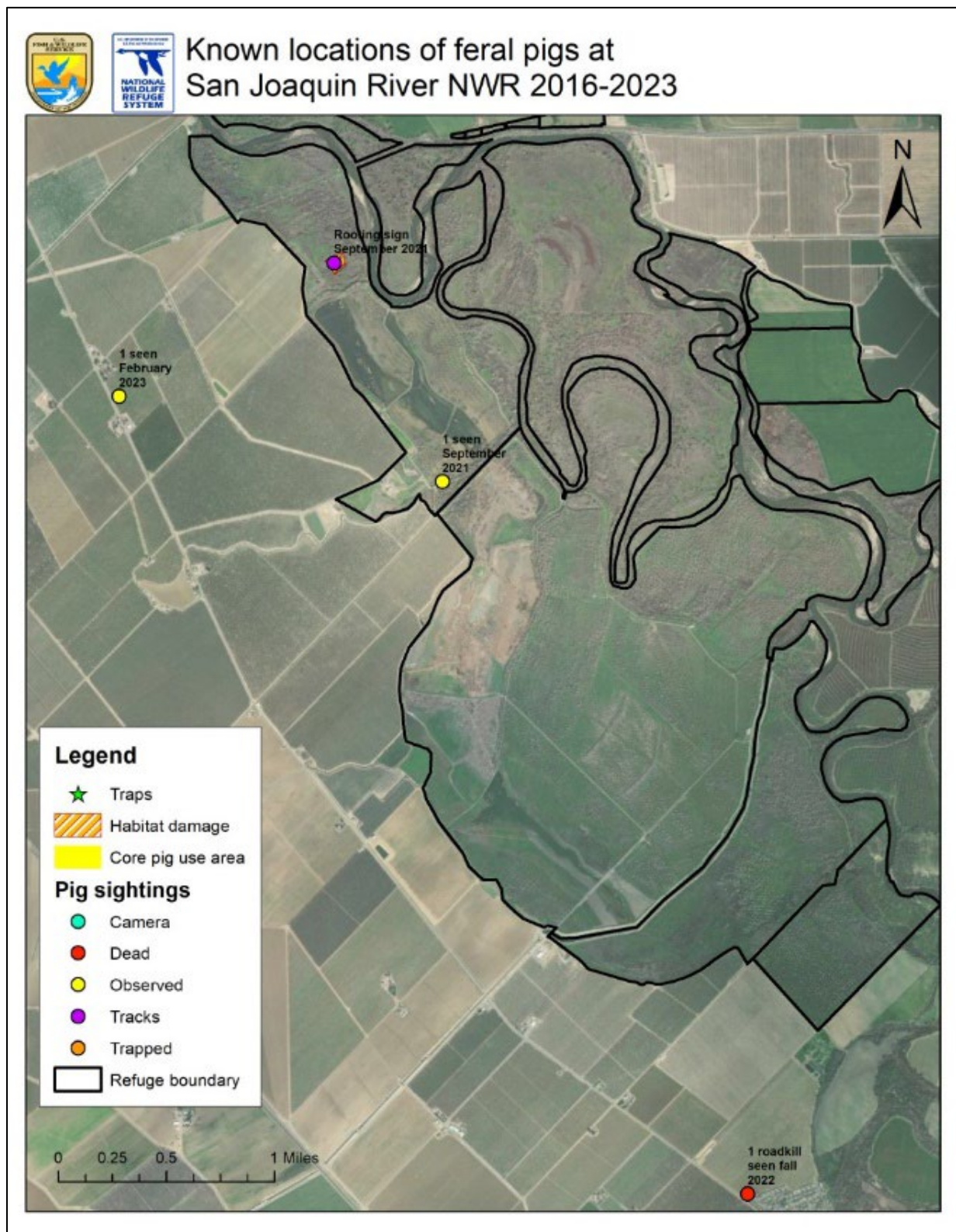


Figure 12. Southern Portion of San Joaquin River NWR – Feral Pig Distribution Map



Methods

Survey timing

Staff will set cameras with the goal of setting all cameras within one day, although it may take multiple days initially. Cameras will be pulled after two weeks (14 days). The initial survey will be conducted in Fall of 2023 at the San Joaquin River NWR where the majority of feral pigs have been observed within the San Luis NWR Complex and will be repeated annually to measure the success of the trapping program. The survey will not be conducted during inclement weather (i.e. rain).

