Natomas Basin Habitat Conservation Plan Area Biological Effectiveness Monitoring Report

2022 ANNUAL SURVEY RESULTS

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the NATOMAS BASIN conservancy

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FINAL

BIOLOGICAL EFFECTIVENESS MONITORING FOR THE NATOMAS BASIN HABITAT CONSERVATION PLAN AREA 2022 ANNUAL SURVEY RESULTS

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Acronyms and Abbreviations

Basin	Natomas Basin
BEMT	Biological Effectiveness Monitoring Team
Cal-IPC	California Invasive Plant Council
CESA	California Endangered Species Act
CMR	capture-mark-recapture
Covered Species	species covered by the Plan
DFG	California Department of Fish and Game
DFW	California Department of Fish and Wildlife
ESA	Endangered Species Act
g	grams
GIS	Geographic information system
I-	Interstate
ICF	ICF International and ICF Jones & Stokes
km^2	square kilometers
MAP HCP	Metro Air Park Habitat Conservation Plan
mm	millimeters
NAIP	National Agricultural Imagery Program
NBHCP	Natomas Basin Habitat Conservation Plan
NLIP	Natomas Levee Improvement Program
PIT	passive integrated transponder
Plan	Natomas Basin Habitat Conservation Plan
plan area	NBHCP Area
SAFCA	Sacramento Area Flood Control Agency
SCAS	Sacramento County Airport System
SMF	Sacramento International Airport
SR	State Route
SSMP	Site-Specific Management Plan
SUL	snout-urostyle-length
SVL	snout–vent length
TAC	Technical Advisory Committee
TNBC	The Natomas Basin Conservancy
TVL	tail–vent length
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
UTM	Universal Transverse Mercator

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Chapter 1
Introduction

CHAPTER HIGHLIGHTS

- 2022 marked the 19th year of comprehensive biological effectiveness monitoring for the Natomas Basin and Metro Airpark Habitat Conservation Plans.
- This annual report fulfills the monitoring and reporting requirements of the federal incidental take permit issued by the U.S. Fish and Wildlife Service and the state permit issued by the California Department of Fish and Wildlife.
- A summary of monitoring results for 2022 is provided at the end of this chapter.

1.1 Background

In November 1997, the Natomas Basin Habitat Conservation Plan (NBHCP) (City of Sacramento 1997) was submitted to the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (DFG, now the Department of Fish and Wildlife [DFW]) in support of an application for a federal permit under Section 10(a)(1)(B) of the Endangered Species Act (ESA) and a state permit under Section 2081 of the California Fish and Game Code. USFWS and DFG subsequently approved the NBHCP and issued permits. A modified version of the NBHCP was approved in 2003 (City of Sacramento et al. 2003).

The NBHCP (also referred to as the *Plan*) was designed to promote biological conservation while allowing economic development and the continuation of agriculture in the Natomas Basin (Basin) (Figure 1-1). The Plan establishes a multispecies conservation program to minimize and mitigate the expected loss of habitat values and the incidental take of species covered by the Plan (hereafter referred to as *Covered Species*) that could result from urban development and certain actions associated with implementation of the conservation activities that are required as mitigation.

The overall goal of the NBHCP is to minimize incidental take of Covered Species in the NBHCP Area (also referred to as the *plan area*) and to mitigate the impacts of covered activities on Covered Species and their habitats. Mitigation is accomplished primarily through the acquisition and management of reserve lands for the benefit of Covered Species. The primary biological goal of the NBHCP is to create a system of reserves that contain both wetland and upland components that will support viable populations of Swainson's hawk (*Buteo swainsoni*), giant gartersnake (*Thamnophis gigas*), and other species covered under the Plan.

The Natomas Basin Conservancy (TNBC) is the nonprofit entity responsible for administering and implementing the NBHCP and the Metro Air Park Habitat Conservation Plan (MAP HCP).[1] TNBC serves as the Plan Operator on behalf of the City of Sacramento, Sutter County, and the MAP Property Owners Association. TNBC's actions are governed primarily by the terms of the NBHCP and the commitments set forth in the NBHCP Implementation Agreement. TNBC's primary function is

[1] The MAP HCP covers a 2,015-acre portion of the Basin, adjacent to Sacramento International Airport (SMF), that is part of the 17,500 acres of planned urban development considered in the NBHCP.

the acquisition and management of reserve lands. To fulfill this function, TNBC develops and implements Site-Specific Management Plans (SSMPs) and Site-Specific Biological Effectiveness Monitoring Plans for its mitigation land holdings within the Basin. A Technical Advisory Committee (TAC) provides technical assistance to TNBC as needed and as described in the NBHCP.

To achieve the goals of the Plan, TNBC retained ICF (formerly ICF International and ICF Jones & Stokes) to conduct the biological effectiveness monitoring required by the NBHCP. ICF has assembled a Biological Effectiveness Monitoring Team (BEMT) to conduct biological effectiveness monitoring to document the progress made toward meeting the biological goals and objectives of the NBHCP and to inform the adaptive management strategy.

By April of 2022, TNBC owned and managed 36 separate tracts totaling approximately 5,104 acres (2,066 hectares) in the Basin on which biological effectiveness monitoring was implemented (Table 1-1). Since 2007, individual tracts of mitigation land have been organized into three main reserves: the North Basin Reserve, the Central Basin Reserve, and the Fisherman's Lake Reserve (Figure 1-2).

1.1.1 Location

The Basin is a low-lying area of the Sacramento Valley that encompasses portions of northern Sacramento County and southern Sutter County (Figure 1-1). The 54,206-acre (21,666-hectare) plan area is bounded on the west by the Sacramento River, on the north by the Natomas Cross Canal, on the east by Steelhead Creek (formerly known as the Natomas East Main Drainage Canal), and on the south by Garden Highway (Figure 1-2).

The plan area contains incorporated and unincorporated areas within the jurisdictions of the City of Sacramento, Sacramento County, and Sutter County. The southern portion of the Basin is mostly urbanized, but the rest remains primarily agricultural.

1.1.2 Setting

The Basin is in the historical floodplain of the Sacramento and American Rivers. The historical land cover types in the Basin were wetlands, narrow streams with associated riparian vegetation, shallow lakes, and grasslands on the terraces along the Basin's eastern edge. During the late 1800s and early 1900s, most of the Basin was converted to agriculture and many native habitats were removed. Channelized water delivery and drainage systems replaced the natural stream corridors.

The lowest areas of the Basin are in the central and northern portions, which are flat, open areas with deep clay soils and which primarily support rice farming (Figure 1-3). Very few trees or native vegetation types are present, except for the mature riparian forest and wetland complex that occur along the length of the Natomas Cross Canal on the Basin's northern boundary (Figure 1-3).

The southern and western portions of the Basin contain mostly alluvial soils and support a mixture of row, grain, and hay crops. Small remnant stands of valley oak woodland and remnant patches of riparian woodland (e.g., along Fisherman's Lake), persist throughout this area (Figure 1-4). The Sacramento River, on the Basin's western edge, supports mature cottonwood-dominated riparian forest. Most of the southern portion of the Basin has been urbanized and consists of residential development (Figure 1-5).

The highest portion of the Basin is the eastern edge, which is on a terrace with gently rolling topography. The eastern edge contains loam and clay-loam soils and supports annual grasslands and both dry and irrigated pastures. Steelhead Creek forms the eastern Basin boundary and is a channelized drainage with an extensive wetland complex and sparse riparian vegetation along its length (Figure 1-6).

1.2 The Biological Effectiveness Monitoring Program

1.2.1 Goals and Objectives

The purpose of the Biological Effectiveness Monitoring Program is to evaluate the effectiveness of the NBHCP with respect to meeting its biological goals and objectives, and to inform the adaptive management strategy. In general, monitoring is designed to establish baseline conditions, track changes over time, and evaluate the effectiveness of management actions. Specific purposes of the Biological Effectiveness Monitoring Program are listed below.

- Track population trends of Covered Species within the plan area to evaluate the effectiveness of the NBHCP in sustaining populations of Covered Species in the Basin.
- Evaluate the effectiveness of reserve design and management.
- Provide information that can be used to improve the design and management of reserves.

Monitoring must be conducted in accordance with the guidelines set forth in the NBHCP to achieve compliance with the provisions of the ESA 10(a)(1)(B) permit.

1.2.2 Covered Species

The NBHCP's 22 Covered Species are listed in Table 1-2. Two Covered Species—Swainson's hawk and tricolored blackbird—are currently listed under the California Endangered Species Act (CESA), while a third Covered Species—giant gartersnake—is listed under both CESA and the federal ESA. Swainson's hawks and giant gartersnakes are widely distributed in the Basin. Accordingly, most of the monitoring effort is devoted to these two species. These species are addressed individually in Chapter 3, *Giant Gartersnake*, and Chapter 4, *Swainson's Hawk.* The remaining Covered Species are collectively referred to as *Other Covered Species* and are addressed in Chapter 5, *Other Covered Wildlife Species,* with the exception of covered plant species, which are addressed in Chapter 2, *Land Cover Mapping, Botanical Inventory, and Noxious Weed Monitoring*.

1.2.3 Types of Monitoring

The NBHCP and its Implementation Agreement require that monitoring be conducted in accordance with conditions of the ESA 10(a)(1)(B) permit from USFWS and the 2081 permit from DFW. Therefore, a comprehensive monitoring strategy has been developed to satisfy these conditions.

1.2.3.1 Land Cover Mapping, Botanical Inventory, and Noxious Weed Monitoring

Comprehensive land cover mapping began in 2004 and informs the baseline for all the monitoring efforts. Land cover mapping is conducted both on reserve lands and Basin-wide. The mapping efforts on reserve lands are conducted at a higher resolution than the Basin-wide mapping efforts.

The land cover mapping efforts have built a comprehensive, chronological picture of changes in the distribution and abundance of habitat types in the Basin.

Botanical surveys on reserve lands were initiated in 2004 and are conducted to monitor the vegetative composition, to assess changes in vegetation over time, and to document occurrences of covered plant species.

Noxious weed surveys on reserve lands were also initiated in 2004 to monitor the presence and extent of weed populations that can affect the ability of native habitats to support Covered Species. The methods and results of these surveys are described in Chapter 2, *Land Cover Mapping, Botanical Inventory, and Noxious Weed Monitoring*.

1.2.3.2 Giant Gartersnake Monitoring

Monitoring efforts for giant gartersnake have been conducted in the Basin since the late 1990s. A standardized monitoring protocol and survey design was initiated in 2004. The monitoring protocol was modified in 2011 to address issues associated with the low capture probabilities typically encountered with giant gartersnake, and again in 2018 to take advantage of advances in sampling and analytical techniques. Chapter 3, *Giant Gartersnake*, describes the sampling protocol and methods and presents the results of these surveys.

1.2.3.3 Swainson's Hawk Monitoring

Systematic Swainson's hawk monitoring has been conducted under the auspices of the NBHCP since 1999. Because Swainson's hawks are far-ranging birds, this species is intensively monitored throughout the Basin and on both sides of the drainages that form the periphery of the Basin. The methods and results of the Swainson's hawk surveys are described in Chapter 4, *Swainson's Hawk*.

1.2.3.4 Other Covered Wildlife Species Monitoring

Monitoring of populations of Other Covered Species was initiated in 2004. Surveys on reserve lands are conducted to evaluate the effectiveness of reserve design and management in meeting objectives for Other Covered Species. Surveys on non-reserve lands are conducted to serve as "controls" for comparison to reserve lands to evaluate the success of design and management in increasing the numbers of Other Covered Species. The methods and results of surveys for Other Covered Species are described in Chapter 5, *Other Covered Wildlife Species*.

1.3 Summary of the 2022 Biological Effectiveness Monitoring Program Results

This section summarizes the 2022 results of the Biological Effectiveness Monitoring Program. It should be noted that 2017 ended 5 consecutive years of extreme drought in California, with one of the wettest years on record, followed by several more years of extreme drought. These extremes in weather and climate would be expected to negatively affect populations of Covered Species in both predictable and unpredictable ways.

In 2015, construction was completed for the portion of the Natomas Levee Improvement Program (NLIP) setback levee managed by SAFCA along the rural portions of the Sacramento River. Large swaths of grassland, riparian habitat, and managed marsh habitat that were created as mitigation for NLIP have been fully functional for more than 5 years and should contribute significantly to the conservation of Other Covered Species in the Basin.

Changes in land cover types from 2021 to 2022 were significant, with an unprecedented number of acres of rice and upland agricultural lands being fallowed due to extreme drought conditions. Concomitantly, the rate of development has continued to increase.

The sampling effort for giant gartersnake in 2022 was similar to 2021 and higher than 2020 at the height of the COVID-19 pandemic, but was still lower than other previous years due to issues related to the pandemic. The trapping season and the sampling period have remained consistent since 2021. The number of snakes caught per unit effort was lower in 2022 than 2021. The size distribution of captured snakes in 2022 was consistent with a healthy population, and estimates of occupancy increased from 2021 to 2022, although the probability that the proportion of occupied sites was stable (i.e., did not change by more than 10%) from 2011 to 2022 was approximately 99%. Apparent survival at the BKS site was higher from 2018 to 2019 than in subsequent years.

The total number of Swainson's hawk pairs in the Basin declined substantially from 2020 to 2021, but increased in 2022 to the third highest number recorded since monitoring began in 2000, and the total number of pairs continues to exhibit a statistically significant increase over time. Following a substantial decrease in all measures of reproductive success in 2021, reproductive metrics rebounded in 2022 but remained. A statistically significant long-term decline in the number of young produced per successful nest was still evident in 2022, a phenomenon observed across the range of the species in California.

The mean number of loggerhead shrike (*Lanius ludovicianus*) detections per survey on reserve lands decreased to zero in 2022. Loggerhead shrike detections have been decreasing substantially on reserve lands since 2012, with a more severe decline evident on non-reserve lands. The reasons for the decline are unknown, but are likely related to decreases in insect prey populations.

White-faced ibis (*Plegadis chihi*) did not nest in the Basin in 2022. Both the mean number of detections per survey and the proportion of surveys with detections decreased in 2022 on both reserve and non-reserve lands. However, white-faced ibis appear to be thriving in the Basin.

Tricolored blackbirds (*Agelaius tricolor*) did not nest in the Basin in 2022 after nesting successfully for the first time in 9 years in 2020. Both the mean number of detections per survey and the proportion of surveys in which the species was detected on reserve lands decreased slightly from 2021 to 2022. On non-reserve lands, both the mean number of detections per survey and the proportion of surveys on which tricolored blackbirds were detected increased. The species has declined significantly throughout its range, and in 2018 it was listed under CESA as threatened.

Both the mean number of burrowing owls (*Athene cunicularia*) detected per survey and the proportion of surveys with detections on both reserve and non-reserve lands decreased from 2021 to 2022.

Both the mean number of Pacific pond turtle (*Actinemys marmorata*) and unknown pond turtle detections per survey and the proportion of surveys with detections increased slightly in 2022. This species now appears to be well established on most (if not all) tracts with managed marsh habitat.

1.4 References

City of Sacramento. 1997. *Natomas Basin Habitat Conservation Plan, Sacramento and Sutter Counties, California*. November. Sacramento, CA.

City of Sacramento, Sutter County, and the Natomas Basin Conservancy. 2003. *Natomas Basin Habitat Conservation Plan; Sacramento and Sutter Counties, California*. Sacramento, CA.

Natomas Basin Conservancy. 2022. Current Base Map. Available: https://www.natomasbasin.org/helpful-documents/preserve-maps/. Accessed: February 9, 2022.

Table 1-1. Reserve Lands Acquired under the NBHCP on which Biological Effectiveness Monitoring was Conducted [a, b]

Reserve/Tract	Date Acquired	Acres
North Basin Reserve		
Atkinson	6/12/03	199
Bennett North	5/17/99	227
Bennett South	5/17/99	132
Bolen North	4/29/05	114
Bolen South	4/29/05	102
Bolen West	9/01/06	155
Frazer	7/31/00	93
Huffman East	9/30/03	136
Huffman West	9/30/03	158
Lauppe North	1/5/22	185
Lauppe South	6/30/20	172
Lucich North	5/18/99	268
Lucich South	5/18/99	352
Nestor	9/1/06	233
Ruby Ranch	6/23/03	91
Verona	7/02/20	116
Vestal	9/12/05	95
Willey	10/19/20	108
Central Basin Reserve		
Betts	4/5/99	139
Bianchi West	11/7/06	110
Elsie	11/7/06	158
Elverta	7/13/21	288
Frazer South	11/7/06	110
Kismat	4/16/99	40
Paulsen South	9/28/20	52
Richter	1/03/20	81
Sills	7/15/02	436
Silva	1/7/99	159
Silva South 1	9/28/12	29
Tufts	9/29/04	148
Fisherman's Lake Reserve		
Alleghany	11/7/02	50
Cummings	11/7/02	67
Natomas Farms	7/9/01	55
Rosa Central	3/23/05	100
Rosa East	3/23/05	106
Souza	7/2/01	40
Total		**5,104**

Source: The Natomas Basin Conservancy 2021.

[a] Includes only properties owned by TNBC in fee title. Does not include 27.08 acres under easement.

[b] Acreage totals gathered through land cover mapping and GIS analysis may vary slightly.

Table 1-2. Species Covered under the NBHCP

Common Name	Scientific Name
White-faced ibis	*Plegadis chihi*
Aleutian cackling goose[a]	*Branta hutchinsii leucopareia*[a]
Swainson's hawk	*Buteo swainsoni*
Burrowing owl	*Athene cunicularia*
Loggerhead shrike	*Lanius ludovicianus*
Bank swallow	*Riparia riparia*
Tricolored blackbird	*Agelaius tricolor*
Giant gartersnake	*Thamnophis gigas*
Pacific pond turtle	*Actinemys marmorata*
California tiger salamander	*Ambystoma californiense*
Western spadefoot	*Spea hammondii*
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*
Vernal pool fairy shrimp	*Branchinecta lynchi*
Midvalley fairy shrimp	*Branchinecta mesovallensis*
Vernal pool tadpole shrimp	*Lepidurus packardi*
Delta tule pea	*Lathyrus jepsonii* ssp. *jepsonii*
Sanford's arrowhead	*Sagittaria sanfordii*
Colusa grass	*Neostapfia colusana*
Boggs Lake hedge-hyssop	*Gratiola heterosepala*
Sacramento Orcutt grass	*Orcuttia viscida*
Slender Orcutt grass	*Orcuttia tenuis*
Legenere	*Legenere limosa*

[a] Formerly Aleutian Canada goose (*Branta canadensis leucopareia*).