Equipment List:

- 30 Cuddeback infrared cameras with batteries (8 per camera)
- 60 memory cards
- 30 t-posts
- 90 Zip ties
- 200 pounds of Bait- whole cracked “deer” corn (5 bags)
- 5 Buckets
- 5 Scoops
- 5 Rubber mallets (1 per team) or drilling hammer or t-post driver tool
- 5 iPhones with Field Maps App downloaded
- Portable Battery chargers
- 5 Compasses
- Print out maps
- Pink Flagging tape
- Markers
- 5 Meter sticks
- 5 Protractors

Data Collection

Study Area

The San Joaquin River NWR will be divided into 30 grid cells (**Figure 13**). Each grid cell will measure 1 km². Estimates of home range sizes for feral pigs in California are near 2 km² for females, while male home ranges can be 50 percent larger (Baber and Coblentz 1986; Saunders and McLeod 1999, Sweitzer et al 1996). Therefore, grid cells with half the size of a female home range size, which should have an increased chance of detecting a feral pig in the vicinity, if present.

Walking/Driving Survey for Feral Pig Sign

Surveyors will travel by vehicle along roads and on foot through habitats to search the 1 km² grid cells for feral pig sign. Any observations of feral pig sign (tracks/trails, scat, wallows, rooting, beds, and tree rubbings) may be uploaded as point locations on the Field Maps App with an attached photo. The survey area searched may be tracked using the streaming tool in the Field Maps App and uploaded as paths to the map. The survey tracks may be used to detect areas that were not searched for future reference. Each grid cell should be thoroughly searched for up to 1 hour. The search time may be less if most of the grid cell lies on private property or is easily searched by driving through with a vehicle. An ATV/UTV may be used by qualified personnel, in order to search grid cells that have less road access. The purpose of the walking/driving survey will be to document feral pig sign and scout for the best location to place the camera station. Surveyors should attempt to search as much of the area as possible in the 1-hour

window in order to pick the best location for the camera. It is unrealistic for the whole grid to be searched in 1 hour and therefore staff will be recording the search areas on the map for follow-up surveys.

Initial Camera Placement and Setup

Each grid cell will have 1 camera. Previous research suggests at least 20 cameras (~1.3 cameras/km²) and 11 monitoring days should be used to detect feral pigs (Davis et al 2020). To increase probability of detections, cameras will be placed in areas with feral pig sign (i.e., rooting, tracks, or tree scars) or where feral pigs had been reported in the past. If no feral pig sign is detected within 1 hour of searching the grid cell, observers will place the camera in an area likely to be used by feral pigs, such as along a travel corridor, within 100 meters of roads, near a water source, or other suitable habitat (Davis et al 2020). Each camera may be located at least 750 meters (2,460 feet) from the nearest camera in adjacent cells (Davis et al 2020, Schlichting et al 2020). Holtfreter et al (2008) similarly used a 1km² grid with a single camera placed near feral pig sign per grid cell.

Camera posts will be set 3 meters from the bait pile at a height of 1 meter (measured with a meter stick) and at a downward angle of 15 degrees (measured with a protractor) (Bastille-rousseau et al 2021). Surveyors will use a rubber mallet, hammer, or post driver to pound the t-post into the ground. The camera viewshed will be cleared of any tall herbaceous vegetation that would obstruct the camera. Tree or shrub branches interfering with the camera will be trimmed. All cameras will be placed facing north to reduce glare and shadows from the sun. The camera will be attached to the t-post using at least 2 zip-ties. Surveyors will determine where the middle of the camera viewshed is by extending a stick from the camera to the ground.

Bait

About 10 pounds of corn (measured by a marked bucket) will be placed in a single pile in the center of the camera viewshed (Weste et al 2009). Based on the results of the pilot survey, the amount of corn used for bait may change, previous studies have used between 20 to 50 pounds of corn for bait (Holtfreter et. al 2008, Davis et al 2020). Whole-kernel dried, shelled corn is a known attractant for feral pigs (West et al 2009, Hamrick et al 2016). Cameras may not be rebaited during the two weeks, in order to reduce staff time (for the pilot survey, may need to be adjusted for future surveys). If the corn attracts too many non-target species (deer, riparian brush rabbits, etc.) in the first survey, staff may need to switch to fermented corn in subsequent surveys. Fermented corn is a similar attractant and will reduce non-target species (West et al 2009).

Camera Settings

Surveyors will check that the date and time are correct on the camera (turn knob to date, time). Cameras will be set to a motion activated, five second delay (photo side setting) with one photo taken per event. Surveyors will test that the camera is picking up movement near the bait pile by waving a hand in front of the camera. After the 30 second set up delay, it should trigger moving “worms” if it is working properly. A piece of paper with the date, time, and camera identification will be placed in front of the camera and triggered. The camera lid should be closed when finished. Cameras should already be prepared with the proper date and time, as well as the proper memory card, but staff should note any error messages if they occur.

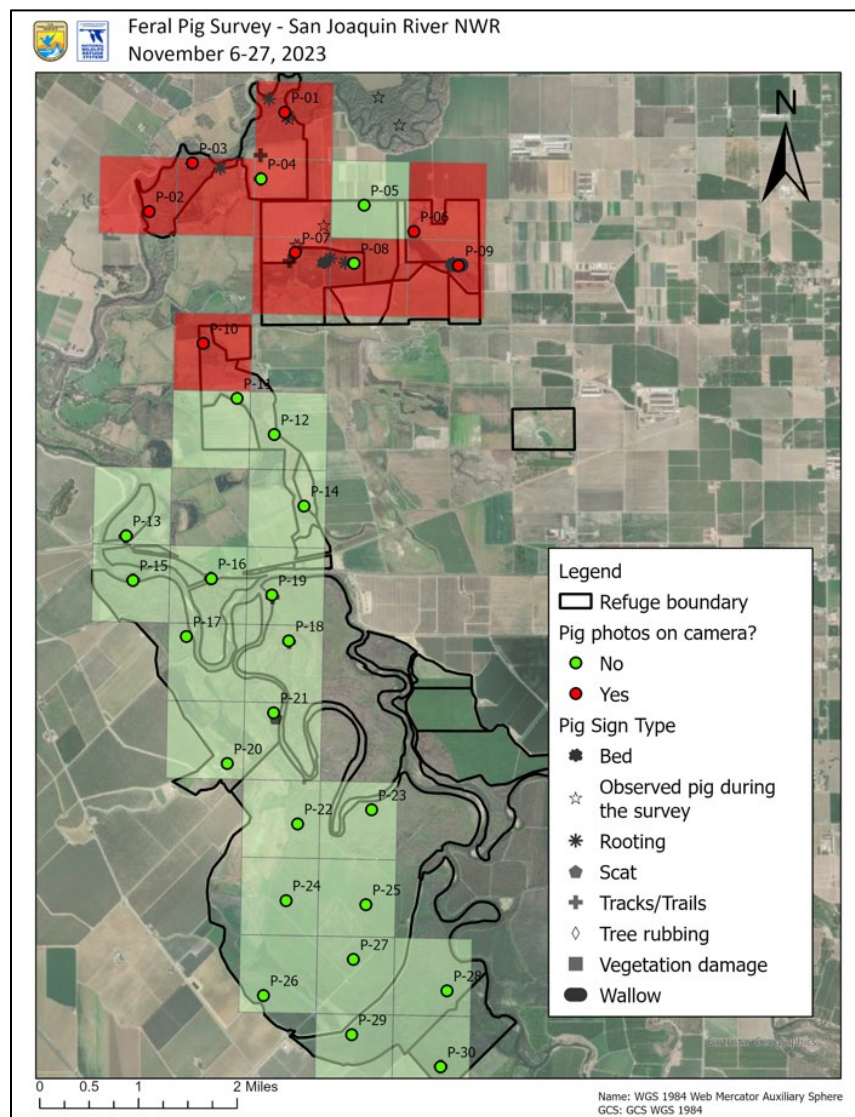
The location of the camera may be logged in the field on the Field Maps App and a photo of the setup will be attached to the point location. Each camera will be flagged and labeled near the camera with the

camera identification number and flag the path to the camera if it is difficult to find. Once finalized, the camera locations will be used for the remainder of the survey. When removing the camera after the 14 days, the surveyor will first trigger the camera with a photo of the date, time and location written on a piece of paper in the field and may update the Field Maps App.

Rabbit Hemorrhagic Disease Virus 2 (RHDV2)

To limit the spread of RHDV2, staff will sanitize boots/trucks before entering/leaving remote land with a 10 percent bleach solution in a spray bottle (USDA 2020).

Figure 13. San Joaquin River NWR Survey Study Area



Data forms and Entry

Location data may be uploaded in the field on the Field Maps App. The digital map will be updated by staff in real-time with locations and photos of pig sign, pig damage and camera locations. The map layers and files will be easily shareable with refuge staff and/or the USDA contractors who will be leading the trapping operations. Traps will also be added to the online map once trapping commences.