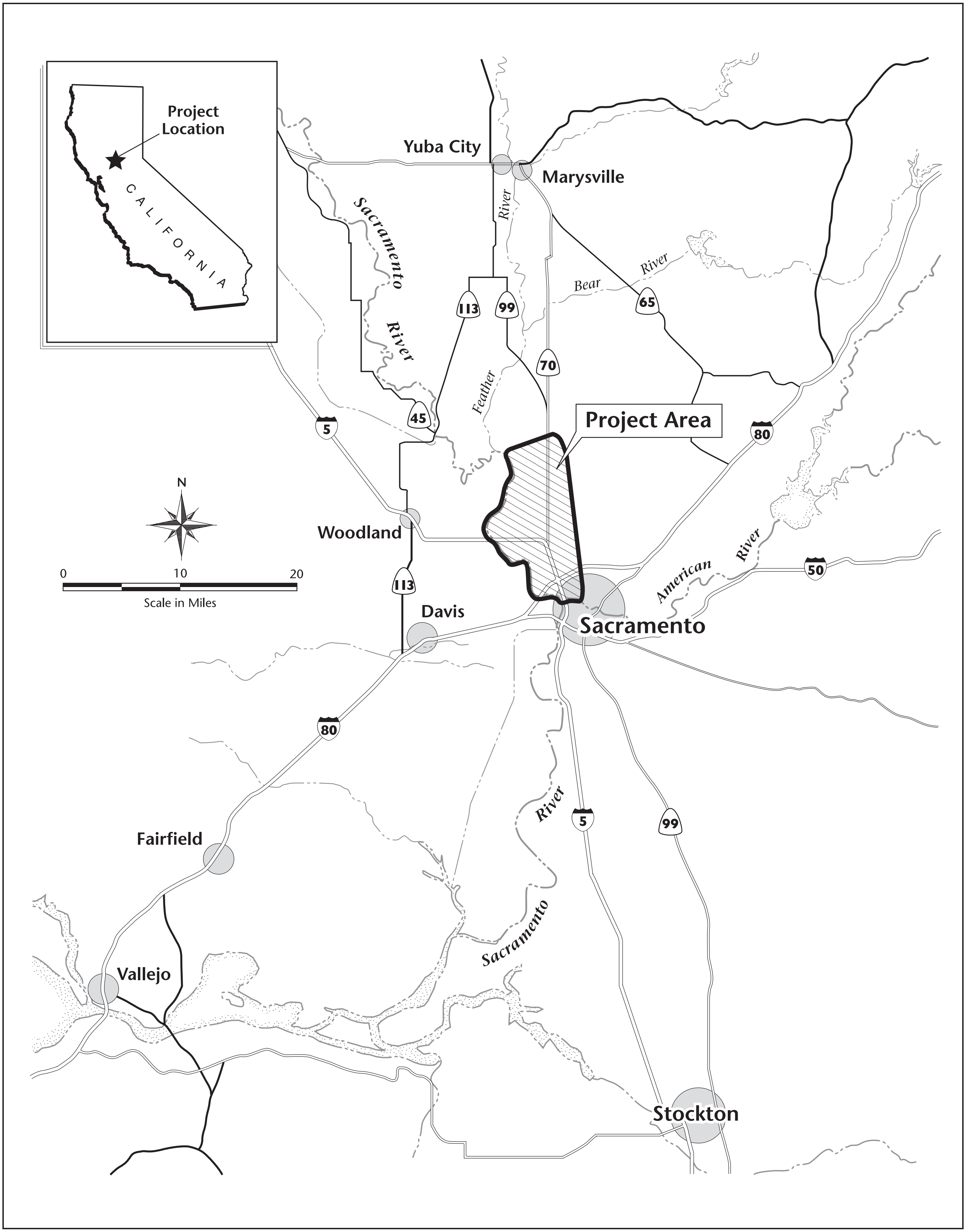

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FIGURE 1-1
Project Location

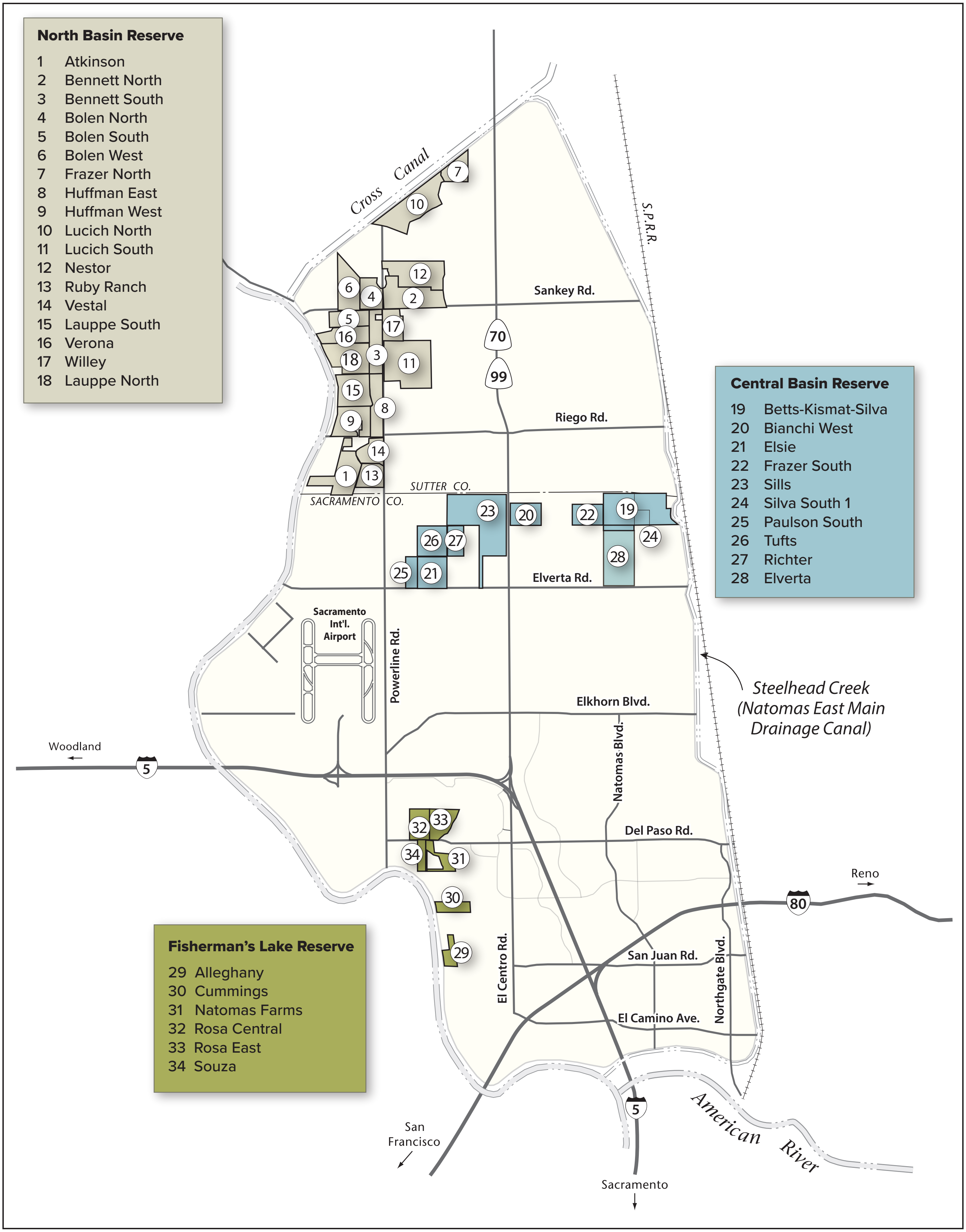

FIGURE 1-2
Natomas Basin Reserves

Typical habitat of the central and northern Natomas Basin

Natomas Cross Canal

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FIGURE 1-3
Central and Northern Basin Habitats

Fisherman's Lake

Mature riparian forest along the Sacramento River

Graphics … 890.10 (3-11-2021) TAG

FIGURE 1-4
Riparian Habitats in the Northern Basin

Typical habitat of the west and south Natomas Basin

Residential development in the south basin

Graphics … 890.10 (3-11-2021) TAG

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FIGURE 1-5
Southern and Western Basin Habitats

Typical habitat of the east basin

Steelhead Creek (formerly the Natomas East Main Drain Canal)

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FIGURE 1-6

Eastern Basin Habitats

Chapter 2
Land Cover Mapping, Botanical Inventory, and Noxious Weed Monitoring

CHAPTER HIGHLIGHTS

- Across the plan area, active rice fields decreased by more than 7,000 acres between 2021 and 2022, while fallow lands increased by over 6,300 acres.
- Large developments in the north and west of the plan area have been steadily increasing the acreage of developed land in the plan area.
- There was a spike in noxious weed observations between 2021 and 2022. Large patches of yellow-star thistle, milk thistle, mustard, and Harding grass were identified. Additionally, water primrose was found in all marshes within the reserves.
- No covered plant species were detected, and vernal pools did not pond long enough in 2022 for any Covered Species—if they were present—to be detected.

2.1 Introduction

2.1.1 Background

Biological effectiveness monitoring is designed to measure the progress of the NBHCP toward meeting the Plan's goals and objectives for Covered Species *and their habitats* [emphasis added]. The land cover and habitat mapping component of the biological effectiveness monitoring program applies to all Covered Species and tracks changes in land cover and habitats over time. The two types of land cover and habitat monitoring being implemented to meet the NBHCP goals and objectives are (1) monitoring on reserve lands and (2) monitoring off reserves to identify changes Basin-wide.

Land cover and habitat monitoring on reserves follows comprehensive, systematic procedures in accordance with the *Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities* (California Department of Fish and Wildlife 2018). Botanical surveys are conducted to identify sensitive plant species and noxious weeds.

Basin-wide land cover and habitat monitoring entails annual field verification of each land cover polygon originally mapped in 2004 (i.e., when the comprehensive monitoring program was established) and documenting any changes that have occurred since the previous year.

2.1.2 Goals and Objectives

Effective resource monitoring requires baseline information on the distribution and abundance of the resources of interest. The land cover and habitat mapping component of the biological effectiveness monitoring effort establishes the baseline for the entire biological effectiveness monitoring effort. The objectives of the Basin-wide land cover and habitat monitoring component are listed below.

- Quantify the distribution and abundance of land cover and habitat types throughout the Basin.
- Provide spatially explicit information on the distribution and abundance of land cover and habitat types throughout the Basin to guide future acquisitions of mitigation lands, to provide information on potential dispersal corridors between reserves, and to assess changes in the distribution and abundance of suitable habitats for Covered Species over time.

Botanical surveys on reserves are conducted annually. The objectives of these surveys are listed below.

- Document changes in the distribution and condition of land cover and habitat types.
- Document the location, numbers, and/or cover of covered plant species and invasive/noxious plant populations where they occur.

2.2 Methods

2.2.1 Land Cover Mapping

The baseline conditions for land cover in the plan area were first documented in 2004 using aerial imagery. Geographic information system (GIS) specialists generated a base map of the permit area using true-color digital ortho-rectified aerial imagery of Sacramento and Sutter Counties purchased from AirPhotoUSA. The original aerial imagery from Sacramento County was taken in April 2004 at a resolution of 1 foot (i.e., each cell represents an area on the ground of approximately 1 square foot); the original aerial imagery from Sutter County was taken in spring 2004 at a resolution of 2 feet (i.e., each cell represents an area of 4 square feet). The aerial imagery was updated in 2008 and 2012 to achieve a resolution of 1 foot for both counties. National Agricultural Imagery Program (NAIP) imagery at a resolution of 1 meter has been used subsequently.

Botanists experienced with aerial imagery interpretation and vegetation signatures of the southern Sacramento Valley mapped land cover types on screen using Environmental Systems Research Institute's ArcGIS 10.3.1 software. Lines were drawn to delineate polygons following visible differences in color tone and texture on the photographs. Polygons were delineated at a scale of 1:2,500–1:5,000 (approximately 1 inch = 200–400 feet). Riparian areas and wetlands were in some cases digitized at larger scales. Minimum polygon size (i.e., the minimum mapping unit) was generally 5 acres (2 hectares) for agricultural habitat types and developed areas, 0.25 acre (0.1 hectare) for seasonal wetlands, and 0.5 acre (0.2 hectare) for other sensitive habitat types. Polygons were then field-checked to ensure accuracy of the digitizing and photo-interpretation effort. Ditches were mapped as line features, and no attempt has been made to calculate their area.

Field verification of land cover polygons Basin-wide is conducted annually, primarily while conducting surveys for other purposes. All polygons are checked before the fall harvest begins, with the exception of a few off-reserve, privately owned polygons that cannot be checked because access is not available. In these areas, the most current aerial imagery from Google Earth is used to verify land cover types.

Surveys were conducted in late spring and summer, at times appropriate for mapping habitat polygons. In addition, the surveys were conducted at optimal times for observing and documenting potential invasive/noxious weed species and sensitive plant populations.

Appendix A lists the acreages of each mapped land cover type by reserve and tract.

2.2.2 Botanical Surveys

Botanical surveys were completed from June through August 2022 on reserve lands. Surveys were conducted to record any changes in vegetation, habitat, or crop type; detect any changes in the distribution and abundance of suitable habitat for Covered Species; and document any potential noxious weeds and sensitive plants. Plant species encountered for the first time were added to the cumulative list of species observed on each tract (Appendix B). In addition, the following data were collected for each polygon on reserve lands.

- All plant taxa (identified to genera level or level appropriate to determine if the plant is sensitive or a noxious weed)
- Any changes in land cover or crop type, or in the distribution of suitable habitat for covered plant species

Nomenclature follows the second edition of *The Jepson Manual: Vascular Plants of California* (Baldwin et al. 2012) and updates published online by the Jepson Flora Project (Jepson Flora Project 2022). The plant list in Appendix B has been updated to reflect any nomenclature changes from the first edition of *The Jepson Manual* (Hickman 1993).

2.2.3 Noxious Weed Mapping

A complete list of noxious weeds known to occur in Sutter and Sacramento Counties was initially compiled from information in CalFlora (CalFlora n.d.) and ICF file data. This list has been annually updated to reflect the current status of noxious weeds with the potential to occur on the reserves. The noxious weeds tracked during botanical surveys are those rated High or Moderate or designated a Red Alert species by the California Invasive Plant Council (Cal-IPC). These lists identify plants considered invasive to wildlands and natural vegetation, rather than weeds of agricultural importance that are found primarily in disturbed habitats.

The list of weeds tracked on TNBC reserves is reviewed and updated annually on the basis of Cal-IPC updates and input from local land managers. Also included are plants that are potentially invasive in wetlands and may be of management concern to TNBC.

Each noxious weed occurrence observed during the botanical surveys on reserves was hand-mapped on aerial imagery or mapped with an iPad and then added to the cumulative list of weed occurrences. The level of infestation (i.e., population size) was recorded in five cover/distribution categories:

- T = Trace (rare): less than 1% cover.
- L = Low (occasional plants): 1–5% cover.
- M = Moderate (scattered plants): 5–25% cover.
- H = High (fairly dense): 25–75% cover.

- D = Dense (dominant): more than 75% cover.

Whenever highly invasive species requiring immediate management action are detected, a KMZ file is created and immediately sent to TNBC that identifies the weed type and location.

2.3 Results

2.3.1 Land Cover Types Basin-Wide

Table 2-1 lists the acreages of each land cover type mapped in the Basin from 2005 to 2022. The distribution of these types is shown on Figure 2-1 (note that several land cover types have been combined in the figure for clearer representation). The major land cover types that provide habitat for Covered Species in the Basin are rice, wetlands, upland agricultural lands, fallow agricultural fields, and grasslands. Upland agricultural fields, fallow agricultural fields, and grasslands constitute the majority of foraging habitat for Swainson's hawk, one of the three Covered Species that are listed under either the California or federal ESAs. Active rice fields and the irrigation and drainage ditches that supply them are important habitats supporting giant gartersnake (federally listed as endangered), while created wetlands provide critical habitats for giant gartersnake and several other Covered Species. The acreages of these land cover categories are shown in Table 2-2, along with the proportion of the Basin comprising each type. Figure 2-2 shows changes in the acreage of major land cover types since 2005; these changes are summarized below.

- Although active rice fields continue to dominate the landscape, they decreased substantially from 2021 to 2022 by approximately 7,866 acres dropping from 36.4% of the Basin in 2021 and 21.9% of the Basin in 2022.
- Fallow lands increased by 6,399 acres between 2021 and 2022, covering 6.3% of the Basin in 2021 and 18.1% of the Basin in 2022.
- Upland agricultural lands decreased by approximately 1,032 acres, covering 16.2% of the Basin in 2021 and 14.3% in 2022.
- Grassland cover increased by 1,377 acres, but most of this is probably due to fallow lands being classified as ruderal habitat in 2022.
- Developed land cover increased by approximately 840 acres.

The most significant long-term changes in land and habitat values over the last 10 years continues to be driven by construction of the NLIP. Mitigation for impacts from the NLIP setback levee construction project have included the creation of fresh emergent marsh habitats from soil borrow sites and the creation and preservation of large swaths of grassland and riparian habitats adjacent to the new setback levee.

The other significant change over the last few years has been the rapid increase in development resulting from the lifting in 2017 of the moratorium on development issued in December 2008 out of concern for flood protection in the Basin. In 2021, developed—low density decreased by 499 acres and developed—high density increased by 611 acres; approximately 164 acres of developed—low density was converted into developed—high density. In 2022, developed—low density decreased by 324 acres as it was converted to high density use. Developed—high density increased by 511 acres. The rate of development is expected to increase in the coming years.

Natural vegetation, composed of tree- and shrub-dominated natural communities such as valley oak woodland, riparian woodland, and riparian scrub, constitutes an extremely small proportion of the Basin (i.e., 2.6% of the land area), but provides high-quality habitat for a large number of species, including the Swainson's hawk and loggerhead shrike, both Covered Species under the NBHCP. As noted above, the Basin-wide acreage comprising these habitat types has been increasing due to mitigation from the NLIP. The maturation of tree plantings at freeway off-ramps resulted in those areas being mapped as woodland land cover types (e.g., mixed oak woodland, live oak woodland) in 2022. The small area of terrace grassland on the eastern edge of the Basin was not differentiated from the nonnative annual grassland category, although this area includes some remnant valley floor grassland.

2.3.2 Land Cover Types on Reserves

The total acreage of each land cover type mapped on reserves from 2005 to 2022 is shown in Table 2-3; the major categories of land cover types providing habitat for Covered Species on reserves (rice, wetlands, upland agricultural lands, fallow agricultural fields, and grasslands) are shown in Table 2-4, along with the proportion of reserve lands comprising each type.

With the acquisition of the Elverta, Richter, Paulsen South, Lauppe North, Lauppe South, Verona, and Willey Reserves, the acreage of reserve lands increased by approximately 1,000 acres from 2021 to 2022. This resulted in an increase in both rice and upland agricultural habitats on reserve lands, although these changes are not reflected in the tables due to the severe drought that resulted in drastic increases in both fallow rice and fallow upland agriculture.

Table 2-5 summarizes the major habitat types on reserves as a proportion of those habitats in the entire Natomas Basin. In 2022, reserve lands accounted for 43% of the managed marsh/wetlands in the Basin, but only 12.8% of the rice lands and 11.3% of upland agricultural habitats. Reserve lands now account for a smaller proportion of wetlands in the Basin due to the creation of the managed marsh complex by the Greenbriar development.

The area of plantings that was added on the Souza Tract in 2016 is continuing to thrive and mature.

2.3.3 Noxious Weed Surveys

Noxious weed occurrences recorded from 2005 to 2022 are summarized in Table 2-6.

A total of 224 new weed occurrences were documented in 2022: 8 tree of heaven (*Ailanthus altissima*), 10 black mustard (*Brassica nigra*), 7 Italian thistle (*Carduus pycnocephalus*), 5 bull thistle (*Cirsium vulgare*), 40 yellow star-thistle (*Centaurea solstitialis*), 7 stinkwort (*Dittrichia graveolens*), 1 water hyacinth (*Eichhornia crassipes*), 4 medusahead (*Elymus caput-medusae*), 2 edible fig (*Ficus carica*), 22 short pod mustard (*Hirschfeldia incana*), 22 water primrose (*Ludwigia peploides*), 2 pennyroyal (*Mentha pulegium*), 12 Harding grass (*Phalaris aquatica*), 71 milk thistle (*Silybum marianum*), 8 Himalayan blackberry (*Rubus armeniacus*), and 3 puncture vine (*Tribulus terrestris*).

Conversely, a total of 106 weed occurrences documented in 2021 were not found in 2022: 18 bull thistle, 3 edible fig, 6 Harding grass, 9 Himalayan blackberry, 4 Italian thistle, 2 milk thistle, 8 pennyroyal, 5 perennial pepper weed, 37 stinkwort, 3 fennel (*Foeniculum vulgare*), and 11 yellow star-thistle.

Historically, these populations have been controlled by active management practices. Due to regeneration from seedbanks or root segments, invasive species eradication on reserve lands may require multiple removal efforts over several growing seasons.

Active management has targeted plant species that are known to be or are very likely to become invasive and that are locally considered to be particularly invasive and/or difficult to control. Specific examples of highly invasive species with the potential to compromise habitat values include perennial pepperweed, and water primrose species (*Ludwigia* sp.). Construction activities are a major cause of noxious weed dispersal. Given the projected increase in development activities in the coming years, careful monitoring and active management should continue.

Vegetation management to prevent the spread of water primrose, perennial pepperweed, cattail (*Typha* sp.), and other invasive and undesirable species using mechanical means (e.g., pulling, mowing, managing water levels) and chemical means (e.g., herbicide applications) has been very effective historically. Water primrose, mosquito fern (*Azolla filiculoides*), and cattail can never be completely eradicated, but management efforts to date indicate that they can be controlled and contained using aggressive management.

2.3.4 Botanical Surveys

No covered plant species were recorded on TNBC reserves in 2022. Freshwater marsh and banks adjacent to open water canals provide suitable habitat for Delta tule pea and Sanford's arrowhead. Potential vernal pool habitat for the remaining covered plants is extremely rare in the Basin. However, due to a lack of rainfall, created vernal pools on the BKS tract—which could potentially provide habitat for covered plant species—have not ponded for a sufficient duration over the last 4 years to allow for vernal pool-dependent plants to germinate. The cumulative list of plant species recorded on each tract through the 2022 field season is presented by reserve in Appendix B.

2.4 Discussion

2.4.1 Land Cover Types Basin-Wide

Significant changes in the distribution and abundance of land cover and habitat types across the Basin have been primarily due to: (1) the fallowing of rice lands in 2006 and subsequent return to rice over the last decade; (2) the implementation of the NLIP, which resulted in a substantial increase in grasslands and managed marsh/wetland habitats; (3) the rapid resumption of development after the lifting of the moratorium on development in 2017; and (4) the fallowing of rice land in 2022 due to extreme drought.

The resumption of rice agriculture in areas fallowed in 2006 and the increase in managed marsh habitats in the Basin resulting from the creation of marshes in areas soil-mined for the NLIP have resulted in a significant increase in habitats available for use by giant gartersnake.

Variation in the amount of rice, fallow lands, and upland agricultural lands has been significant over the last 4 years and may be due in part to variation in weather patterns that result in some lands being left fallow. Rainfall that occurs late in the season has also likely resulted in some rice lands being fallowed, particularly in 2017 and 2019. Severe drought resulted in the fallowing of a substantial portion of rice and upland agricultural fields in 2022.

2.4.2 Land Cover Types on Reserves

Habitats on reserve lands are important components of the habitat landscape throughout the Basin. Managed marsh on TNBC reserves provides important habitats for a number of Covered Species. Because these marshes constitute almost half the wetlands in the entire Basin, they are an extremely important component of the mosaic of Basin-wide habitats.

Rice and upland agriculture are the other two important agricultural habitat types for Covered Species in the Basin. In 2022, active rice fields on reserve lands constituted 12.8% of the Basin-wide total, up from 11.3% in 2021. Upland agriculture on reserve lands accounted for approximately 11.3% of the upland agriculture in the Basin in 2022, up from 7.5% in 2021.

2.4.3 Botanical Surveys

A cumulative total (2005–2022) of 386 plant species from 66 families has been recorded on reserve lands. Nonnative species account for more than half (55%) of this total. Approximately two-thirds of these species were dicotyledons and one-third were monocotyledons; the two groups included similar proportions of nonnative species. The four most common families have remained unchanged from 2006; in descending order these are the grass family (*Poaceae*) with 51 species (13% of the total), the sunflower family (*Asteraceae*) with 38 species (10%), the bean family (*Fabaceae*) with 21 species (5%), and the mustard family (*Brassicaceae*) with 13 species (3%). The sedge family (*Cyperaceae*), and the dock family (*Polygonaceae*) are represented by more than 10 species each.

Species richness of the flora of each tract was correlated with the size of the reserve and the diversity of habitat types. Large tracts with aquatic habitats (e.g., BKS and Lucich North) had the highest number of plant species, while smaller tracts with a high proportion of upland agriculture (e.g., Souza and Alleghany) generally had the lowest number of plant species.

2.4.4 Noxious Weeds

The majority of noxious weed species on reserves are common and widespread in the Central Valley's agricultural habitats. Occurrences typically composed small patches with low to moderate levels of infestation. Annual weed control is highly recommended to keep noxious weed populations and their seed banks small and manageable.

Noxious weed monitoring detected an expansion of nonnative species not tracked in monitoring efforts prior to 2022, consisting of black mustard, shortpod mustard, and medusahead. These species occurrences are now being tracked annually as a part of the noxious weed monitoring. Should their coverage become problematic and reduce habitat value for Covered Species, manual removal and control of the species would be warranted.

2.5 Effectiveness

Biological effectiveness as it pertains to habitat management is measured on the basis of successful implementation of habitat management recommendations outlined in the NBHCP and those developed by TNBC in consultation with species and vegetation management experts to maintain and enhance habitat values for Covered Species. Given that reserve lands are surrounded by a mosaic of urban, agricultural, and disturbed areas, management of noxious weed occurrences is necessary to sustain habitat values.

Improved communication and coordination among TNBC, the BEMT, and Triangle Properties, the land management and weed control contractor hired by TNBC several years ago, have been effective in ensuring that management actions are implemented in a timely fashion. Control of perennial pepperweed has historically been successful in preventing its spread on reserve lands. Mechanical removal of some noxious weed occurrences (e.g., giant reed) has also been highly effective. The program of early detection and removal of water primrose has proven effective in past years since marsh maintenance and enhancement activities had resulted in its near complete removal. However, a surge in noxious weeds that began in 2018 as a result of record drought being followed by record high rainfall resulted in a resurgence of aquatic weed species, particularly water primrose. However, water primrose can provide habitat for giant gartersnake when kept to moderate levels, so eradication as a goal may not be warranted at some sites.

2.6 Recommendations

Continue to monitor the distribution and abundance of noxious weeds on reserves, with a particular focus on aquatic plants (e.g., water primrose, mosquito fern, perennial pepperweed, and small smutgrass) that may compromise habitat values for Covered Species.

Continue to ensure that all TNBC personnel, consultants, and contractors can identify and immediately report the highest priority noxious weeds to ensure that management action can be taken before the species becomes established. Where possible, removal should occur before the summer when many species disperse their seeds.

Monitor results of the created wetland maintenance and enhancement activities to measure the effectiveness of new designs for maintaining open water habitats by preventing sedimentation and invasion by cattails and other aquatic vegetation that could potentially threaten the functionality and habitat values of created managed marsh, while maintaining and increasing emergent tule habitats.

Document the methods used to treat noxious weed infestation on all reserves and monitor their effectiveness over time to further refine weed management protocols specific to TNBC reserves. Amend Site-Specific Management Plans to include successful management strategies.

2.7 References

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Table 2-1. Basin-Wide Extent (acres) of Mapped Land Cover Types, 2005–2022

Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Rice	22,321	14,792	14,590	14,224	15,014	15,023	15,287[a]	16,956	19,001	20,104	20,796	20,482	16,329	19,092	17,442	20,256	19,758	11,892
Fallow	1,625	10,101	10,033	10,076	5,869	2,912	2,323	2,282	2,160	1,555	1,366	1,712	6,442	3,307	4,667	3,234	3,414	8,951
Alfalfa	931	1,401	1,189	1,519	2,194	1,302	2,417	2,023	1,303	1,179	1,200	1,386	877	470	352	555	794	695
Irrigated grassland	452	374	451	373	378	345	746	750	757	757	352	326	326	311	311	310	314	295
Grass hay	178	153	2,212	2,367	2,769	6,724	5,423	6,504	6,250	6,850	7,582	7,043	7,211[f]	7,570	7,571	6,220	5,271	4,265
Wheat	1,824	2,375	1,104	804	3,919	695	585	413	440	978	650	1,192	383	172	792	705	321	552
Milo	0	328	211	161	0	0	0	0	155	94	0	0	0	303	104	111	289	14
Tomatoes	50	145	112	113	8	10	0	0	0	108	63	40	0	51	261	175	389	528
Sunflower	709	572	0	251	166	804	714	362	821	903	388	519	355	464	181	55	443	690
Safflower	886	532	244	426	162	214	278	322	0	29	448	426	345	511	196	262	193	404
Other row and grain crops	2,537	582	2,396	2,279	2,096	3,770	4,937	3,645	2,370	906	1,151	958	1586	1445	719	445	770	308
Orchard	184	184	184	99	99	94	53	50[b]	50	307[d]	406[d]	406	406	480	480	482	463	626
Fresh emergent marsh (created)	575	575	676	897	897	897	897	897	897	1,042	1,042	1,042	1,042	1,042	1042	1,042	1,199	1,199
Fresh emergent marsh	138	154	154	155	155	155	154	154	154	154	154	154	154	154	154	154	154	154
Seasonal wetland	105	105	108	105	105	110	103	103	115	115	115	115	115	115	115	116	116	103
Grassland (created)	49	71	68	74	74	80	74	75	469[c]	511	511	511	506	506	506	506	506	506
Nonnative annual grassland	7,389	6,786	5,192	4,988	5,016	4,032	3,670	3,652	3,609	3,594	2,887	2,723	3,035	2,939	2,887	2,877	2,896	3,537
Ruderal	329	406	409	399	704	747	864	766	754	856	946	924	824	814	801	661	639	1,375
Valley oak woodland	191	195	192	192	194	209	240	242	257	248	261	322[e]	322	322	322	340[i]	341	328
Live oak woodland	–	–	–	–	–	–	–	–	–	–	–	–	–	–	38[h]	34[h]	28	28
Mixed oak woodland	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11[i]	11	11
Riparian woodland	348	346	357	357	354	359	357	398	398	393	389	390	393	393	393	393	407	407
Riparian scrub	117	117	114	133	133	133	133	133	133	134	134	138	138	138	137[g]	137	137	137
Non-riparian woodland	52	50	51	51	51	29	28	43	43	43	28	28	26	26	26	43[i]	43	51
Open water	352	340	340	337	337	360	381	387	490	459	459	462	462	462	462	462	462	456
Developed—low density	1,565	1,639	1,706	1,949	1,961	1,977	2,114	2,202	2,307	2,296	2,310	2,306	2,115	2,194	3,000	3,072	2,573	2,249
Developed—high density	9,859	10,764	11,533	11,304	11,260	10,910	10,770[a]	10,604	10,529	10,533	10,505	10,539	10,753	10,868	11,191	11,470	12,081	12,592
Disturbed/bare	1,440	1,127	578	573	291	2,321	1,659	1,243	744	58	63	62	62	58	55	81[j]	177	830
Vineyard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	19	2
Total	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**

[a] In 2011, 586 acres of rice were erroneously mapped as developed—low density; acreages for both land cover types have been corrected in this report.
[b] Decrease in orchard acreage due to availability of new aerial imagery that allowed visibility of private property. This 3-acre crop is now irrigated grassland.
[c] Increase in grassland (created) due to conversion of disturbed/bare by SAFCA.
[d] Increase in orchard due to conversion of land west of the airport from row crops to orchard in 2014 and 2015.
[e] Increase in valley oak woodland due to establishment of woodland planted during the SAFCA revegetation of the setback levee.
[f] In 2017, 10 acres of grass hay were erroneously mapped as grassland (created), and 15 acres of grassland (created) were mapped as grass hay. Acreages for both land cover types have been corrected in this report.
[g] Small swath of riparian scrub along a canal was developed for housing.
[h] Maturation of live oak woodland plantings along freeway off-ramps; acreage was refined in 2020
[i] Maturation of woodlands along off-ramps.
[j] Disturbed/bare land cover was incorrectly labeled as fallow in 2019 and 2020; in 2021 the parcel's restoration was finished and it is now a fresh emergent marsh (created).

Table 2-2. Basin-Wide Summary of Major Habitat Types, 2005–2022

Habitat Type[a]	2005		2006		2007		2008		2009		2010		2011		2012		2013	
	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin
Rice	22,321	41.2	14,782	27.3	14,590	26.9	14,224	26.2	15,017	27.7	15,023	27.7	15,287[b]	28.2[b]	16,956	31.3	19,001	35.1
Managed marsh/ wetlands	818	1.5	834	1.5	938	1.7	1,157	2.1	1,157	2.1	1,162	2.1	1,153	2.1	1,153	2.1	1,165	2.1
Upland agriculture	7,567	14.0	6,462	11.9	7,919	14.6	8,293	15.5	11,692	21.6	13,863	25.6	15,100	27.9	14,019	25.9	12,096	22.3
Grassland	7,767	14.3	7,263	13.4	5,669	10.5	5,461	10.1	5,794	10.7	4,853	9.0	4,608	8.5	4,493	8.3	4,832	8.9[c]
Fallow	1,625	3.0	10,101	18.6	10,033	18.5	10,076	18.5	5,869	10.8	2,912	5.4	2,323	4.3	2,282	4.2	2,160	4.0
Developed	12,864	23.7	13,531	25.0	13,817	25.5	13,826	25.5	13,512	24.9	15,208	28.1	14,543[b]	26.8[b]	14,049	25.9	13,581	25.1
Other	1,245	2.3	1,233	2.3	1,239	2.3	1,169	2.2	1,168	2.2	1,184	2.2	1,192	2.2	1,254	2.3	1,371	2.5
Total	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**

Habitat Type[a]	2014		2015		2016		2017		2018		2019		2020		2021		2022	
	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin	Acres	% of Basin
Rice	20,104	37.0	20,796	38.4	20,482	37.8	16,329	30.1	19,092	35.2	17,442	32.2	20,256	37.4	19,758	36.4	11,892	21.9
Managed marsh/ wetlands	1,311	2.4	1,311	2.4	1,311	2.4	1,311	2.4	1,311	2.4	1,311	2.4	1,311	2.4	1,468	2.7	1,455	2.7
Upland agriculture	11,601	21.4	11,771	21.7	11,890	21.9	11,084[d]	20.4	11,777	21.7	10,488[e]	19.3	8,837	16.3	8,784	16.2	7,752	14.3
Grassland	4,961	9.2	4,344	8.0	4,157	7.7	4,364[d]	8.0	4,257	7.8	4,193	7.7	4,043	7.5	4,041	7.4	5,418	10.0
Fallow	1,555	2.9	1,366	2.5	1,712	3.2	6,442	11.9	3,307	6.1	4,667	8.6	3,234	6.0	3,414	6.3	9,813	18.1
Developed	12,887	23.8	12,878	23.8	12,907	23.8	12,929	23.9	13,120	24.1	14,246	26.3	14,623	27.0	14,831	27.3	15,671	28.9
Other	1,787	3.3	1,740	3.2	1,746	3.3	1,204	2.2	1,342	2.5	1,860	3.4	1,902	3.5	1,909	3.5	2,205	4.1
Total	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**	**54,206**	**100**

[a] The managed marsh/wetlands habitat category includes the following land cover types: fresh emergent marsh, fresh emergent marsh (created), and seasonal wetland. The upland agriculture habitat category includes the following land cover types: alfalfa, grass hay, irrigated grassland, tomatoes, milo, safflower, sunflower, wheat, and other row and grain crops. The grassland habitat category includes the following land cover types: grassland (created), nonnative annual grassland, and ruderal. The fallow habitat category includes the following land cover types: fallow, fallow rice, and fallow row and grain crops. The developed habitat category includes the following land cover types: developed—low density, developed—high density, and disturbed/bare.

[b] In 2011, 586 acres of rice were erroneously mapped as developed—low density; acreages for both land cover types have been corrected in this report.

[c] Increase in grassland (created) due to conversion of disturbed/bare by SAFCA.

[d] In 2017, 10 acres of grass hay were erroneously mapped as grassland (created), and 15 acres of grassland (created) were mapped as grass hay. Acreages for both land cover types have been corrected in this report.

[e] In the 2019 annual report, orchard was erroneously included in this category; it has been corrected here.

Table 2-3. On-Reserve Extent (acres) of Mapped Land Cover Types, 2005–2022

Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Rice	1,671	1,529	1,715	1,849	2,136	2,059	1,930	2,200	2,273	2,205	2,442	2,344	1,820	2,262	2,000	2,344	2,606	1,526
Fallow	820	593	727	373	375	450	668	348	177	206	64	214	643	58	558	144	213	1,655
Alfalfa	106	106	150	150	204	127	126	259	204	348	348	348	143	143	88	161	335	437
Irrigated grassland	0	96	0	0	4	5	0	0	0	0	0	0	0	0	0	0	0	0
Grass hay	19	19	81	160	157	144	57	84	147	135	158	57	295[f]	356	145	241	136	196
Wheat	207	497	77	79	132	187	58	58	58	58	47	74	11	23	299	204	71	0
Milo	0	0	49	0	0	0	0	0	155	94	0	0	0	0	0	0	0	0
Tomatoes	0	0	55	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower	0	0	0	0	0	104	116	84	56	50	0	0	29	104	0	0	204	226
Safflower	0	0	0	0	104	0	68	11	0	0	0	23	41	0	0	0	0	0
Other row crops	10	157	279	472	26	32	27	6	27	0	37	59	132	127	28	23	58	0
Fresh emergent marsh (created)[a]	561	561	627	627	627	627	627	627	627	627	627	627	627	627	627	627	627	626
Fresh emergent marsh	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Seasonal wetland	6	6	4	4	4	4	3	3	4	4	4	4	4	4	4	4	3	3
Grassland (created)	47	76	76	72	72	72	71	72	72	73	73	73	67[f]	67	67	67	52	52
Nonnative annual grassland	318	225	254	254	254	254	254	228	226	226	226	203	203	203	203	203	204	204
Ruderal	38	33	29	29	29	28	25	25	25	36	36	36	47	47	42	44	34	34
Valley oak woodland	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5[g]	6	6
Riparian woodland	13	13	12	12	12	12	12	12	12	12	12	12	12	12	12	12	9	9
Riparian scrub	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Nonriparian woodland	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Open water	0	0	0	0	0	0	0	0	20[c]	20	20	20	20	20	20	20	22	22
Developed—low density	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Developed—high density	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Disturbed/bare	0	0	0	0	0	0	63[b]	47	11	0	0	0	0	0	0	0	0	10
Total[d]	**3,835**	**3,931**	**4,154**	**4,154**	**4,154**	**4,124[b]**	**4,124**	**4,082[b]**	**4,112[e]**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,593**	**5,052**

[a] The fresh emergent marsh (created) land cover type includes some, but not all, of the associated uplands for most, but not all, tracts with wetlands. When patches of associated uplands are smaller than the minimum mapping unit, they are included in the fresh emergent marsh (created) land cover type; when they are larger than the minimum mapping unit, they are mapped as the land cover type that characterizes them.
[b] Acreage change from previous years is due to the SAFCA NLIP.
[c] Completion of improvements to linear water conveyance features in the North Basin Reserve resulted in the change of 20 acres of disturbed/bare to open water habitat in 2013.
[d] Discrepancies between this total and the surveyed acreages are due to inclusion here of a 12-acre easement of the Sills tract and minor GIS rounding errors.
[e] Acreage increase is due to the acquisition of the Silva South 1 tract.
[f] In 2017 on the Atkinson tract, 10 acres of grass hay were erroneously mapped as grassland (created), and 15 acres of grassland (created) were mapped as grass hay. Acreages for both land cover types have been corrected in this report.
[g] Valley oaks were removed as a part of levee improvements and maintenance.

Table 2-4. On-Reserve Summary of Major Habitat Types, 2005–2022

Habitat Type	2005 Acres	2005 % of Reserve Lands	2006 Acres	2006 % of Reserve Lands	2007 Acres	2007 % of Reserve Lands	2008 Acres	2008 % of Reserve Lands	2009 Acres	2009 % of Reserve Lands	2010 Acres	2010 % of Reserve Lands
Rice	1,671	43.6	1,529	38.9	1,715	41.3	1,849	44.5	2,136	51.5	2,059	49.93
Managed marsh/ wetlands	569	14.8	569	14.4	631	15.2	631	15.2	631	15.2	631	15.2
Upland agriculture	342	8.9	875	22.3	691	16.7	916	22.1	627	15.1	594	14.4
Grassland	403	10.5	334	8.5	359	8.6	355	8.5	355	8.5	331	8.02
Fallow	820	21.4	593	15.1	727	17.5	373	9.0	375	9.0	450	10.9
Developed	5	0.1	5	0.1	5	0.1	5	0.1	5	0.1	5	0.1
Other	25	0.7	26	0.7	25	0.6	25	0.6	25	0.6	54	0.8
Total[c]	**3,835**	**100**	**3,931**	**100**	**4,154**	**100**	**4,154**	**100**	**4,154**	**100**	**4,124[b]**	**100**

Habitat Type	2011 Acres	2011 % of Reserve Lands	2012 Acres	2012 % of Reserve Lands	2013 Acres	2013 % of Reserve Lands	2014 Acres	2014 % of Reserve Lands	2015 Acres	2015 % of Reserve Lands	2016 Acres	2016 % of Reserve Lands
Rice	1,930	46.8	2,200	53.9	2,273	55.3	2,205	53.6	2,442	59.4	2,344.4	57.0
Managed marsh/ wetlands	630	15.3	631	15.4	631	15.3	630	15.3	630	15.3	630.1	15.3
Upland agriculture	452	11	502	12.3	647	15.7	591	14.4	591	14.4	560	13.6
Grassland	350	8.5	325	8.0	323	7.8	334	8.1	334	8.1	312	7.6
Fallow	668	16.2	348	8.5	177	4.3	206	5.0	64	1.5	214	5.2
Developed	68[b]	1.6	51	1.2	16	0.4	5	0.1	5	0.1	5	0.1
Other	26	0.6	25	0.6	45	1.1	140	3.4	46	1.1	46	1.1
Total[c]	**4,124**	**100**	**4,082[b]**	**100**	**4,112[d]**	**100**	**4,112**	**100**	**4,112**	**100**	**4,112**	**100**

Habitat Type	2017 Acres	2017 % of Reserve Lands	2018 Acres	2018 % of Reserve Lands	2019 Acres	2019 % of Reserve Lands	2020 Acres	2020 % of Reserve Lands	2021 Acres	2021 % of Reserve Lands	2022 Acres	2022 % of Reserve Lands
Rice	1,819.7	44.3	2,262.2	55.0	2,000.1	48.6	2,343.9	57.0	2,231	54.9	1,526	30.2
Managed marsh/ wetlands	630.1	15.3	630.1	15.3	630.1	15.3	630.1	15.3	626	15.4	626	12.4
Upland agriculture	651[e]	15.8	794	19.3	560.2	13.6	629.6	15.3	655	16.1	873	17.3
Grassland	317[e]	7.7	317	7.7	312	7.5	314.0	7.6	289	7.1	290	5.7
Fallow	643	15.6	58	1.4	558.0	13.6	144.0	3.5	213	5.2	1,674	33.1
Developed	5	0.1	5	0.1	5	0.1	5	0.1	5	0.1	16	0.3
Other	46	1.1	46[f]	1.1	46	1.1	44.9	1.1	44	1.1	47	0.9
Total[c]	**4,112**	**100**	**4,112**	**100**	**4,112**	**100**	**4,112**	**100**	**4,063**	**100**	**5,052**	**100**

[a] The fresh emergent marsh (created) land cover type includes some, but not all, of the associated uplands for most, but not all, tracts with wetlands. When patches of associated uplands are smaller than the minimum mapping unit, they are included in the fresh emergent marsh (created) land cover type; when they are larger than the minimum mapping unit, they are mapped as the land cover type that characterizes them.

[b] Acreage change from previous years is due to the SAFCA NLIP.

[c] Discrepancies between this total and the surveyed acreages are due to inclusion here of a 12-acre easement of the Sills tract and minor GIS rounding errors.

[d] Acreage increase is due to the acquisition of the Silva South 1 tract.

[e] "Other" acreage reported incorrectly as 0 acres in 2018; acreage fixed in this report.

[f] In 2017 on the Atkinson tract, 10 acres of grass hay were erroneously mapped as grassland (created) and 15 acres of grassland (created) were mapped as grass hay. Acreages for both land cover types have been corrected in this report.