Surveyors will track locations of search areas using handheld GPS devices. These tracks may be uploaded to the online map to keep track of areas that were searched for feral pigs.

Information on the camera deployments will be recorded in the camera log excel sheet i.e. (camera identification, deployment season, year, date setup, date removed, latitude, longitude, unit of the San Luis NWR Complex, if feral pig was detected, and notes). Service staff will upload the photos to the San Luis NWR Complex's drive, followed by photo analysis. Information from the camera photo analysis will be recorded in the camera check excel sheet (i.e. camera identification, deployment season, date, day, if the station is compromised, if feral pig is present, number of adult feral pig photos, number of juvenile feral pig photos, if bait is gone, if riparian brush rabbit is detected, and notes).

Data Compilation and Analysis

The results from the camera survey will be used to create a relative abundance index for feral pigs that can be used to compare feral pig abundance and distribution over time. Indices of feral pig activity will include the number of feral pig detections/camera, number of cells with detections, and total number of individually identifiable feral pigs. Other indices include number of feral pigs/group, and the percent of juvenile/adult feral pigs. The number of detections/camera day will be used as the relative abundance index of feral pigs over time (Treichler et al. 2023).

Products and Archiving

The San Luis NWR Complex wildlife biologist will compile the survey data into an annual report in December, which will be distributed to project partners and Service staff.

Personnel Requirements and Training

Staff conducting the survey will need to be trained on the proper identification of feral pig sign. Staff will also need to be trained in collecting data using the Field Maps App.

The minimum number of staff required to conduct the survey is five, in order to complete the camera setup in one day (five staff visiting six cells, for one hour each). Camera setup and supply preparation prior to the survey will be approximately four to eight hours. Field survey and camera installation will require five staff working one full day or 40 hours total. The camera removal will take five staff four hours to remove or 20 full hours. Data analysis and camera photo processing will depend on the total number of photos taken; however, it will likely take a minimum of 40 hours. Report writing will include an additional 20 to 40 hours.

Literature Cited

- Bastille-Rousseau, G., Schlichting, P. E., Keiter, D. A., Smith, J. B., Kilgo, J. C., Wittemyer, G., & Pepin, K. M. 2021. *Multi-Level Movement Response of Invasive Wild Pigs (*Sus scrofa*) to Removal*. Pest Management Science. 77(1):85-95.
- Davis, A. J., D. A. Keiter, E. M. Kierepka, C. Sloodmaker, A.J. Piaggio, J.C. Beasley, and K.M. Pepin. 2020. *A Comparison of Cost and Quality of Three Methods for Estimating Density for Wild Pig (*Sus scrofa*)*. Scientific Reports. 10(1), 2047.
- Hamrick, B., M. Smith, C. Jaworowski, and B. Strickland. 2016. *A Landowner's Guide to Wild Pig Management, Practical Methods for Wild Pig Control*. Mississippi State University Extension Service & Alabama Cooperative Extension System.

- Holtfreter, R. W., B. L. Williams, S. S. Ditchkoff, and J.B. Grand. 2008. *Feral Pig Detectability with Game Cameras*. In Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. Vol. 62:17-21.
- Schlichting, P.E., J.C. Beasley, R.K. Boughton, A.J. Davis, K.M. Pepin, M.P. Glow, and J.S. Lewis. 2020. *A Rapid Population Assessment Method for Wild Pigs Using Baited Cameras at 3 Study Sites*. Wildlife Society Bulletin. 44(2):372-382.
- Sweitzer, R.A., Gardner, I.A., Gonzales, B.J., Van Vuren, D., and W.M. Boyce. 1996. *Population Densities and Disease Surveys of Wild Pigs in the Coast Ranges of Central and Northern California*.
- Treichler, J.W., VerCauteren, K.C., Taylor, C.R., & Beasley, J.C. 2023. *Changes in Wild Pig (Sus scrofa) Relative Abundance, Crop Damage, and Environmental Impacts in Response to Control Efforts*. Pest Management Science.
- USDA. 2020. *General Guidance for Cleaning and Disinfection of Rabbit Hemorrhagic Disease Virus (RHDV) Contaminated Premises*. Downloaded handout.
- West, B.C., A.L. Cooper, and J.B. Armstrong. 2009. *Managing Wild Pigs: A Technical Guide*. Human Wildlife Interactions Monograph. 1:1-55.