Table 2-5a. On-Reserve Extent of Major Habitat Types as a Proportion of Each Habitat Type in the Basin, 2005–2014

	2005			2006			2007			2008			2009		
Habitat Type	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves
Rice	14,782	10.3	1,715	14,745	11.6	1,849	14,224	12.9	7.5	1,529	14,782	10.3	1,715	14,745	11.6
Managed marsh/ wetlands	834	68.2	631	936	67.3	631	1,157	54.5	69.6	569	834	68.2	631	936	67.3
Upland agriculture	6,462	13.5	691	7,919	8.7	916	8,293	11.0	4.5	875	6,462	13.5	691	7,919	8.7
Grassland	7,263	4.6	359	5,669	6.3	355	5,461	6.5	5.2	334	7,263	4.6	359	5,669	6.3
Fallow	10,101	5.9	727	10,035	7.2	373	10,076	3.7	50.5	593	10,101	5.9	727	10,035	7.2
Developed	13,531	0	5	13,817	0	5	13,826	0	0	5	13,531	0	5	13,817	0
Other	1,233	2.1	25	1,239	2	25	1,169	2.1	2	26	1,233	2.1	25	1,239	2
Total	**54,206**	**7.3**	**4,154**	**54,206**	**7.6**	**4,154**	**54,206**	**7.7**	**7.1**	**3,931**	**54,206**	**7.3**	**4,154**	**54,206**	**7.6**

	2010			2011			2012			2013			2014		
Habitat Type	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves
Rice	1,849	14,224	12.9	1,820	16,329	11.1	2,262	19,092	11.8	2,204.1	17,442	11.5	2,205	20,104	11.0
Managed marsh/ wetlands	631	1,157	54.5	630	1,311	48.1	630	1,311	48.1	630	1,311	48.1	630.1		48.1
Upland agriculture	916	8,293	11.0	651	11,089	5.9	794	11,782	6.7	560.2	10,488	5.3	629.6		6.8
Grassland	355	5,461	6.5	319	4,902	6.5	319	4252	7.5	312	4,193	7.4	314.0		7.8
Fallow	373	10,076	3.7	643	6,442	10.0	58	3,307	1.8	558	4,667	12.0	144.0		4.5
Developed	5	13,826	0	5	12,929	0.0	5	13,062	0.0	5	14,246	0.0	5		0.0
Other	25	1,169	2.1	46	1,204	3.8	46	1,399	0	46	1,860	2.5	44.9		3.2
Total	**4,154**	**54,206**	**7.7**	**4,112**	**54,206**	**7.6**	**4,112**	**54,206**	**7.6**	**4,112**	**54,206**	**7.6**	**4,112**	**54,206**	**7.6**

Table 2-5b. On-Reserve Extent of Major Habitat Types as a Proportion of Each Habitat Type in the Basin, 2015–2022

	2015			2016			2017			2018			2019			2020			2021			2022		
Habitat Type	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves
Rice	2,442	20,796	11.70%	2,344.40	20,482	11.4	1,820	2,606	2606	2,262	19,092	11.8	2,000.1	17,442	11.5	2,343.9	20,256	11.6	2,231	19,758	11.3	1,526	11,891	12.8
Managed marsh/wetlands	630	1,311	48.10%	630.1	1,311	48.1	630	630	630	630	1,311	48.1	630	1,311	48.1	630.1	1,311	48.1	626	1,468	42.6	626	1,455	43.0
Upland agriculture	591	11,771	5.00%	560	11,850	4.7	651 [g]	805	805	794	11,782	6.7	560.2	10,488	5.3	629.6	9,319	6.8	655	8,784	7.5	873	7,752	11.3
Grassland	334	4,344	7.70%	312	4,157	7.5	319 [g]	290	290	319	4252	7.5	312	4,193	7.4	314	4,043	7.8	289	4,041	7.2	290	5,418	5.4
Fallow	64	1,366	4.70%	214	1,712	12.5	643	213	213	58	3,307	1.8	558	4,667	12	144	3,234	4.5	213	3,414	6.2	1,674	9,813	17.1
Developed	5	12,878	0.00%	5	12,907	0	5	6	6	5	13,062	0	5	14,246	0	5	14,623	0	5	14,831	0	16	15,671	0.1
Other	46	1,740	2.60%	46	1,787	2.6	46	43	43	46	1,399	0	46	1,860	2.5	44.9	1,420.20	3.2	44	1,909	2.3	47	2,205	2.1
Total	**4,112**	**54,206**	**7.60%**	**4,112**	**54,206**	**7.6**	**4,112**	**4,593**	**4593**	**4,112**	**54,206**	**7.6**	**4,112**	**54,206**	**7.6**	**4,112**	**54,206**	**7.6**	**4,063**	**54,206**	**7.5**	**5,052**	**54,206**	**9.3**

Table 2-6. Noxious Weed Occurrences on TNBC Reserve Lands, 2005–2022

		Number and Degree of Occurrences																	
Reserve	Noxious Weed Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
North Basin Reserve																			
Atkinson	Edible fig	1, T	1, T	1, T	1, T	1, T	1, T	1, T	1, T	1, T	1, T	1, T	1, T	–	–	–	–	1, T	–
	Perennial pepperweed	3, M-H	3, M-H	1, M	1, M	1, M	–	–	–	–	–	–	–	–	–	–	2, L-M	2, T, H	–
	Himalayan blackberry	1, H	1, H	3, M-H	3, M	3, M-H	3, M	3, M	2, M	2, M	1, M	1, M	2, M	1, T	2, M	3, L-D	8, T-D	7, L-D	2, H-D
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L	1, M	–	–	–
	Bull thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	5, T-L	1, T	4, T-M	1, L	–
	Yellow star-thistle	–	–	–	–	2, L-M	2, L	1, L	2, L	3, L	1, L	3, L	4, L	2, T	2, T-H	3, T-M	–	–	2, L-M
	Harding grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	2, L-H
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6, M-D
Bennett North	Yellow star-thistle	1, L	1, L	1, L	–	–	1, L	2, M	1, L	1, T	–	1, T	1, L	–	1, T	5, T-M	–	–	3, M-H
	Bull thistle	–	–	–	–	–	1, L	–	1, L	2, T	3, T	2, T	1, T	1, T	–	–	–	–	–
	Harding grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	–
	Water primrose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10, L_H
	Himalayan blackberry	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3, L_M
	Black mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5, L-M
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8, L-H
	Edible fig	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
Bennett South	Bull thistle	–	–	–	–	–	–	–	2, L	–	–	1, L	–	1, T	2, T	–	–	1, T	1, L
	Edible Fig	–	–	–	–	–	3, M	–	–	–	–	–	–	–	2, T	–	–	–	–
	Perennial pepperweed	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L	–	–	–	–
	Yellow star-thistle	2, L-M	2, L-M	2, M	1, M	3, L	2, L-M	1, L-M	1, L	–	–	2, L	1, L-M	–	–	–	1, T	–	1, L
	Italian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, H	1, M
	Water primrose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5, L-D
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4, L-M
Bolen North	Perennial pepperweed	1, M	1,L	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Himalayan blackberry	1, T	1,T	–	–	–	–	–	–	–	–	–	–	–	–	–	1, D	1, L	1, L
	Yellow star-thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	1-L	6, T-M	3, T-L	–	3, M-H
	Bull thistle	–	–	–	–	–	3, L	2, L	2, L	1, T	2, T	1, T	3, T	–	3, T-L	–	–	5, T-M	–
	Italian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M	–
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	–
	Black mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3, L-M
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8, L-H
	Edible fig	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
	Water primrose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10, L-H
Bolen South	Himalayan blackberry	5, L-H	5, L	–	–	–	2, M	2, M	–	–	–	–	–	3, T-L	1, M	–	–	1, D	2, D
	Perennial pepperweed	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M	–	–	–	–
	Bull thistle	–	–	2, L	2,L	2, L	–	–	1, L	2, L	–	1, L	1, L	–	–	–	–	4, T-L	–
	Harding grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M	–
Bolen West	Bull thistle	–	–	–	–	–	1, M	–	1, L	–	1, T	2, T	–	–	–	6, T-M	–	4, L-M	–
	Yellow star thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, T	–	4, L-M
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, T	–	9, L-H
	Italian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, L-M	1, L
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L
	Himalayan blackberry	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
	Russian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
Frazer	Bull thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	1, T	2, T	2, T-L
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	3, L-T	4, T	4, T-M
	Yellow star-thistle	1, H	2, L-H	4, M-L	4, M-L	5, M-L	4, M	1, L	3, L	2, T	3, M	3, L	2, L-M	2, L-M	–	1, T	–	–	2, M
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12, T-M
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M	6, T-M	4, L-M
	Harding grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, L-M	–
Huffman East	Yellow star-thistle	7, L-H	7, L-M	–	–	3, L	2, M-L	3, M-L	1, L	1, L	–	1, T	1, L	–	1, M	2, T-M	2, T	6, T-M	2, M-H
	Himalayan blackberry	1, M	1, M	–	–	–	–	1, M	–	–	–	–	–	2, T	–	–	–	–	-
	Bull thistle	–	–	2, T	3, T	3, T	–	–	1,L	–	2, T	–	1, L	–	–	–	–	–	–
	Water primrose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, M-D
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, L-M
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	–	6, L-H
Huffman West	Yellow star-thistle	–	–	–	–	–	1, L	1, L	2, L	3, T	-	2, L	4, T	–	–	–	2, T	1, T	–
	Sweet fennel	2, T	2, T	–	–	1, T	–	–	–	–	–	–	–	–	–	–	–	–	–
	Himalayan blackberry	–	–	1, H	1, H	1, M	2, M	–	–	–	–	–	–	1, T	–	–	–	–	–
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	–	–

Table 2-6. Continued

Reserve	Noxious Weed Species	Number and Degree of Occurrences																	
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Lucich North	Yellow star-thistle	10, L-H	10, L-H	5, L-M	2, L	4, L-M	3, L	–	1, L	4, L	3, L	2, L	5, L	3, L-M	–	1, M	–	1, H	–
	Perennial pepperweed	3, H	3, H	1, T	1, T	1, T	1, T	–	–	–	–	–	–	–	3, L-D	3, L-M	–	2, L, H	–
	Bull thistle	–	–	4, T-H	4, T-H	3, T-H	2, T	–	1, T	1, T	4, T	3, L-M	2, T	–	49, T-D	25-T-M	12, T-L	12, T-H	10, T-H
	Edible fig	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	1, T	1, L	2, T	–
	Pennyroyal	–	–	–	–	–	–	1, M	1, M	1, M	1, M	1, M	1, M	2, T-L	–	–	–	–	2, T-M
	Italian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	–	1, L	–
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10, T-M	1, T	5, T-L	1, M
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6, T-D	17, T-M	21, L-H
	Water primrose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3, M-H
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, M-H
	Harding grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, H	–
Lucich South	Yellow star-thistle	3, M	3, M	9, T-H	4, T-H	4, T-M	3, L	1, L	1, T	2, T	3, T	2, M	4, T-M	–	8, M-D	9, T-D	6, T-D	11, T-M	10, L-H
	Bull thistle	1, T	–	1, H	2, L-M	2, L-M	2, L-M	3, L-M	2, L	1, T	–	2, L	3, L-M	–	1, T	–	–	–	-
	Italian thistle	–	–	1, L	1, L	1, L	1, L	1, L	–	–	–	1, L	2, L	–	–	–	–	–	1, M
	Water primrose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8, L-H
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
Nestor	Bull thistle	–	–	–	–	–	–	1, L	–	–	–	–	1, T	–	–	–	–	–	–
	Yellow star-thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L	–	–	–	5, L-M
	Himalayan blackberry	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M	–	–
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3, L-M
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6, L-H
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
Ruby Ranch	Yellow star-thistle	1, T	1, T	–	–	1, L	–	1, L	–	1, T	–	1, L	2, T	–	–	–	–	–	3, L-M
	Italian thistle	–	–	1, H	1, H	1, M	–	–	–	–	–	1, T	–	–	–	–	–	–	1, M
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3, L-M
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
	Medusahead	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
Verona	Yellow star-thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	–
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4, M-H
	Bull thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, L-H
	Italian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L
	Puncture vine	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
	Black mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, M-H
	Wild radish	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, H
Vestal	Yellow star-thistle	–	3, T	–	–	–	3, L-M	2, L-M	2, L	3, T	2, T	1, L	3, T	1, T	1, L	2, T-M	2, T	–	4, L-M
	Himalayan blackberry	–	–	1, M	1, M	1, M	–	–	–	–	–	–	–	1, T	–	–	–	–	1, H
	Bull thistle	–	–	–	–	–	2, L	3, L	1, L	2, T	–	1, L	2, L	–	–	–	–	–	–
	Edible fig	–	–	1, L	1, L	1, L	1, L	1, L	1, L	1, L	1, L	1, L	1, L	1, L	–	–	–	–	1, H
	Water primrose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, D
	Tree of Heaven	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, M
Willey	Bull thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M	–
Central Basin Reserve																			
Betts-Kismat-Silva	Bull thistle	–	–	–	–	2, T	1, T	–	–	1, T	2, T	1, T	2, T	1, T	6, T-D	2, T	8, T-L	4, T-L	–
	Yellow star-thistle	L-H	L-H	7, T-H	5, T-L	5, T-L	–	–	–	–	–	2, T	1, T	–	–	–	–	–	–
	Perennial pepperweed	T	T	1, H	1, L	2, T-L	–	–	5, T-M	–	–	–	–	–	1, M	–	–	1	–
	Giant reed	L	L	L	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Italian thistle	1, T	–	–	–	–	–	–	–	–	–	–	–	–	2, T-L	1, T	–	1, T	2, M
	Pennyroyal	L-M	L-M	–	–	–	2, M	2, M	1, M	1, M	2, M	1, M	1, M	1, T	7, T-L	6, T-M	11, T-L	8, T-M	–
	Catalpa	One tree	One tree	One tree	One tree	One tree	One tree	One tree	One tree	One tree	One tree	One tree	One tree	One tree	One tree	One tree	One tree	–	–
	Tree-of-heaven	1, M	1, M	–	1, H	1, H	–	–	–	–	–	–	–	–	–	–	–	–	–
	Himalayan blackberry	D	D	3, M-H	3, M-H	3, M-H	2, M	2, M	–	–	–	–	–	–	–	–	–	–	1, L
	Edible fig	–	–	1, M	2, M	2, M	2, M	2, M	1, M	1, M	1, M	1, M	1, M	–	–	–	–	–	–
	Small smutgrass	–	–	–	–	–	1,T	–	–	–	–	–	–	–	–	–	–	–	–
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	9, L-M	10, L-M	7, T-D	31, T-M	35, T-H	8, L-M
	Licorice	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M	2, L, H	–
	Harding grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L	1, H
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4, L-M
	Water primrose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11, M-H
	Medusahead	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5, H-D
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, M

Table 2-6. Continued

		Number and Degree of Occurrences																	
Reserve	Noxious Weed Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Bianchi West[b]	Harding grass[b]	–	–	–	–	–	3, L	2, L	2, L	1, L	2,L	–	–	–	–	–	–	–	–
	Yellow star-thistle	–	–	–	–	–	1, M	2, L	1, L	1, T	–	1, T	2, T	–	3, T-L	–	4, L-H	–	2, M-H
Elsie	Yellow star-thistle	–	–	–	–	–	–	2, T	1, M	2, T	–	2, T	1, T	–	–	–	–	–	1, M
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	–	1, H
Frazer South	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, T-L	1, T	–	1, M
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, M
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
	Italian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
Sills	Yellow star-thistle	–	–	1, M	1, M	2, L	1, L	2, L	1, M	2, T	–	1, T	2, T	–	4, L-T	6, T-D	2, L-H	–	16, T-H
	Bull thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	–	1, L
	Water primrose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, H
	Italian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, H
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5, L-H
	Black mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, H
	Purple top vervain	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, H
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
Tufts	Yellow star-thistle	1, M	1, M	–	–	–	–	–	–	–	–	1, M	–	–	–	–	–	–	2, L-H
Fisherman's Lake Reserve																			
Alleghany	Sweet fennel	1, T	1, T	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Edible fig	1, T	1, T	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Himalayan blackberry	1, D	1, D	2, M-H	2, L-M	2, L-M	3, L-M	2, M	2, M	1, M	2, T	2, M	1, M	2, M-H	1, L	1, L	–	–	–
	Harding grass[b]	–	–	1, L	1, L	1, L	–	–	–	–	–	–	–	–	–	–	–	–	3, M-H
	Bull thistle	–	–	1, L	1, L	1, L	2, L	1, L	2, L	1, T	2, T	–	–	–	–	–	–	–	–
	Italian thistle	–	–	2, L	2, T-L	1, L	–	–	–	1, T	–	–	1, L	–	–	–	–	1, L	–
	Yellow star-thistle	–	–	–	–	–	1, L	1, L	2, L	2, T	–	3, L	2, T	–	–	–	–	–	–
	Tree of Heaven	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2, M	–	–
	Black mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, H
	Shortpod mustard	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, H
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, H
Cummings	Himalayan blackberry	1, M	1, M	1, M	1, M	1, M	1, M	1, M	–	–	1, T	1, M	1, L	2, T	–	–	–	–	–
	Sweet fennel	1, T	1, T	–	–	1, T	–	–	–	–	–	–	–	–	–	–	–	–	–
	Perennial pepperweed	1, L-M	1, L	–	–	–	–	–	1, M	–	–	–	–	–	1, T	1, T	–	–	–
	Pampas grass	–	–	1, L	1, L	1, L	–	–	1, M	1, M	–	–	–	–	–	–	–	–	–
	Italian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L	–	–	–	1, L
	Bull thistle	–	–	–	–	–	–	–	–	1, T	2, M	3, L	1, T	–	–	5, L-T	1, T	–	3, M-H
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	–	–	–
	Harding grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3, L-M	I, L	4, L-H
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, H
	Tree of Heaven	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3, M	–	–
Natomas Farms	Sweet fennel	1, L	1, L	–	1, T	1, T	1, T	–	–	–	–	–	–	–	–	–	–	–	–
	Himalayan blackberry	1, M	1, L	1, L	1, L	1, L	1, L	–	2, L	1, L	1, T	2, L	1, T	1, L	–	–	–	1, D	–
	Edible fig	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L	–	–	–	–
	Bull thistle	–	–	–	–	–	–	–	–	–	–	–	–	1, T	3, L-D	3, T-D	6, T-D	2, M	3, T-M
	Italian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, M
	Harding grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10, L-M	9, T-M	13, M-H
Rosa	Himalayan blackberry	5, L-D	5, L-M	5, M-D	4, M-D	4, M	6, L-M	4, L-M	7, L-M	5, L-M	6, L-M	4, L-M	5, L-M	2, T-M	2, L	1, M	2, T-M	2, H-D	3, L-H
	Perennial pepperweed	3, T-M	3, T-L	4, T-H	4, T-H	4, T-M	3, L-M	2, L-M	6, T-M	2, T	1, T	2, T	1, T	1, M	1, H	–	–	–	–
	Sweet fennel	1, L	1, L	3, T	3, T	3, T	1, M	1, M	–	–	–	–	–	–	–	–	–	–	–
	Poison hemlock	1, H	1, M	–	–	–	–	–	1, T	1, T	–	–	–	–	–	–	–	–	–
	Bull thistle	–	–	3, L-M	4, T-L	3, T-L	5, L-M	4, L	1, M	2, M	3, T	4, T	3, L	–	1, T	–	1, T	–	–
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, T	–	–
	Harding grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L	4, L-H
	Tree of Heaven	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L	8, L-H
	Water primrose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, D
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14, L-H
	Italian thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3, M-H

Table 2-6. Continued

		Number and Degree of Occurrences																	
Reserve	Noxious Weed Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Souza	English ivy	1, D	1, M	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Himalayan blackberry	–	–	1, L	1, L	1, L	–	–	–	–	–	–	–	1, H	2, L-M	–	–	–	3, M-H
	Bull thistle	–	–	1, L	1, L	1, L	1, L	–	1, L	2, L	3, T	–	2, T	–	–	–	–	–	–
	Harding grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L	–	3, M-H
	Milk thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5, L-H
	Stinkwort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1, L

[a] Occurrences reflect the number of occurrences on each tract followed by the level of infestation, as shown below:

- T = Trace (rare): less than 1% cover.
- L = Low (occasional plants): 1–5% cover.
- M = Moderate (scattered plants): 5–25% cover.
- H = High (fairly dense): 25–75% cover.
- D = Dense (dominant): more than 75% cover.

[b] Harding grass was not tracked in 2018 and 2019 because the species did not demonstrate an invasive distribution in the reserves. After several more occurrences were detected in 2020, vegetation monitoring efforts resumed tracking Harding grass.

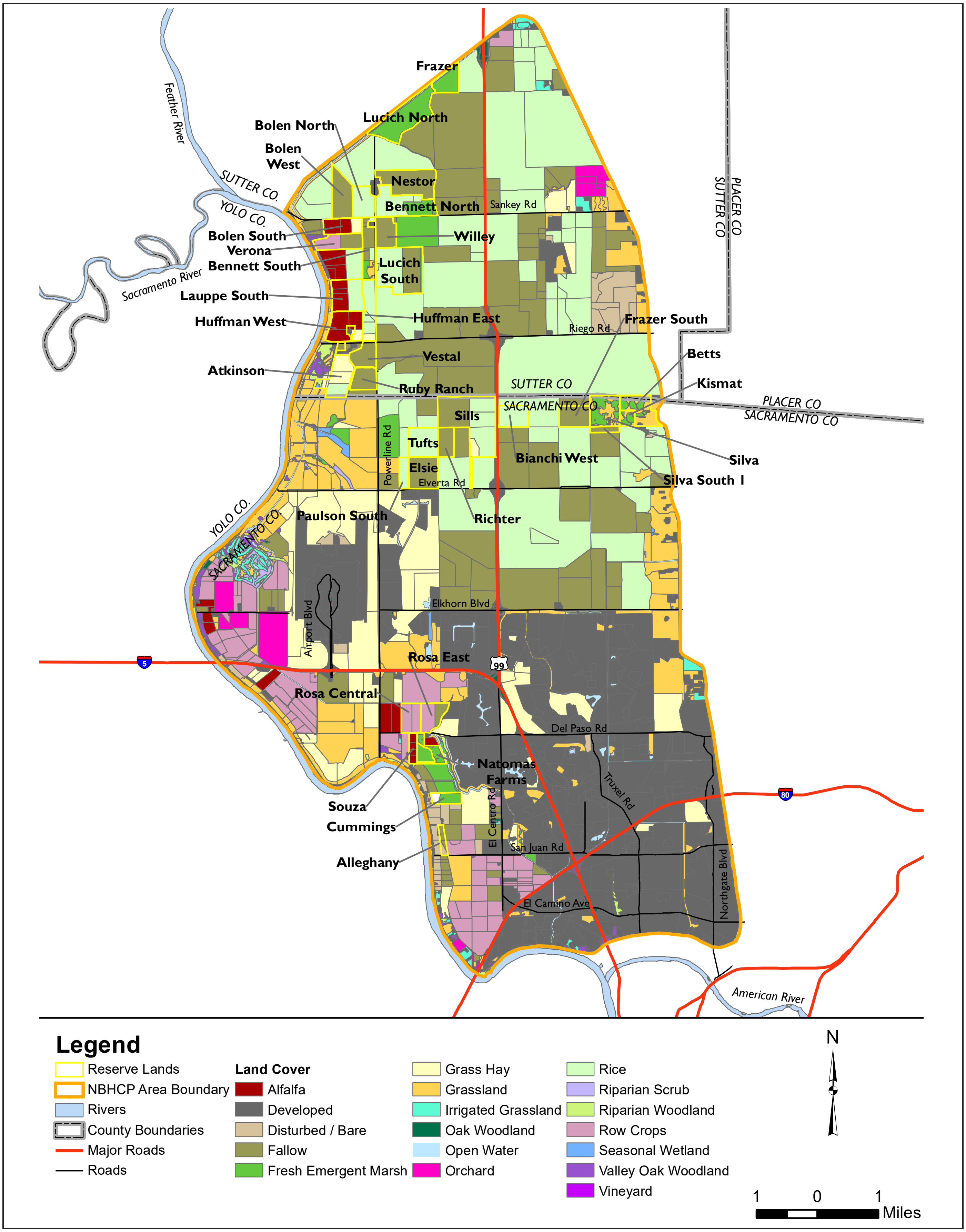

FIGURE 2-1

Distribution of Land Cover Types in the Natomas Basin, 2022

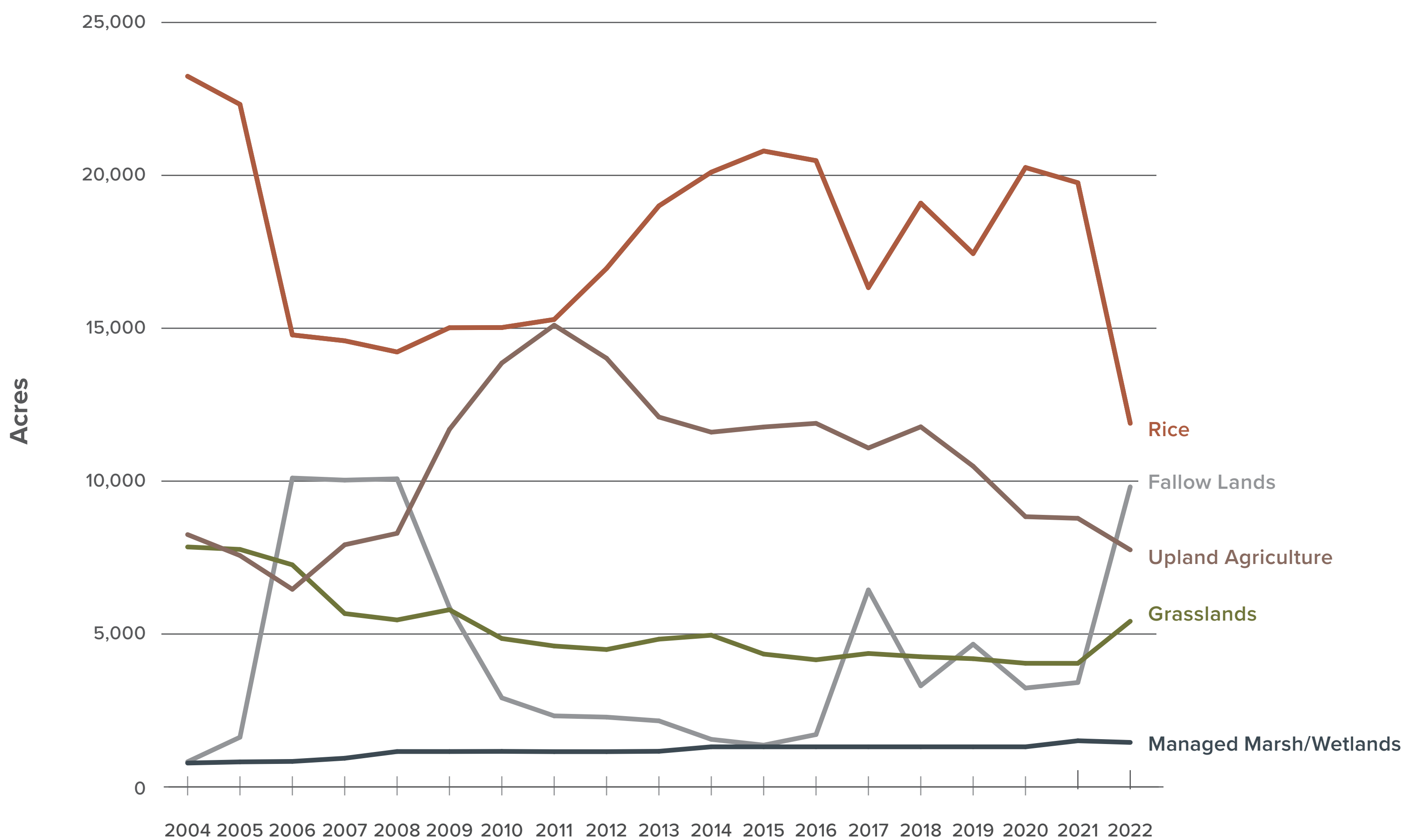

FIGURE 2-2

Changes in Acreage of the Major Habitat Types in the Natomas Basin, 2004–2022

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Chapter 3
Giant Gartersnake

CHAPTER HIGHLIGHTS

- Sampling effort in 2022 was comparable to 2021 and higher than in 2020, but was reduced overall compared to 2011–2019.
- The trapping season (May–August) and sampling period (21 days) has been consistent since 2021. The number of sites sampled was comparable, from 40 in 2020, 45 in 2021, and 41 in 2022.
- Catch-per-unit of effort decreased from 2021 to 2022. The size distribution of captured snakes in 2022 was consistent with a healthy population. Estimates of occupancy increased between 2021 and 2022, although the probability that the proportion of occupied sites was stable (i.e., did not change by more than 10%) from 2011 to 2022 was approximately 99%.
- Apparent survival of giant gartersnakes at BKS was higher from 2018–2019 than in subsequent years.
- Giant gartersnake populations throughout the Basin and on reserve lands would likely benefit from: (1) creating more managed marsh; (2) increasing the amount of emergent tule vegetation in existing marshes (e.g., Cummings, Natomas Farms, and Lucich South); (3) flooding up existing marshes earlier in the season (early spring); (4) maintaining rice agriculture; and (5) continued research into conservation actions such as translocation and habitat and water management, that target giant gartersnake.

3.1 Introduction

3.1.1 Background

The NBHCP (City of Sacramento et al. 2003) and its Implementing Agreement require an annual assessment of giant gartersnake populations within the Natomas Basin (Chapter VI, Section E [2][a][2] of the 2003 NBHCP). The NBHCP also requires an assessment of habitat connectivity for giant gartersnake within and between reserves. This chapter addresses these requirements.

Studies from 2001 through 2003 focused on the distribution of giant gartersnake in the Natomas Basin (Wylie et al. 2003:21). Subsequent surveys attempted to assess population trends across a broad array of habitats and geographic areas, but detection probabilities were too low and the range of environmental conditions too variable to allow for estimation of abundance that accounted for variable detection probabilities. In 2011, the study was redesigned to increase sample sizes and account for the detection and capture process in a more statistically rigorous and defensible manner. In 2018, the study design was further revised to take advantage of advances in analytical methods for wildlife populations and knowledge gained about giant gartersnake since 2011. The 2018 revision allows for estimation of giant gartersnake occupancy, abundance, and demographic parameters from a larger sample of sites throughout the Natomas Basin and increases the efficiency of sampling and the ability to estimate the effects of management actions on giant gartersnake.

3.1.2 Goals and Objectives

Monitoring protocol revisions implemented in 2011 were designed to assess progress toward achieving the goals of the NBHCP. In particular, the revised protocol was designed to meet the following objectives.

- Examine the demography of giant gartersnake populations at a larger sample of locations within the Natomas Basin, with an emphasis on measuring abundance and estimating survival, recruitment, and population growth rate.
- Quantify the effects of management practices on giant gartersnake demography to promote positive population growth.
- Examine the distribution of giant gartersnake on TNBC reserves, with an emphasis on evaluating evidence for trends in the proportion of reserves occupied, and quantify environmental variables associated with the occurrence of giant gartersnake.

The 2018 revisions to the study design were designed to better meet the objectives outlined above. Changes included removing the “demography” traplines and implementing an occupancy and abundance sampling approach throughout the Basin. The sampling period at each sampling site was also extended to 21–29 days (this was modified in 2020 due to the COVID-19 pandemic but was resumed in 2021, as described further in Section 3.2.1, *Trapping Giant Gartersnake*), allowing for enough recaptures in many cases to estimate abundance and demographic rates at more sites throughout the Basin. In cases where adjacent or nearly adjacent wetland units or rice canals are sampled, the information from those traplines can be combined, resulting in more precise estimates of abundance and demographic rates and increasing the probability of recapture because a larger area is being sampled. By increasing sample sizes, the new design also allows for better inferences about the effect of habitat on giant gartersnake and the effects of management actions.

However, the change in sampling design precludes comparison of results from previous years under the old sampling design. Accordingly, it is not possible to track changes in abundance or demographic rates from years prior to 2019.

The purpose of monitoring giant gartersnake demography is to determine the abundance, apparent survival (the probability of surviving and remaining in the sampled area from 1 year to the next), recruitment (the rate at which individuals are born in the sampled area [and survive their first year] or migrate to the sampled area), and population growth rate of giant gartersnake at occupied sites in the Natomas Basin. The management goal with respect to demography is to maintain stable or positive population growth.

The purposes of monitoring the distribution of giant gartersnake on TNBC reserve lands are to determine what proportion of sites within reserve lands are occupied, to determine what variables correlate with the probability that a site is occupied, and ultimately to calculate trends in occurrence probability. The management goal with respect to occupancy is to maintain a stable or increasing trend in the probability of occurrence throughout the reserve system.

3.1.3 Life History

Giant gartersnake (Figure 3-1) is a large aquatic gartersnake endemic to wetlands in California’s Central Valley. It was first described in the southern San Joaquin Valley by Fitch (1940) as a subspecies of the aquatic gartersnake (at that time, *Thamnophis ordinoides*). Further taxonomic revisions resulted in the consideration of giant gartersnake as a subspecies of Sierra gartersnake (*Thamnophis couchii*). Because giant gartersnake is morphologically distinguishable from and allopatric with its most closely related species, aquatic gartersnake (*Thamnophis atratus*) and Sierra gartersnake, it was recognized as a full species in 1987 (Rossman and Stewart 1987).

Giant gartersnake is highly aquatic and historically occurred in marshes, sloughs, and other habitats with slow-moving, relatively warm water and emergent vegetation, especially tules. Although conversion of wetlands to agriculture has nearly extirpated giant gartersnake from the San Joaquin Valley, this species persists in rice fields and nearby agricultural canals in the Sacramento Valley (Halstead et al. 2010). Canals associated with rice agriculture can provide marsh-like habitat conditions throughout the giant gartersnake active season—late March through early October (Wylie et al. 2009)—and rice fields themselves are emergent wetlands for a portion of the giant gartersnake active season. The quality of rice habitats relative to natural or restored marshes is an area of active research. Recent work has shown that although giant gartersnake does not spend much time in rice fields compared to irrigation canals, snakes have higher survival when inhabiting areas with more active rice fields surrounding them (Halstead et al. 2019).

Giant gartersnake feeds primarily on small fish, frogs, and tadpoles (Rossman et al. 1996). Specific prey items may include tadpoles and small adults of American bullfrog (*Lithobates catesbeianus*) and tadpoles and adults of Sierran treefrog (*Pseudacris Sierra*). Fish prey items include mosquitofish (*Gambusia affinis*) and small cyprinid and centrarchid fishes. Little is known about the diet of juvenile giant gartersnake, but neonates preferred tadpoles to fish in laboratory feeding trials (Ersan et al. 2020a, b).

Giant gartersnake is the longest gartersnake (Rossman et al. 1996), and like many snakes within its genus, it is sexually dimorphic for size, with females as the larger sex (Wylie et al. 2010). Smaller giant gartersnakes grow more rapidly than larger giant gartersnakes (Coates et al. 2009; Rose et al. 2018d). Males and females exhibit differing patterns of seasonal growth, with males forgoing foraging (and growth) for reproductive opportunities in the early spring (Coates et al. 2009). Similarly, male body condition is much lower than female body condition during the spring mating season, but males and females enter hibernation in similar condition (Coates et al. 2009). Body condition might be related to the thermal ecology of giant gartersnake. Female giant gartersnakes exhibit elevated body temperatures during June, July, and August (Wylie et al. 2009), which is the period during which they are gravid. In contrast, males elevate body temperature in the winter and early spring (Wylie et al. 2009), likely to prepare for the spring mating season. The elevated body temperature of male snakes might be metabolically costly, causing decreased body condition for them in spring.

Although some aspects of giant gartersnake demography remain elusive, detailed study of populations in the Sacramento Valley has yielded some insight into the population ecology of giant gartersnake. Giant gartersnakes in the Sacramento Valley tend to produce smaller litters than those historically observed in the San Joaquin Valley. In the San Joaquin Valley, mean litter size was 23 (Hansen and Hansen 1990). In the Sacramento Valley, mean litter size was 17 (95% credible interval[1] = 13–21) based on females captured from 1995 to 1997 (Halstead et al. 2011a) and 16 (range = 5–35) based on females examined from 2013 to 2016 (Rose et al. 2018a). Mean parturition date in the Sacramento Valley was August 13, although parturition can occur from early July through

[1] *Credible intervals* are the Bayesian equivalent of confidence intervals in traditional frequentist statistics. All ranges reported in this chapter represent 95% credible intervals.

early October (Halstead et al. 2011a). Neonates in the Sacramento Valley are born at approximately 209 millimeters (mm) snout–vent length (SVL) with a mass of 4.9 grams (g) (Halstead et al. 2011a). Litter size varies temporally, potentially with resources, and larger females produce more, rather than larger, offspring (Halstead et al. 2011a; Rose et al. 2018a).

Survival of adult female giant gartersnakes in the Sacramento Valley varies among sites, years, and conditions. The annual survival probability of adult females greater than 180 g was 0.61 (0.41–0.79) at an average site in an average year (Halstead et al. 2012). Individuals are at 2.6 (1.1–11.1) times greater daily risk of mortality when in aquatic habitats than in terrestrial habitats (Halstead et al. 2012), likely because most terrestrial locations consist of subterranean refuges. The effect of linear habitats on daily risk of mortality varied with context: in rice agricultural systems, daily risk of mortality was lower in canals than away from canals, but in systems with natural or restored marshes, risk of mortality was lower in these two-dimensional habitats than in simple linear canals (Halstead et al. 2012). Overall survival was greatest in a site with a relatively large network of restored marshes (Halstead et al. 2012). A recent capture-mark-recapture (CMR) study found survival of giant gartersnake is also positively related to SVL up to peak, after which survival likely plateaus for the largest individuals (Rose et al. 2018b). This study also found a positive relationship between snake survival and the cover of emergent vegetation at a site (up to approximately 40% emergent vegetation cover; Rose et al. 2018b). Giant gartersnake population growth is highly dependent on the survival rate of adult females (Rose et al. 2019); therefore, fostering wetland characteristics that support high adult female survival is important for population persistence.

Abundance, density, and body condition of giant gartersnake vary by site, presumably as a result of site differences in habitat. Abundances and densities were greatest at a natural wetland, lower in a natural wetland modified for agricultural uses, lower still in rice agriculture, and lowest in seasonal marshes managed for waterfowl (moist soil management in summer, flooded in winter; Wylie et al. 2010). Body condition of females followed a similar pattern (Wylie et al. 2010). Habitats that most closely approximate natural marshes are therefore most likely to support dense populations of healthy giant gartersnakes.

The historical range of giant gartersnake extended from Butte County in the north to Kern County in the south (Fitch 1940; Hansen and Brode 1980). The draining of wetlands and subsequent urban and agricultural development have contributed to the loss of over 95% of giant gartersnake's original habitat (Frayer et al. 1989). The few remaining natural wetlands are fragmented, the natural cycle of seasonal valley flooding by high Sierra Nevada snowmelt has been limited, and the waters have been diverted by a network of dams and levees. As a result, giant gartersnake populations have become fragmented with only small, isolated populations remaining in the San Joaquin Valley. These factors precipitated the listing of giant gartersnake by the State of California (California Department of Fish and Game Commission 1971) and later by the U.S. Fish and Wildlife Service as a threatened species with a recovery priority designation of 2C: full species, high degree of threat, and high recovery potential (U.S. Fish and Wildlife Service 1993, 1999). The recovery of giant gartersnake will require the restoration and protection of marsh habitats, a reliable supply of water to these habitats throughout the year, and further research into the most effective conservation practices for this species.

3.1.4 History of the Natomas Basin

The lands of the Natomas Basin were historically subject to frequent flooding events because of the Basin's proximity to the American and Sacramento Rivers. Situated just north of the confluence of these major river systems, the Natomas Basin was characterized by abundant marshlands, small streams, and a mixture of riparian, oak woodland, and grassland vegetation. The presently available information about the historical range of giant gartersnake indicates that the Natomas Basin would have been within the distribution of giant gartersnake and was likely home to an abundant population.

3.2 Methods

3.2.1 Trapping Giant Gartersnake

All aspects of the giant gartersnake monitoring effort involve using trap transects composed of floating galvanized minnow traps (Casazza et al. 2000) for capture. Beginning in 2012, traps were modified to contain one-way valves constructed from cable ties placed in the small opening of the funnels. Beginning in 2013, traps were also modified to include two pieces of hardware cloth attached to each end of the funnel using zip ties (Halstead et al. 2013a). These modifications help to direct snakes moving along the edge of a habitat into the trap and keep the snake within the trap, thus increasing capture probability.

Giant gartersnake occurrence and demography were monitored at 60 sites in 2018 and 2019, 40 sites in 2020, 45 sites in 2021, and 41 sites in 2022. Between 2020 and 2022, we dealt with substantial challenges caused by the COVID-19 pandemic. In 2022, we faced additional obstacles such as heat waves and drought that caused low water levels and high water temperatures. The start date of our field season was delayed to train all technicians on a rigorous safety protocol that prioritized the health of our technicians and the public. Although our season was safe and successful, the protocols added time constraints to our already delayed season. Like the previous year, in 2022 we were able to continue the 21-day sampling periods as opposed to the 14-day period in 2020, but some traplines had to be pulled early due to low water level or high water temperature. Despite these caveats, our total number of sampled sites 2022 was higher than in 2020, although still lower than the number sampled in 2018, 2019, and 2021. We selected which sites to sample using a Generalized Random Tessellation Stratified approach to ensure a random, spatially dispersed sample (Table 3-1; Figure 3-2). Random selection of sites allows inference to TNBC reserves as a whole. Sampled sites consisted of individual wetland units (defined as being contained within water control structures) and canals adjacent to rice, and the selection of sampled sites was stratified by reserve area (22 sites in the North Basin Reserve, 11 sites in the Central Basin Reserve, and eight sites in the Fisherman's Lake Reserve) to ensure adequate representation of each reserve. At each site, one transect of 50 traps was deployed, with traps spaced approximately 10–20 meters apart. In 2022, trap transects were deployed for approximately 14–21 days each, from as early as possible in the active season, after we determined field work could proceed safely (beginning May 2, 2022), until August 31, 2022. Sampling did not take place on Memorial Day, Juneteenth Independence Day, and Independence Day.

For sites that were sampled as "occupancy traplines" in previous years, transects were generally placed in the same location in 2022; this approach maintains the same extent of sampling to provide inference about giant gartersnake occurrence to the same areas. However, at the five "demography sites" on the BKS, Lucich North, Lucich South, Natomas Farms, and Sills tracts, sampling from 2018 to 2022 differed from the areas sampled from 2011 to 2017. From 2011 to 2017, three transects were sampled at each demography site each year. In 2018 and 2019 at the BKS tract, all three "old" demography traplines were sampled, along with an additional five traplines placed in other wetland units, while beginning in 2020 only two "old" demography traplines (BKS 2 and 3) were sampled, along with three of the additional traplines sampled in 2018 and 2019. These same five traplines sampled at BKS in 2020 were also sampled in 2021 and 2022, with the exception of one of the additional traplines, which was not sampled in 2021 (only four BKS traplines were sampled in 2021). At Lucich North, only one of the three "old" demography traplines (Lucich North 4) has been sampled during the past five years, however seven additional traplines were added to wetlands at this tract in 2018. Lucich North 4 was sampled in 2018, 2019, 2020, and 2022, but was not sampled in 2021. The seven additional traplines added at Lucich North in 2018 were all sampled in 2018 and 2019, six were sampled in 2020 and 2022, and four were sampled in 2021. Within Lucich South, one of the three "old" demography traplines (Lucich South 3) was sampled each year from 2018–2022, and two additional traplines were added to canals in 2018. Of these two additional canal traplines, both were sampled in 2018, 2019, and 2022, while only one was sampled in 2020 and 2021. At the Natomas Farms tract, one "old" demography trapline (Natomas Farms 1) was sampled each year from 2018–2020, three "old" demography traplines (Natomas Farms 1, 2, and 3) were sampled in 2021, and two "old" demography traplines (Natomas Farms 1 and 2) were sampled in 2022. In addition to these "old" demography traplines, one additional wetland trapline was sampled at Natomas Farms in 2018, 2019, 2021, and 2022. At the Sills tract, two "old" demography traplines (Sills 2 and 3) were sampled in 2018 and 2019 while no "old" demography traplines were sampled from 2020–2022. However, three additional traplines were added to canals at Sills in 2018 and all three were sampled each year from 2018–2022. These changes made to our study's sampling methods allowed us to survey a broader area at most of the "old" demography sites (except in 2020 when the entire study was truncated); however, they also meant that some areas that were sampled from 2011–2017 were not covered by trap arrays from 2018–2020. As noted above, these changes present ramifications for modeling giant gartersnake demography and interpreting changes in abundance estimates, as described below in Section 3.2.2, *Analytical Methods.*

Trap transects were positioned along the banks, at the edges of emergent vegetation in wetlands, or along the edges of canals because giant gartersnake forages along habitat edges. Habitat edges also act as natural drift fences that direct snake movement to traps. While deployed, traps were checked daily.

Environmental conditions relevant to giant gartersnake behavior were monitored daily at each trap transect including water temperatures, air temperatures, and fluctuations in water level. To obtain a measure of the relative abundance and diversity of potential local aquatic prey, contents of every fifth trap were recorded and then all contents were removed. All other traps were monitored, but prey items such as fish, tadpoles, and small frogs were left in the traps so that they became naturally "baited" over time. In some instances, large fluctuations in water level (draining of wetlands, canals, or ditches) necessitated opening traps temporarily or relocating transects to a suitable nearby location within the selected site.

Universal Transverse Mercator (UTM) coordinates of all trap locations were recorded and vegetation and habitat surveys conducted at points within and adjacent to each trap transect. Percent cover of habitat types (water, submerged aquatic vegetation, floating aquatic vegetation, emergent vegetation, terrestrial vegetation, rock, or bare ground) and vegetative composition (species or higher taxonomic category) was estimated within a 0.5-meter radius of every fifth trap. Associated with each habitat and vegetation survey along the transect, a point to the left (odd-numbered traps) or right (even-numbered traps) of the transect was selected at a random perpendicular distance of 2–5 meters, and percent cover of habitats and vegetative composition was estimated within a 1-meter radius of this point to better characterize habitat surrounding the traps.

Each captured giant gartersnake was measured, sexed, and uniquely marked. Scale measurements in Rossman et al. (1996) were used to verify the species of each captured gartersnake. The SVL and tail-vent length (TVL) of each individual were measured to the nearest millimeter, and each individual was weighed to the nearest gram. The sex of each individual was determined by probing the cloaca to detect the presence or absence of hemipenes. After examination, each individual that showed no sign of previous capture was given a unique brand on its ventral scutes (Winne et al. 2006) and, if large enough (>35 grams), implanted with a passive integrated transponder (PIT) tag. PIT tags were implanted using syringe injector needles swabbed with alcohol before each use, and the injection site on the snake was swabbed with alcohol prior to tag insertion. The tag was injected subcutaneously, approximately one-third of the SVL anterior to the cloaca. After insertion of the tag, cyanoacrylate glue was applied to the insertion site to seal the dermis and prevent tag loss. Most individuals were processed in the field within a few minutes of their capture. If snakes were held for more than a few minutes, they were kept in the shade in cooled and insulated containers to prevent overheating until they could be examined and released. Each individual was released at its location of capture immediately after processing.

3.2.2 Analytical Methods

Most analyses were conducted in a Bayesian analytical framework. In Bayesian analyses, the probabilities are interpreted slightly differently from traditional frequentist statistical analyses. The *posterior probability* is the probability of a random event or uncertain proposition given the data at hand and is most analogous to the probabilities used in frequentist statistics. The posterior probability is how most people intuitively think about probability (e.g., how people interpret a weather forecast). Bayesian analyses also require specification of a *prior* probability distribution, which allows for the inclusion of information obtained through other sources into the analysis. The prior can be an *informative prior* (i.e., a distribution based on previously collected data or a hypothesis about the probability distribution of interest) or an *uninformative prior* (i.e., a probability distribution that will have no effect on the outcome of the analysis). All parameter estimates are accompanied by 95% credible intervals. Unless otherwise noted, for all parameter estimates posterior medians are reported with equal-tailed 95% credible intervals in parentheses.

3.2.2.1 Demography

Abundance of giant gartersnake was estimated at each site where the species was detected using Bayesian analysis of CMR data, closed population models, and data augmentation (Royle and Dorazio 2008; Kéry and Royle 2016).[2] In contrast to occurrence, where site was defined as the area between two water control structures, for the purposes of this analysis, site refers to clusters of

[2] Data augmentation is an approach to CMR analysis in which a large number of all-zero capture histories is appended to the observed capture histories. This approach is much more flexible than other approaches to estimation of demographic rates and allows a unified framework for analysis of detection-nondetection and CMR data (Royle and Dorazio 2008).

transects that snakes could likely move between (see below). Closed population models are those that assume no migration in or out of the population of interest over the sampling period (in this case, the 14–21 days during which a site was sampled). These models are used to estimate abundance using simplifying assumptions. A single model was used to estimate abundance for each site, and information on capture probability was shared among sites which resulted in more precise estimates of abundance at each site.[3] The effects of water temperature, snake SVL, snake sex, and a behavioral response on capture probabilities were tested. Models also included temporal variation in capture probability (i.e., variation in capture probability among days of sampling) and individual heterogeneity in capture probability (i.e., variation in capture probability among individual snakes).

Because some traplines were proximate to one another, four snakes were caught in multiple traplines, and it is likely that other individuals moved between traplines as well. To account for demographic linkage between nearby traplines, captures of snakes were grouped into eight "demographic clusters," and abundance was estimated for each cluster. Clustering traplines avoided duplicate counting of snakes captured at more than one trapline and provided abundance estimates relevant to larger reserve areas rather than a single section of a canal or wetland. Because larger areas were sampled at BKS, Lucich North, and Sills in 2018 and 2019 compared to 2011–2017, less area was sampled overall in 2020 due to the COVID-19 pandemic, and because not all of the old demography traplines were sampled from 2018 to 2022, abundance estimates for these tracts from 2018 to 2022 are not directly comparable to previous years.

In addition to abundance estimates from closed population models, we estimated the density of giant gartersnake (in snakes per [hectare] ha of habitat) at four sites in 2022 using spatially-explicit capture-recapture (SECR) models. SECR models use the spatial locations where animals are captured or observed to estimate their "activity centers" as a measure of their use of space. Importantly, SECR account for both the location of traps and the period during which each trap was active and therefore able to capture an animal. Fitting SECR models requires sufficient recaptures of individuals within a single active season to estimate how capture probability decreases with the distance from the detector (in this case, a funnel trap). Therefore, we pooled data from nearby sites to ensure we had a dataset rich enough in recaptures to estimate the necessary parameters. The four sites for which we estimated density were BKS (BKS + Frazer South traplines), Sills (Sills + Tufts + Elsie traplines), Lucich South (Lucich South + Bennett South traplines) and Lucich North (Lucich North, Frazer North, and Bennett North traplines). We defined giant gartersnake habitat by creating polygons corresponding to wetland reserve habitat from satellite imagery in ArcMap version 10.8

[3] To estimate abundance accurately, the probability of capturing a giant gartersnake must also be estimated. Investigators fit a single "multinomial N-mixture model" (Kéry & Royle 2016) using capture data from all eight demographic cluster sites, with random effects of site, date, and individual on capture probability. This type of joint model has the advantage of sharing information on capture probability among sites, which allows for more precise estimates of capture probability and abundance at each site. This model has proven effective at estimating abundance of giant gartersnake (Rose et al. 2018c). The capture histories of trapped individuals were augmented with enough all-zero capture histories to give a total pool of 1,200 individual snakes. The number of pseudo-individuals was deemed adequate because the posterior density for abundance fell far below the number of augmented individuals. Uninformative priors were used for all parameters of all models: Uniform(0,1) for probabilities, N(0,1.648) for regression coefficients, and half-Cauchy (0,1) for standard deviations. The closed population model was run on five independent chains of 100,000 iterations after a burn-in of 5,000; each chain was thinned by a factor of 10 to give a final output of 50,000 samples for inference. The model was analyzed by calling JAGS 4.3.0 (Plummer 2003) from R 4.1.2 (R Core Team 2021) using the package "runjags" (Denwood 2016). Posterior distributions were summarized with the posterior median and 95% credible interval (2.5% and 97.5% quantiles of the posterior distribution).

(ESRI). For habitat in canals, we created a line feature representing the center of the canal and buffered this line by 10 m on either side to create a 2-dimensional approximation of the habitat area. We fit SECR models using the "secr" R package (Efford 2022) and report the mean, standard error, and 95% credible interval of the density of snakes.

Since the revision of our study design implemented in 2018, we have collected four annual intervals of mark-recapture data. This allowed us to start estimating apparent survival using open-population models. Although there is overlap between the areas sampled from 2011 to 2017 and the areas sampled from 2018 to 2022, the change in spatial coverage could lead to biased estimates of these vital rates. For example, individual giant gartersnakes with home ranges overlapping trapping arrays in 2016 and 2017 that were not captured in 2018, 2019, or 2020 could be treated as mortalities by the open-population CMR model, when in reality they survived this time interval but were unlikely to be caught in traps based on the new trapping locations from 2018 to 2022. Therefore, our estimates of apparent survival, annual recapture probability, and availability for capture (i.e., presence "on site") are only based on capture data from 2018 to 2022.

We calculated estimates of apparent survival using CMR data each year from 2018 to 2022 at three tracts (BKS, Lucich North, and Sills) that had greater than 15 individual giant gartersnakes captured over this period and more than one giant gartersnake recaptured subsequent to its first year of capture. All other tracts had fewer than 15 individuals captured over the period from 2018 to 2022. We estimated apparent survival (ϕ) using a robust-design CMR model designed to give unbiased estimates of survival by accounting for availability of individuals for capture (γ, i.e., temporary emigration) in addition to recapture probability (Riecke et al. 2018). We estimated separate survival rates for female and male giant gartersnake, and the apparent survival estimate also varied by site and year according to random effects of each. We estimated a single shared recapture probability parameter (p) for the two sexes, because preliminary model runs indicated no difference in recapture probability between female and male giant gartersnake.[4]

Sex ratios and size distributions were calculated using data from all captured individuals, regardless of method of capture or date of capture. Bayesian analytical methods were used to estimate sex ratios with binomial tests of proportions for all sampling locations within the Basin.[5] Bayesian methods were also used to describe the mean SVL and mass of giant gartersnakes of each sex from all sampling locations within the Basin.[6] Sexual size dimorphism in SVL and mass was examined throughout the Basin using separate means and variances for males and females. These tests are

[4] The robust-design model used uninformative Beta(1,1) prior distributions for the probabilities of apparent survival (ϕ), recapture (p), and availability on site during sampling (γ). All random effects parameters were drawn from normal distributions centered on zero with a standard deviation estimated from the data. Standard deviation parameters had Exponential(1) priors to shrink values toward zero if variation among sites and years was minimal but allow for larger values if warranted by the data. The model included random effects of year and site on ϕ, p, and γ. The robust-design model was fit using JAGS 4.3.0 (Plummer 2003) from R 4.1.2 (R Core Team 2021) using the R package runjags (Denwood 2016). The model was fit using five independent chains of 80,000 iterations each after a burn-in of 10,000 iterations. Each chain was thinned by a factor of 10, resulting in a final posterior sample of 40,000 iterations.

[5] The binomial model assumes sampling with replacement (Skalski et al. 2005); accordingly, counts of captures rather than individuals were used for analysis.

[6] Normal models were fit for each size measurement (mass and SVL), and the goodness of fit of each model was examined with a Bayesian p-value. Normal models fit well to the mass and SVL data, with Bayesian p-values of 0.51 and 0.52 for mass and SVL, respectively.

equivalent to t-tests with unequal variances (Kéry 2010).[7] Sexual size dimorphism, sex ratios, and mean SVL and mass were not examined at individual sites because of the great uncertainty in estimating means with small sample sizes.

3.2.2.2 Distribution of Giant Gartersnake on Reserve Lands

The probability of occurrence of giant gartersnake on TNBC reserves in 2022 was estimated using Bayesian analysis of single-season occupancy models (Royle and Dorazio 2008; Kéry 2010). The probability of occurrence was modeled as a linear function of selected habitat variables, and the probability of occurrence was allowed to vary among reserve areas (North Basin, Central Basin, and Fisherman's Lake). We initially modeled habitat effects only to identify supported habitat variables, then added a fixed effect of reserve area to a model containing only supported habitat variables. The habitat variables included effects of wetland or rice habitat and the percent cover of emergent vegetation, floating aquatic vegetation, open water, and terrestrial vegetation on the probability of occurrence of giant gartersnake. Priors for the occupancy component of each model were chosen to be uninformative (Table 3-2).[8]

In addition to the single-season occupancy models evaluated above, a Bayesian state-space dynamic occupancy model (MacKenzie et al. 2006; Royle and Kéry 2007; Kéry and Schaub 2011) was evaluated to identify any evidence for changes in the probability of occurrence of giant gartersnake on TNBC reserves over time from 2011 to 2022. Occurrence of giant gartersnake among various wetland units can change between years due to colonization of sites that were previously unoccupied and extinction at sites that were previously occupied. Accordingly, the dynamic occupancy models account for these changes and are used to estimate the rates at which these changes occur and the annually varying colonization and extirpation probabilities.[9] The effects of the same habitat variables that were evaluated using static occupancy models were evaluated to determine if they were related to extinction and colonization probabilities, and we used uninformative priors for the parameters related to occurrence, site-survival, site-colonization, and detection components of the model.

[7] Each model was run on five independent chains of 20,000 iterations after a burn-in of 2,000; each chain was thinned by a factor of five. Each model was analyzed by calling JAGS 4.3.0 (Plummer 2003) from R 3.6.2 (R Core Team 2019) using the R package jagsUI (Kellner 2016). Posterior distributions were summarized with the posterior median and 95% credible interval.

[8] All continuous variables were standardized to improve behavior of the Markov Chain Monte Carlo (MCMC) algorithm and to allow direct comparison of model coefficients. The posterior probability of each subset of the full model was calculated using indicator variables on model parameters (Kuo and Mallick 1998; Royle and Dorazio 2008). Each model was run on five independent chains of 110,000 iterations each after a burn-in of 2,000; each chain was thinned by a factor of 5, resulting in a final total of 110,000 samples for inference after pooling chains. Each model was analyzed by calling JAGS 4.3.0 (Plummer 2003) from R 3.6.2 (R Core Team 2019) using the package runjags (Denwood 2016). Posterior distributions were summarized with the posterior median and 95% symmetrical credible interval.

[9] All probabilities were given U(0,1) priors. The dynamic occupancy model was run on five independent chains of 200,000 iterations each after a burn-in of 20,000; each chain was thinned by a factor of 100, resulting in 10,000 samples for inference. Each model was analyzed by calling JAGS 4.3.0 (Plummer 2003) from R 3.6.2 (R Core Team 2019) using the package R2jags (Su and Yajima 2015). Posterior distributions were summarized with the posterior median and 95% symmetrical credible interval (2.5% and 97.5% quantiles of the posterior distribution).

3.2.3 Habitat Assessment

3.2.3.1 Habitat Distribution and Abundance

The distribution and abundance of land cover/crop types throughout the Natomas Basin, both on and off reserve lands, are documented annually (see Chapter 2, *Land Cover Mapping, Botanical Inventory, and Noxious Weed Monitoring*). These data are used to document large-scale changes in the distribution and abundance of suitable habitat for giant gartersnake on reserve lands and throughout the Basin.

3.2.3.2 Habitat Connectivity

Connectivity among and between tracts and reserves was assessed by examining habitat variables along the major linear water conveyance features based on assessment in the field and using aerial imagery available from Google Earth. All culverts crossing major roadways were examined during field checks.

3.3 Results

Overall, 130 individual giant gartersnake were captured 159 times by hand or trap at 41 sites on TNBC reserve tracts over the course of 42,997 trap days in 2022 (Table 3-1; Figure 3-2). The 2022 monitoring year had a similar number of trap days to 2021 but was still lower than any year from 2011 to 2019, likely contributing to low numbers of both unique giant gartersnake individuals captured, and total captures compared to the years before the pandemic. The catch-per-unit effort (snakes captured per trap-night) across the Natomas Basin was 0.0037 in 2022. For comparison, catch-per-unit effort was 0.0049 in 2021 when 153 individuals were captured 226 times over 46,567 trap days; 0.0068 in 2020 when 147 individuals were captured 185 times over 27,398 trap days; 0.0062 in 2019 when 274 individuals were captured 394 times over 63,297 trap days; and 0.0054 in 2018 when 265 individuals were captured 374 times over 67,022 trap days. Catch-per-unit effort was 0.0047 in 2017, 0.0037 in 2016, 0.0017 in 2015, 0.0033 in 2014, 0.0035 in 2013, 0.0028 in 2012, and 0.0031 in 2011.

3.3.1 Demography

3.3.1.1 Estimates of Abundance Using Closed Population Models

Capture probability, which is the variable with the greatest influence on estimates of all demographic parameters, averaged over all sites was 0.0017 (0.0005–0.0056). The standard deviation of capture probability among sites (0.0008 [0.0001–0.0047]) was slightly lower than the standard deviation of capture probability among days (0.0009 [0.0002–0.0030]). There was more variation in capture probability among individuals (0.0012 [0.0004–0.0028]). There was evidence for a positive ephemeral behavioral response to capture, and for a positive effect of water temperature on capture probability (Figure 3-3; Table 3-3).

Four instances of giant gartersnakes moving between traplines were detected in 2022. Three snakes were captured in multiple traplines within the Sills tract, and one snake was detected moving between traplines in the Bennett North tract. Traplines in close enough proximity that giant gartersnakes did or would be expected to move between traplines were grouped together and treated as a single site for this analysis (e.g., all traplines in the Natomas Farms wetland complex; one trapline in the Frazer South tract was grouped with traplines in the BKS tract), resulting in seven demographic "clusters." Estimates of abundance at each of the seven demographic clusters where giant gartersnakes were captured are summarized in Table 3-4.

At the six traplines within the BKS cluster (including one trapline from Frazer South), 79 individuals were captured 87 times over 6,300 trap days in 2022 (Table 3-4). Of 88 individuals that were captured in 2021, 11 were recaptured in 2022. Five snakes captured at BKS in 2020 were recaptured in 2022, six snakes captured in 2019 were recaptured in 2022, and four individuals first captured in 2018 were recaptured in 2022. The estimated abundance in sampled areas at BKS in 2022 was 385 (211–681) individuals (Figure 3-4, Table 3-4). The estimated abundance at BKS was 200 (147–352) individuals in 2021, 566 (256–1,303) individuals in 2020, and 559 (374–944) individuals in 2019.

At five traplines within the Sills cluster (including one trapline in the Elsie tract and one trapline in the Tufts tract), 31 individuals were captured 48 times over 4,752 trap days in 2022 (Table 3-4). For comparison, 36 individuals were captured 73 times over 4,178 trap days in 2021. Of the 36 individuals captured at Sills in 2021, 8 were recaptured in 2022. Of the 39 individuals captured at Sills in 2020, 2 were recaptured in 2022, and a single snake caught in 2018 was recaptured in 2022. The estimated abundance at Sills in 2022 was 148 (76–267) snakes (Figure 3-5, Table 3-4). In 2021, the estimated was 74 (51–137). The estimated abundance at Sills in 2020 was higher, with an estimate of 258 (117–590) individuals.

At 10 traplines within the Lucich North cluster (including two traplines in the Frazer North tract and one in the Nestor tract), eight individuals were captured nine times in 2022 over 10,241 trap days (Table 3-4). The estimated abundance at Lucich North in 2022 was 46 (23–83) individuals (Figure 3-6, Table 3-4). For comparison, the estimated abundance in 2021 was 31 (19–55) individuals. In 2021, 10 individuals were captured 14 times at Lucich North over 5,241 trap days. The estimated abundance of giant gartersnake at Lucich North in 2021 was 31 (19–55) individuals at five traplines. None of the eight snakes captured at Lucich North in 2022 had been captured in previous years.

At three traplines within the Lucich South demographic cluster, nine individuals were captured 15 times over 2,788 trap days in 2022. At two traplines within the Lucich South demographic cluster, one individual was captured once over 1,550 trap days in 2021. In 2020, two individuals were captured three times at two traplines. The estimated abundance at Lucich South in 2022 was 46 (22–84) individuals (Figure 3-7, Table 3-4). For comparison, the estimated abundance at Lucich South in 2021 was lower, at 23 (12–43) individuals. None of the nine snakes captured at Lucich South in 2022 had been captured in previous years.

In the Fisherman's Lake Reserve area, no giant gartersnakes were captured at eight traplines in the Cummings, Natomas Farms, and Rosa tracts over 8,293 trap days in 2022. Likewise, in 2021 and 2020, no giant gartersnakes were captured at the three tracts (Cummings, Natomas Farms, and Rosa) over 8,335 trap days (2021) and over 2,798 trap days (2020). In 2019, one giant gartersnake was captured at two traplines, while in 2018, no giant gartersnakes were captured at either trapline in the Fisherman's Lake Reserve area.

The other traplines at which snakes were captured were in the Bennett North, Bennett South, and Huffman West tracts. At Bennett North, two individuals were captured a total of three times, and the median estimated abundance was 42 (19–77) snakes (Table 3-4). At Bennett South and Huffman

West, one individual was captured a single time at each site. The median estimated abundance at Huffman West was 42 (20–77) individuals and the median estimated abundance at Bennett South was 42 (20–77).

3.3.1.2 Estimates of Density Using SECR Models

The highest density of giant gartersnake in the Natomas Basin in 2022 was at BKS, with a mean estimate of 10.5 snakes/ha of habitat (5.1–21.7 snakes/ha). The lowest density of giant gartersnake in 2022 was at Lucich North + Bennett North, with a mean estimate of 0.16 snakes/ha (0.05–0.59 snakes/ha). Snake density estimates at the Sills tract (mean = 1.11 snakes/ha; 0.63–1.97 snakes/ha) and Lucich South + Bennett South (mean = 1.53 snakes/ha; 0.70–3.34 snakes/ha) were comparable and intermediate to BKS and Lucich North.

3.3.1.3 Size Distribution and Sex Ratio

The overall sex ratio of captured snakes in the Natomas Basin was slightly female-biased. The sex ratio was 0.74 (0.51–1.02) males per female for all sites in the Basin combined. Basin-wide mean SVL was 612 mm (585–639 mm), and Basin-wide mean mass was 109.13 g (94.88–125.66 g). Mean female SVL (674 mm [637–712 mm]) was 148 mm (102–194 mm) greater than mean male SVL (526 mm [499–553 mm]), and mean female mass (150.9 g [125.16–182.29 g]) was 81.74 g (52.53–114.16 g) greater than mean male mass (69.16 g [58.53–81.74 g]; Figure 3-8).

3.3.1.4 Survival Estimates from 2018–2022

Average annual recapture probabilities, given 21 days of sampling at a site, were 0.14 (0.07–0.35). There was no support for a difference in apparent survival rate between female and male giant gartersnake. Apparent survival varied among years and sites. At BKS, apparent survival was highest from 2018 to 2019 and lower from 2019 to 2020, 2020 to 2021, and 2021 to 2022 (Figure 3-9). At Lucich North, apparent survival was similar over each of the year-long intervals (Figure 3-10). At the Sills tract, apparent survival estimates were highest for the interval from 2019 to 2020 (Figure 3-11). The probability a snake was available on site for capture (γ) was slightly higher for female than male giant gartersnake (Table 3-5). As for the closed CMR model, there was a positive relationship between capture probability and water temperature (Table 3-5).

3.3.2 Distribution of Giant Gartersnake on Reserve Lands

Giant gartersnakes were detected at 20 of 41 sites sampled in 2022 (Figure 3-2). Of the 35 sites surveyed in both 2021 and 2022, giant gartersnakes were detected at four sites in 2021 where no giant gartersnakes were detected in 2022. There were six sites where giant gartersnakes were detected in 2022 but had not been detected in 2021. Of the sites monitored in 2022, 30 (22–37) were estimated to be occupied (Figure 3-12).

The effects of habitat variables on the probability of occurrence were not supported in 2022 (Table 3-6). Water temperature had a positive effect on daily detection probability, but the effect of date of sampling on daily detection probability was not supported (Table 3-7; Figure 3-13). Daily detection probabilities for giant gartersnake in 2022 at an occupied site on a day with average conditions (e.g., average water temperature) were 0.07 (0.03–0.23). Over 21 days of trapping, this corresponded to a cumulative probability of detecting giant gartersnake at least once, given they occurred at a site in 2022, of 0.94 (0.43 – >0.99).

The probability of occurrence of giant gartersnake varied by reserve (i.e., North Basin, Central Basin, and Fisherman's Lake). The probability of occurrence in wetlands in the North Basin Reserve was 0.91 (0.42–0.99), the probability of occurrence in wetlands in the Central Basin Reserve was 0.95 (0.50–0.99), and the probability of occurrence in wetlands in the Fisherman's Lake Reserve was 0.09 (0.01–0.82). Most sites in the Fisherman's Lake Reserve were wetland sites (six of eight), whereas most sites in the Central Basin Reserve were rice sites (10 of 14), and sites were nearly evenly divided between the two types in the North Basin Reserve (13 of 22 sites were wetlands).

The dynamic occupancy model indicated evidence for a slight decrease in the probability that sites on TNBC reserves were occupied by giant gartersnakes from 2011 to 2013, followed by a period of stability from 2013 to 2018, an increase from 2018 to 2019, a decrease from 2019 to 2021, and an increase in 2022. Large uncertainty in occupancy in 2011 encompassed the modal estimates from all later years (Figure 3-14). The number of occupied sampled sites followed a similar pattern, with a decrease from 2019 to 2021 and an increase in 2022 (Figure 3-15). Both occupancy parameters were estimated with much greater precision in 2018 and 2019, when the number of sites increased to 60 as part of the revised sampling design, than in previous years. Conversely, precision of these parameters was much lower between 2020 and 2022 compared to the two previous years, due to decreasing the number of sites to 40 (2020), 45 (2021), and 41 (2022) because of the COVID-19 pandemic. The annual probability that occupied sites would become unoccupied (site extirpation) was generally low and stable between 2011 and 2019; while it was higher from 2020 to 2022 compared to previous years, site-extirpation probability consistently declined since 2020 (Figure 3-14). The annual probability that unoccupied sites were colonized exhibited no trend from 2011 to 2018; increased from 2018 to 2020; decreased from 2020 to 2021; and increased from 2021 to 2022 (Figure 3-14). The mean intrinsic growth rate of occupancy from 2011 through 2022 was -0.042 (-0.072 to -0.006; Figure 3-16). Overall, although mean estimates of occupancy growth were slightly negative, credible intervals were close to zero, indicating occupancy was relatively stable from 2011 to 2022. Notably, there was clear evidence of positive occupancy growth from 2018 to 2019 and from 2021 to 2022. Occupancy growth was most negative between 2019 and 2020, potentially because of the reduction in the number of sampled sites, but it rebounded since the 2020–2021 period (Figure 3-16). The probability that the number of occupied sites was stable from 2011 through 2022 (less than 10% change; >0.99) was higher than the probability that the number of occupied sites decreased by more than 10% from 2011 through 2022 (<0.01), or that occupancy increased by more than 10% annually (<0.01). Beginning in 2017 three additional trap transects were surveyed ("NACONN" 1–3 in 2017 and NACONN 1, 3, and 5 from 2018–2021) in the Giant Gartersnake Drainage Canal that connects the North Drainage Canal to the West Drainage Canal along the southwestern edge of the Natomas Basin. No giant gartersnakes were detected at any of these trap transects between 2017 and 2021, and their addition could have caused the estimated occupancy for 2017, 2018, 2020, and 2021 to be slightly lower. However, occupancy increased in 2019 despite surveying these newly created, and as-yet unoccupied, sites. No giant gartersnakes were detected at Natomas Farms 2 and Natomas Farms 3, which had been "old" demography sites prior to our study design change in 2018. Addition of these sites to the occupancy analyses likely contributed to the lowest estimate of occupied sites in 2021; however, occupancy increased in 2022 despite including these sites to the analyses.

There was no support for effects of habitat on site-survival probabilities nor strong evidence for effects of habitat variables on occupancy dynamics (Table 3-8).

3.3.3 Habitat Assessment

3.3.3.1 Habitat Distribution and Abundance

TNBC reserve lands provide better giant gartersnake habitat than that present in the Natomas Basin as a whole. Created marsh, seasonal wetlands, and other emergent wetlands are the highest quality giant gartersnake habitat and constituted 12.9%[10] (667 acres) of the area of reserve properties but just 1.6% (789 acres) of non-reserve lands. TNBC reserves provided 46% of the wetland habitat within the Natomas Basin. Rice agriculture, which along with its supporting infrastructure of canals provides the only remaining suitable giant gartersnake habitat in the Basin, comprised 30.5% (1,573.3 acres) of the area of reserve properties compared to 21.0% (10,319.2 acres) of the non-reserve lands. The reduction of active rice habitat compared to 2021 (56.7% [2,606.4 acres]) is likely transient due to fallowing of rice fields; for example, of the 23 reserves in 2021 with active rice agriculture, 17 were fallowed in 2022.

Overall, 2,281.3 acres (44.3%) of the total acres of TNBC reserve lands was potential giant gartersnake habitat, while only 37.4% (18,323.1 acres) of the total acres of non-reserve area in the Basin was potential giant gartersnake habitat. It should be noted, however, that only marsh and a fraction of the linear water conveyance features that make up a very small proportion of the total acreage in rice provide suitable giant gartersnake habitat in all seasons, and that even these land cover types are only suitable if they contain adequate water to provide usable giant gartersnake habitat (i.e., a non-negligible amount of surface water immediately adjacent to emergent vegetation or steep canal banks). Giant gartersnakes require enough water to submerge themselves for foraging and predator escape, and they require this water to be immediately adjacent to basking and hiding sites, like emergent vegetation and steep canal banks. If water is not properly managed to ensure that all components of giant gartersnake habitat are present, marshes and canals no longer function as giant gartersnake habitat. Rice fields and their associated linear water conveyance features provide almost no giant gartersnake habitat for much of the year (i.e., September through June), so the amount of created marsh with adequate water is a better measure of giant gartersnake habitat for comparison than the sum of created marsh and rice. As noted above however, even the total acreage of created marsh may overestimate giant gartersnake habitat if it does not contain enough water.

Tracts in the Fisherman's Lake Reserve cover approximately 388 acres. A total of 72.1 of these acres (18.6%) were created marsh in 2022. No rice existed in the Fisherman's Lake Reserve tracts in 2022. Recently constructed wetlands (SAFCA wetlands) constitute much of the landscape immediately southeast of the Natomas Farms tract and between the Natomas Farms and Cummings tracts, and these wetlands have developed into suitable giant gartersnake habitat. Of the six tracts in the Fisherman's Lake Reserve, one (Alleghany) contained no habitat for giant gartersnake in 2022, while the other five contained habitat suitable for giant gartersnake.

Tracts in the Central Basin Reserve cover approximately 1,423 acres. A total of 140 of these acres (9.8%) were created marsh and 551 acres (38.7%) were active rice in 2022. This represents a decrease of 507 acres (48%) compared to the 1,058 acres (74.3%) of rice that existed in the Central Basin Reserve in 2021. A total of 546.7 acres of Central Basin were fallowed rice fields in 2022.

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[10] The fresh emergent marsh (created) land cover type includes some, but not all, of the associated uplands for most, but not all, tracts with created marshes. Therefore, this number is not representative of the percentage of reserve lands in created marsh for purposes of assessing compliance with the terms of the NBHCP.

Overall, 1,199.1 acres (84.3%) of the total acreage of the Central Basin Reserve was potential giant gartersnake habitat in 2022, although—as noted above—only created marsh and some canals associated with rice agriculture provide suitable habitat in all seasons. Of the 12 tracts in the Central Basin Reserve, one (Paulsen South) contained no canal habitat for giant gartersnake in 2022, while the other 11 contained habitat suitable for giant gartersnake.

In 2022, tracts in the North Basin Reserve covered approximately 2,332 acres. A total of 414 of these acres (17.8%) were created marsh and 637 acres (27.3%) were in active rice cultivation. A total of 764.1 acres of the North Basin were fallowed rice fields in 2022. This represents an increase of 616.3 acres from the 147.8 acres that were classified as fallowed rice in 2021. Overall, 1,818.0 acres (78.0%) of the total acreage of the North Basin Reserve was potential giant gartersnake habitat in 2022. Of the 18 tracts in the North Basin Reserve, 16 contained suitable habitat for giant gartersnakes and two (Vestal and Ruby Ranch) contained only marginal habitat, based on the canals, for giant gartersnakes in 2022.

3.3.3.2 Habitat Connectivity

An assessment of habitat connectivity is incomplete without addressing the different means by which animal populations are connected. Connectivity generally occurs via the dispersal of individuals across the landscape. Little is known about reptile dispersal, but radio-telemetry studies suggest that most giant gartersnakes have small home ranges (Valcarcel 2011), although individuals can move several kilometers through appropriate habitat if necessary (Reyes et al. 2017). Two distinct forms of connectivity must also be considered. *Demographic connectivity* refers to the movement of individuals among (sub) populations to the extent that migration plays a role in population dynamics, potentially rescuing local populations from extirpation through migration into them from a source population (Mills 2007). *Genetic connectivity* is the dispersal of enough individuals among populations to prevent genetic differentiation among them. A one-migrant-per-generation rule is often considered an adequate amount of connectivity to avoid the negative effects of inbreeding (Mills 2007). In general, demographic connectivity requires the exchange of far more individuals than genetic connectivity. Both forms of connectivity are addressed in the following discussion.

Although portions of TNBC's reserve system are well-connected, some notable exceptions exist (Figure 3-17). In particular, although surface water connects the Fisherman's Lake Reserve with other reserve areas, the northernmost suitable Fisherman's Lake Reserve tract (Rosa Central), is approximately 14 kilometers (by canal) south of the nearest suitable Central Basin Reserve tract known to be occupied by giant gartersnake (Elsie). Giant gartersnakes have small home ranges and typically move relatively short distances (Valcarcel 2011; Reyes et al. 2017) but nonetheless can exhibit movements up to 5 kilometers over multiple days (U.S. Geological Survey unpublished data). Given the stretches of marginal habitat in canals that connect tracts, the surrounding land uses inhospitable to giant gartersnakes, potential fragmentation caused by I-5, and the distance between tracts of the Central Basin Reserve and the Fisherman's Lake Reserve, it is unlikely that the Fisherman's Lake Reserve is currently demographically connected to the other reserves. Connectivity between the Fisherman's Lake Reserve and other habitats north of I-5 may have improved with the completion of the Giant Gartersnake Drainage Canal, constructed as mitigation for the NLIP project that connects the North Drainage Canal just south of the Sacramento/Sutter County line with the West Drainage Canal just north of I-5. The majority of this new canal was categorized as suitable habitat for giant gartersnake in 2020–2022. Additionally, the canal connects to the Fisherman's Lake Reserve through the West Drainage Canal, which was categorized as suitable habitat in 2020–2022 (Figure 3-17). Within the Fisherman's Lake Reserve, four of the suitable tracts (Rosa East, Rosa Central, Natomas Farms, and Cummings) are connected by approximately 3.5 kilometers of canal habitats that compose Fisherman's Lake, and by the intervening SAFCA wetlands. The eastern boundary of the fifth suitable tract, Souza, is adjacent to the northernmost wetlands of the Natomas Farms and SAFCA tracts. The creation of the SAFCA wetlands provide much greater continuity of habitat within the Fisherman's Lake area than was previously present. Movement data from radio-tagged snakes translocated to the SAFCA wetlands between 2019 and 2021 showed individual snakes moved between the Natomas Farms, SAFCA, and Cummings wetlands, but did not show signs of migration out of the Fisherman's Lake Reserve.

In contrast to the tracts of the Fisherman's Lake Reserve, the tracts of the Central Basin Reserve are near those of the North Basin Reserve, and these two areas are linked by a dense network of canals. The eastern edge of Ruby Ranch tract in the North Basin Reserve is only approximately 3 kilometers (by canal) from the Sills and Tufts tracts of the Central Basin Reserve. Within the Central Basin Reserve, tracts are nearly contiguous, with the exception of a 0.8-kilometer gap between Bianchi West and Frazer South tracts. The intervening tract consists of rice agriculture and a canal with marginal habitat, so demographic connectivity among these tracts is likely and genetic connectivity is nearly certain. Perhaps a greater barrier to connectivity among Central Basin tracts is SR 99, which lies between the Bianchi West and Sills tracts. Although this highway is a formidable barrier, it is possible for giant gartersnakes to cross it. A female giant gartersnake initially marked in 2010 at Bianchi West (east of SR 99) was captured at Sills (west of SR 99) three times in 2011. This individual almost certainly crossed through the 132-meter-long single box culvert under SR 99, providing strong evidence for genetic (and possibly even demographic) connectivity across SR 99 in the Natomas Basin (Halstead et al. 2013b). No such movements were detected in 2022. We did not sample at Bianchi West in 2022 but no movement between the Sills tracts and any of the next closest tracts west of SR 99 (BKS3 and Frazer South N) were detected. Given that the Sills tract and BKS tract contain the two most abundant populations of giant gartersnake in the Central Basin Reserve, connectivity across SR 99 could increase the probability of persistence of giant gartersnake in this region as a whole.

Like the tracts of the Central Basin Reserve, the tracts of the North Basin Reserve are well-connected. No major highways fragment North Basin tracts, and the only discontinuity between tracts containing suitable habitat is 1 kilometer between the Lucich North and Nestor tracts. This gap occurs along the North Drain, which has improved from marginal giant gartersnake habitat in 2020 to suitable habitat in 2021 and remains suitable in 2022; this improvement of habitat suitability will likely contribute to improved connectivity between the two areas. We captured a snake in the Nestor tract in 2018 that was originally marked in the Lucich North tract in 2012, demonstrating the connectivity between these two areas. It is highly likely that all tracts in the North Basin Reserve are genetically connected, and nearly all tracts are demographically connected with at least one other tract as well. Resumption of rice agriculture on the Nestor tract likely enhances the connectivity of the North Basin Reserve tracts.

Overall, it is very likely that all North Basin and Central Basin Reserve tracts are genetically connected and that these tracts are also demographically connected to at least one other tract. These conditions help to promote genetic diversity, limit the effects of genetic drift and inbreeding depression, and may rescue small populations on some reserves by the migration of individual giant gartersnake from neighboring reserves. In the future, maintaining this connectivity and its benefits to giant gartersnake will require the continued availability of suitable habitat in canals that link wetland reserves. In contrast to the North and Central Basin Reserves, connectivity between the Fisherman's Lake Reserve and the other reserves is far more tenuous. Although Natomas Farms and Cummings are almost certainly genetically connected and possibly demographically connected, the very small population in this area and isolation of these reserves from demographic rescue and genetic input from other, more abundant giant gartersnake populations to the north leaves them at risk for founder effects, inbreeding depression, and fixation of deleterious alleles through genetic drift, and it renders them very sensitive to both demographic and environmental stochasticity (e.g., random variation in birth/death rates or climatic conditions). It is hoped that the establishment of these reserves and the additional marsh habitat created by SAFCA can provide the conditions that will allow this population to recover, but detailed demographic study of this population will ascertain whether more intensive management strategies (such as augmentation of the population with genetically distinct individuals to increase genetic diversity [Madsen et al. 1996, 2004]) are warranted in the Fisherman's Lake area. The radio-telemetry study that began in 2018 is an important first step to determine the potential effectiveness of translocation of individuals from more abundant and presumably more genetically diverse populations, as a means to "rescue" sparse populations in the Fisherman's Lake Reserve. Individuals from the Central Basin Reserve were translocated to the SAFCA wetlands in the Fisherman's Lake Reserve in 2019, and current analysis and publication of data collected from these individuals will provide information about the suitability of these recently created marshes for giant gartersnake.

Although some sections of canal in each reserve were downgraded from suitable to marginal habitat from 2021 to 2022, many canals in each reserve were upgraded from marginal to suitable habitat in 2022; overall, the continuity of suitable habitat for giant gartersnakes improved in 2022. The most notable downgrade in habitat suitability in the North Basin occurred in canals between the Nestor and Bennett North tracts, where two larger sections of canals were downgraded from suitable to marginal. However, there was great improvement in habitat (marginal to suitable) in the rest of the tracts in the North Basin and even two sections of canals in the Frazer North tract that were classified as unsuitable in 2021 improved to marginal and suitable in 2022. In the Fisherman's Lake and the Central Basin tracts, no canal sections were downgraded to unsuitable habitat, except for a small section of canal near the Sills tract. Most of this canal was already classified as unsuitable in 2021 but the small portion that was still considered marginal was downgraded to unsuitable. One section of canal along the Elsie and Paulsen South tracts that was classified as no longer a canal in 2021 returned to marginal habitat in 2022. As for the rest of the Central Basin there was about an equal split between habitat that switched from marginal to suitable and habitat that was downgraded from suitable to marginal between 2021 and 2022. These changes occurred throughout the Central Basin and did not appear to be concentrated to a certain area or set of tracts, which could be indicative of natural habitat fluctuations between years. In the Fisherman's Lake tract, six sections of the canals were upgraded from marginal to suitable, one was downgraded from suitable to marginal and no canal sections were downgraded to unsuitable habitat. As seen in previous years the habitat dynamics of canals with respect to giant gartersnake can both improve or degrade from year to year based on annual fluctuations in water availability and growth of emergent vegetation. Monitoring these changes over time will be important to determine if any long-term trends exist and whether those trends are positive or negative for giant gartersnake persistence.

3.4 Discussion

3.4.1 Demography

3.4.1.1 Abundance and Density

Abundance varied substantially among sites. For three of the seven demography clusters, three or fewer snakes were captured, and abundance was estimated to be 19–77 individuals. Similar abundance estimates were obtained for Lucich North and Lucich South, at which only eight and nine individuals were captured in 2022, respectively. For two sites with more than 30 individuals captured, abundance was estimated to be much greater, with more than 75 individuals (Sills), or over 210 individuals (BKS). The daily capture probability of marked giant gartersnake in 2022 was lower than in 2021 and the abundance estimates had larger credible intervals in 2022 compared to 2021. The average number of captures per individual in 2022 (1.25) was lower than in 2021 (1.57 captures per individual), and more comparable to 2020 (1.26 captures per individual). The number of captures per individual was intermediate in 2019 (1.44) and 2018 (1.41). Capture probabilities varied substantially, with similar variance attributable to temporal variation (fluctuations from day to day) and variation among sites. The random variation in capture probability among days likely reflects day-to-day changes in the weather that influence the behavior of giant gartersnake. On cool, cloudy days, snakes are less likely to go foraging in the water and thus are less likely to be captured in traps than on hot days when they spend more time foraging. Capture probability might differ among sites due to differences in habitat that influence the effectiveness of traps—for example, how well traps are able to fit flush to the canal or wetland bank to funnel foraging snakes into the trap. The ability to share information on capture probabilities among sites is valuable because it allows for more precise estimates of abundance, as well as the effect of habitat covariates on capture probability. Heterogeneity in capture probability among individual giant gartersnakes could result from differences in behavior, with some individuals foraging along habitat edges more frequently or learning to forage in traps because they contain concentrations of prey. Heterogeneity can also result from spatial overlap between individual home ranges and traplines. Snakes with home ranges centered in the middle of a trapline would be expected to be captured more frequently than snakes with a home range that only partially overlaps one end of a trapline. This variation in individual home ranges is addressed explicitly in the SECR models used to estimate snake density.

SECR models explicitly account for the spatial locations of traps and where snakes are captured, which enables them to estimate the density of snakes within a defined area. Density estimates from SECR models are more suitable for comparisons among sites, because they account for differences in the area sampled at each site. BKS had both the greatest estimated abundance of giant gartersnake and the highest density, or number of snakes per ha of habitat. A comparison of Sills and Lucich South is instructive of the value of SECR models. The estimated abundance of snakes at Sills was higher than at Lucich South (median value of 148 compared to 46), but the estimated densities of snakes at the two sites were similar. In contrast, despite Lucich North having a similar number of individuals captured and a similar abundance estimate to Lucich South, the density of snakes at Lucich North was estimated to be much lower in 2022. The lower estimated density at Lucich North from the SECR model results from the much greater area sampled compared to Lucich South. In the future, comparisons of snake density among sites, and inclusion of habitat covariates on snake density could help inform what habitat management actions are most likely to support dense, healthy giant gartersnake populations.

In contrast to 2018–2021, there was support for an effect of water temperature on capture probabilities in 2022. The effect of water temperature on snake behavior is likely more important in the spring, when cooler weather may prevent snakes from reaching a high enough body temperature to forage in cool water. In 2022, trapping began a week earlier in May than in 2021, which could partially explain the greater importance of water temperature to snake capture probability in 2022. As in each year from 2018 to 2021, there was evidence of a positive ephemeral behavioral response to capture ("trap-happiness") in 2022. This pattern is likely observed simply because the individuals were in the vicinity of the trap array immediately after release and happened to enter another trap, or because individual snakes might forage for several consecutive days within a relatively small area, then shelter in burrows to digest their meals or shed. The behavioral response could also be caused by individuals that entered traps being rewarded with an easy meal; these individuals were therefore more likely to search for prey within traps the following day—and be trapped—than individuals that had not been trapped the previous day. This effect of behavioral response is a common theme across all years of monitoring. In 2022, there was little support for an effect of giant gartersnake sex or SVL on capture probability. This is in contrast to 2021, when there appeared to be some support for effects of sex and SVL on capture probability.

3.4.1.2 Size Distribution and Sex Ratio

The sex ratio of giant gartersnake in the Natomas Basin in 2022 was slightly lower than one male per female and lower than in 2021. Although the credible interval overlapped 1 in 2022, which may indicate a more equal sex ratio, it was with low precision likely due to the lower sample of captures in this year. This female-biased sex ratio should not limit the reproductive potential of the species, given the mating system in gartersnakes, where both females and males can mate with multiple partners (Schwartz et al. 1989; Shine et al. 2001). The biased sex ratio is largely a result of a low proportion of males among the snakes captured at three sites: BKS (42 females and 29 males), Lucich North (no males and four females), and Lucich South (one male and eight females). Trapping within Lucich North in which moderately more female giant gartersnakes were captured in 2022 occurred during late summer (i.e., mid-July to late August). During this time of year, females are likely to be foraging after giving birth (parturition) to improve their body condition. The likelihood that large adult females foraging after reproduction in part drove the sex-bias in captures is further supported because the average SVL and mass of captured females were higher in 2022 (674 mm SVL, 150.9 g mass), 2021 (611 mm SVL, 131.76 g mass), 2020 (616 mm SVL, 117.45 g mass), 2019 (630 mm SVL, 164.5 g mass), and 2018 (665 mm SVL, 161.9 g mass) than in 2017 (586 mm SVL, 115.5 g mass), and the size distribution of females was shifted toward longer and heavier individuals between 2018 and 2022 (with the revised sampling design) than in 2017, when greater trapping effort occurred earlier in the active season. Continued monitoring of giant gartersnake sex ratios is warranted, but differences in seasonal activity patterns between the sexes must be considered when interpreting the sex ratio of captured individuals. Although managing unharvested populations for sex ratio is not generally feasible, continued monitoring of sex ratios on TNBC reserves could warn of sex-biased mortality factors (assuming an equal sex ratio at birth [Halstead et al. 2011a; Rose et al. 2018a]).

Size distributions of giant gartersnake on TNBC reserves indicated the presence of a mixed-age population. Size distributions indicated the presence of both younger, smaller snakes and larger, older individuals in the population. Small yearling snakes were caught in spring 2022 that were likely born in summer 2021, and neonate snakes likely born in summer 2022 were captured in August 2022. The evidence of recruitment of young individuals provided by size distributions is important supplemental information to determine if recruitment is occurring (at least in part) through in-situ reproduction. It should be noted, however, that inferring the health of a population (i.e., population growth rate) from size (or age) distributions alone is a risky proposition (Caughley 1974).

3.4.1.3 Survival Rate of Giant Gartersnake

With the additional year of sampling in 2022, we were able to obtain more precise estimates of apparent survival (the probability of surviving and remaining available on site for capture) for giant gartersnake in 2022. The only clear trend in the survival estimates was that apparent survival was much higher at BKS from 2018–2019 than in the subsequent years. This decrease in apparent survival could be driven by the decrease in sampling effort in BKS in 2020 (six traplines for approximately 14 days each), 2021 (five traplines), and 2022 (six traplines) compared to 2018 and 2019 (nine traplines). The higher sampling effort in 2018 and 2019 led to a higher recapture rate of snakes in 2019 compared to subsequent years. Therefore, it is possible that some of the snakes that were first captured and marked in 2018 and 2019 survived until 2020 and 2021 but either (1) were not available for capture in the more limited area sampled from 2020–2022 or (2) evaded capture during the shorter sampling period in 2020. Trapping effort was more consistent in the Sills tract, and survival was higher from 2019–2020 than in other years. Despite a drop in trapping effort (fewer traplines and fewer trap days) at Lucich North in 2020 and 2021 compared to 2018 and 2019, apparent survival was similar among years. There was no support for a difference in survival among male and female giant gartersnake. There was weak support for a higher availability for capture for female giant gartersnake than male giant gartersnake, however. One potential explanation for higher availability for capture for female giant gartersnake is that male giant gartersnake disperse farther and are more likely to emigrate from trapped areas.

3.4.2 Distribution of Giant Gartersnake on Reserve Lands

The occupancy analysis for 2022 indicated that giant gartersnake is expected to occur in nearly 60% of wetland and rice units on reserve lands, with occupancy highest in the Central Basin Reserve. It is notable that there was great uncertainty on the effects of whether sites classified as “rice” (i.e., canals next to rice) were more or less likely to be occupied than wetland sites, after accounting for variation in occupancy rates among the three reserves. The results suggest that the presence of rice likely did not affect the occurrence of giant gartersnakes in 2022. This, however, does not minimize the importance of rice agriculture as an alternative wetland habitat for this conservation-reliant species (Halstead et al. 2019). It also should be noted that the Central Basin has historically had the highest proportion of sites occupied and the highest proportion of sites that are considered rice agriculture; these patterns remained evident in 2022. Because the Central Basin is dominated by rice and the Fisherman’s Lake Reserve is dominated by wetlands, it is difficult to fully disentangle the effects of rice from geographic variation in probability of occurrence.

The lack of a strong effect of emergent vegetation on occurrence was notable in 2022. In 2021, emergent vegetation was not found to be an important variable for explaining occurrence probability. In 2020, a negative effect of emergent vegetation on occurrence was seen, but this habitat covariate was found to have an important positive effect in 2017, 2016, and in years prior to 2014. However, this likely does not demote the importance of emergent vegetation; rather, given the model selection results, there could be additional benefits of rice agriculture, not measured in the current analysis, that influence giant garter snake occurrence.

It is suspected that emergent vegetation still provides the best habitat for giant gartersnake cover from predators and higher prey concentrations. Radio-telemetry study of giant gartersnake movement and habitat selection has shown that giant gartersnake preferentially select tule over other vegetation types (Halstead et al. 2016). Because tule marsh is historical habitat for giant gartersnake, management for emergent vegetation, particularly tule, is important. It is notable that there was great uncertainty on the effects of whether sites classified as "rice" (i.e., canals next to rice) were more or less likely to be occupied than wetland sites, after accounting for variation in occupancy rates among the three reserves.

The probability of occupancy was greatest in the Central Basin Reserve, moderate in the North Basin Reserve, and lowest in the Fisherman's Lake Reserve. Both the North Basin Reserve and Central Basin Reserve have a mix of rice and wetland habitat, whereas the Fisherman's Lake Reserve is primarily composed of recently created freshwater marsh. Notably, giant gartersnakes were captured at six sites in the North Basin (Bennett, Frazer, and Lucich sites) in 2022, where no snakes were detected in 2021. In 2023 and beyond, occupancy trapping will track changes in occupancy that follow giant gartersnake translocation efforts into the Fisherman's Lake Reserve. Additional data collection over the coming years, with the greater precision afforded by the larger sample size of the revised study design, will improve inference into the strength of the effects of emergent vegetation, floating aquatic vegetation, open water, and rice on the probability of occurrence, site-colonization, and site-extirpation of giant gartersnake and the mechanisms by which these components of the habitat affect giant gartersnake occupancy.

Based on the dynamic occupancy model, the proportion of occupied wetland units on reserve lands was stable (changing by less than 10% annually) from 2011 through 2022 with over 99% probability, with a near-zero probability (<0.1%) that occupancy decreased by more than 10% during that period. This stability is different from the trend of decreasing giant gartersnake occupancy seen in 2015, 2016, 2020, and 2021 but it matches the findings of the dynamic occupancy model in 2017, 2018, 2019, and 2022. The apparent declines in occupancy, particularly in 2020 and 2021, could be an artifact of reduction in sampled sites and survey effort in 2020 and 2021 compared to prior years. The larger sample of sites surveyed in 2018 and 2019, and the longer survey period used in the revised study design, resulted in more precise estimates of occupancy for 2018 and 2019 than for previous years. However, the shorter survey period used in 2020 resulted in less precise estimates for 2020 than in the 2 previous years. Resuming the 21-day period sampling in 2021 and 2022 likely improved detection and contributed to the slightly higher precision of the parameter estimates from the dynamic occupancy model compared to 2020. Relative to previous years, the probability that occupied sites became unoccupied (site extirpation) declined from 2021 to 2022, but was higher than in 2019. The probability that unoccupied sites became occupied (site colonization) in 2022 was slightly higher than in 2021 and comparable to 2019, but overlapping credible intervals suggest it would be wrong to conclude a large difference. Although there was overwhelming support that giant gartersnake occupancy did not change by more than 10% from 2011 through 2022, there does appear to be a decline in the number occupied sites over this period, with most of that decline appearing to occur from 2011 to 2013, as well as from 2019 to 2021.

One potential mechanism leading to a decrease in the proportion of sites occupied is the extreme drought conditions from 2012 to 2015 and from 2021 to 2022. According to the California Department of Water Resources, California experienced the second driest water year (October 2020–September 2021) in 2021. Although water remained on TNBC reserves during the drought, it is unknown to what extent the source of water (surface water vs. groundwater) affects giant gartersnake occupancy or demography, and precipitation may influence the productivity of lower trophic levels including giant gartersnake prey. Thus far, occupancy does not appear to have completely rebounded to earlier levels (e.g., 2011), but 2022 showed a clear increase after 2 years of decline in 2020 and 2021. This was comparable to 2019, which showed a clear increase after 4 years of stability from 2015 to 2018. The rebound in occupancy in 2019 follows 3 out of 4 years of normal to above-average rainfall (2016, 2017, and 2019). Three years of favorable rainfall in a 4-year period might not be long enough for giant gartersnake to recolonize every site from which it was extirpated during the drought, but 2019 showed some positive signs of recolonization.

Despite the dry water year in 2021, site-extirpation rate decreased, and occupancy growth rate continued to increase (although <0) between the 2021–2022 period and 2020–2021 period, compared to the 2019–2020 period. These may be explained by resuming the longer sampling period in 2021 and the slight increase in sampled sites compared to 2020. It is also possible that the improvement of habitat suitability across the TNBC reserves has protected the giant gartersnake population from adverse effects of the drought; alternatively, the full effects of the drought might not be realized until future years because snakes might have concentrated in the areas we could trap (i.e., that contained water) even as giant gartersnake habitat on non-reserve lands contracted and our sampling likely occurred before the worst effects of drought were realized. Occupancy dynamics on TNBC reserves were not strongly related to any habitat variables at the surveyed sites. Continued monitoring in 2023 and beyond could help understand how habitat improvement in the TNBC reserves might buffer against environmental stress factors on giant gartersnakes.

3.5 Effectiveness

The effectiveness of the NBHCP for conserving giant gartersnake is assessed based upon the acquisition of reserve lands; changes in the abundance or, preferably, demographic rates of giant gartersnake; and land management activities to increase the distribution and health of giant gartersnake in the Natomas Basin.

The primary issue affecting giant gartersnake throughout its range is habitat, and the Natomas Basin is no different in this regard. Marshes that most nearly approximate natural tule marshes provide the best habitat for giant gartersnake, promoting both higher densities and greater body condition than other habitats (Wylie et al. 2010). For example, a recent, long-term study of giant gartersnake throughout the Sacramento Valley found that survival was positively related to the percent cover of emergent vegetation at a site (Rose et al. 2018b). The point estimate of density of giant gartersnake was 946% greater in created marsh habitats in the BKS tract compared to the highest estimates for rice and associated canals on the Sills tract, which had the third highest density (and second highest in abundance) estimate on the Sills tract. Although giant gartersnake has persisted in a rice agricultural landscape in the Sacramento Valley, the limited duration of rice fields as appropriate habitat (mid-May through August), the restriction of giant gartersnake to structurally simple linear canals during the other 4 months of the active season, as well as the rice fallowing in response to drought or late spring rains in recent years likely reduce the carrying capacity of agricultural habitats relative to natural or well-managed created marshes. Nevertheless, rice agricultural habitats are the only agricultural habitats in which giant gartersnake can persist (Halstead et al. 2010), and they provide connectivity between other patches of suitable habitat. Also, the survival rate of radio-tracked giant gartersnake has been found to be positively related to the area of active rice growing surrounding their home range (Halstead et al. 2019). The Lucich South, Sills, and

Lucich North tracts had the second, third, and fourth highest density estimates, respectively, of giant gartersnake in 2022, illustrating the importance of rice agricultural habitats in the Natomas Basin, particularly in the Central Basin Reserve. Nonetheless, giant gartersnake density in the Lucich North cluster of sites, which is dominated, by created marsh, was lower than many rice sites and almost two orders of magnitude less than the giant gartersnake density at BKS. The low water levels at this location, with extensive areas of mudflat or shallow, hot water between emergent vegetation and deeper water, likely contributed to lower giant gartersnake densities at this cluster. TNBC has been effective in creating managed marsh habitats and providing for the continuation of rice agriculture in the Natomas Basin. Maintaining additional water in created marsh habitats would further benefit giant gartersnake.

Managing habitat for giant gartersnake is only effective insofar as adequate water is supplied to these habitats. The persistence of water adjacent to cover on the landscape throughout the active season is important for giant gartersnake, and increased water availability has been shown to be related to higher rates of survival for adult female giant gartersnake (Reyes et al. 2017; Halstead et al. 2019). Drying of marshes, fallowing of rice fields for more than a year, cultivation of alternative crops (especially if accompanied by lack of water in canals), and low or fluctuating water levels in marshes reduce the availability and quality of habitat for giant gartersnake. Reducing the amount of rice grown in an area has the potential to negatively affect the survival of adult giant gartersnake (Halstead et al. 2019). TNBC has created suitable managed marsh habitats that can provide relatively persistent aquatic habitat throughout the year if water levels are maintained to provide aquatic foraging and escape habitat next to, and ideally below, basking sites.

Another important component of giant gartersnake habitat is refuge from predators and, perhaps as important, environmental extremes. Mammal burrows and lodges and crayfish burrows offer important refuge for giant gartersnakes and should be maintained in association with marshes and canals to the maximum extent practical. Unless burrows threaten the integrity of the berms and levees required to maintain water in marshes or canals, or they present a major hazard to humans or livestock, they should be maintained in abundance. Muskrats (*Ondatra zibethicus*), California ground squirrels (*Otospermophilus beecheyi*), and crayfish likely improve habitat quality for giant gartersnakes by providing refugia in the form of burrows; muskrats further enhance habitat suitability by constructing lodges and reducing the density of cattails (thereby promoting the emergent vegetation/open water interface) through their foraging activity. Similar to muskrat lodges, tule thatch that accumulates naturally in mature tule marshes (like BKS) may also serve as important refuge from predators and temperature extremes and should be maintained in abundance. Giant gartersnakes have been found to actively select tule over other microhabitats available in their environment (Halstead et al. 2016).

Overall, management actions in the Natomas Basin are consistent with healthy giant gartersnake populations. Conversion of additional habitats to created marshes and maintaining proper water levels in the marshes would undoubtedly benefit giant gartersnake in the long term, and maintenance of rice agriculture will help achieve connectivity, prey production, high adult survival in canals adjacent to rice fields, and other conservation goals. Continuing to minimize ground disturbance, ensuring aquatic habitat is available in the spring for foraging upon emergence from winter refuges (Halstead et al. 2019) and maintaining stable, high water levels throughout the active season will also enhance the quality of existing habitats for giant gartersnake. Lowering water levels in the early fall may also help to concentrate prey prior to hibernation; the effectiveness of this practice as a management strategy warrants further investigation.

3.6 Recommendations

- Maintain and encourage emergent vegetation (primarily tule) in wetlands and canals.
- Maximize the open water/emergent vegetation interface that increases the probability of occurrence of giant gartersnake and has been shown in other studies (Valcarcel 2011) to be positively selected by individual giant gartersnakes. Maintaining emergent vegetation at wetland edges, clumps of vegetation in open water, and pockets of open water in stands of emergent vegetation would likely benefit giant gartersnake. Importantly, managing for maximization of the open water/emergent vegetation interface includes ensuring that water levels are high enough that snakes can forage and escape predators immediately below and adjacent to the emergent vegetation.
- Vegetation should be managed to promote tules in preference to other emergent aquatic vegetation. Giant gartersnake selection for tules is stronger than its selection of other aquatic vegetation (Halstead et al. 2016).
- Continue to encourage rice agriculture as important alternative habitat for tule marshes.
- Continue to control mosquito fern and other floating aquatic vegetation where possible. Giant gartersnake tends to avoid mosquito fern and other floating aquatic vegetation when it occurs at high densities (U.S. Geological Survey unpublished data), despite apparent positive selection at low densities (Halstead et al. 2016). Apparent selection of floating aquatic vegetation at low densities is likely an artifact of these vegetation types accumulating along the edges of water, where giant gartersnakes forage (Halstead et al. 2016). Floating aquatic vegetation likely alters vegetative and prey communities and water characteristics.
- Maintain herbaceous terrestrial bankside vegetation to provide cover for giant gartersnake when in terrestrial habitats (Halstead et al. 2016). Minimize mowing during the active season near the edge of marshes to the extent practicable, providing tall grasses for snake to hide in when moving between aquatic and terrestrial habitats.
- To the extent possible, avoid rapid changes in water levels during giant gartersnake's inactive season (October through March) to avoid disturbance to hibernating individuals, and restrict changes in water levels to the minimum number of fluctuations possible.
- Maintain as many muskrat burrows, crayfish burrows, and burrows of California ground squirrel and other small mammal burrows as feasible to provide giant gartersnakes abundant summer refuges and winter hibernacula (Halstead et al. 2015). Muskrat lodges also provide potential hibernation, basking, and shelter sites.
- Ensure aquatic habitat is available in wetlands and canals by flooding marsh complexes early in spring when giant gartersnakes emerge from burrows and begin foraging. Snake body condition (body mass relative to length) is low at this critical point in the year (Coates et al. 2009), when individuals' energy reserves are depleted from a long period of overwintering. Likely as a result of poor body condition, risk of mortality is high for giant gartersnake during this time of year (Halstead et al. 2019). Having aquatic habitat available for giant gartersnake to forage in during the early spring would likely lead to higher survival rates.
- Continue to minimize management activities in marsh habitats to the extent practicable to minimize disturbance. When wetlands must be drained during the giant gartersnake active season, do so slowly in the late summer (August or September) to more nearly approximate the

historical drying cycle of natural wetlands in the Central Valley. Doing so may provide giant gartersnake with an abundance of stranded prey and an important source of energy reserves for hibernation. Try to reflood wetlands as soon as possible and maintain stable water levels throughout the hibernation period.

- Attempt to maintain substantial aquatic habitat adjacent to marsh units drained for maintenance to ensure adequate habitat is available to giant gartersnake that might be affected by marsh maintenance activities.
- When excavating marshes during maintenance activities, ensure that slopes are not too steep for snakes that become entrapped in excavated channels to free themselves. If slopes must be steep, provide periodic (every 50 meters) shallower slopes that allow entrapped snakes to exit the channel.
- Minimize channel clearing activities to the extent practicable. Clearing water conveyance channels temporarily degrades giant gartersnake foraging habitat.

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Table 3-1. Summary of Giant Gartersnake Captures and Sampling Effort at Natomas Basin Conservancy Reserves, 2022

Reserve Area and Reserve	Number of Giant Gartersnakes		Dates Trapped (2022)	Total Trap Days
	Individuals	Captures		
North Basin				
Bennett North Central West (wetland)	0	0	22 Jun – 15 Jul	1050
Bennett North Central (wetland)	2	2	28 May – 22 Jun	1050
Bennett North Central East (wetland)	1	1	15 Jul – 5 Aug	1050
Bennett South East (canal)	1	1	24 May – 16 Jun	1050
Bolen North	0	0	2 Aug – 23 Aug	1047
Frazer North Wetland North	1	1	10 Jun – 3 Jul	1047
Frazer North Wetland Central	0	0	15 Jun – 10 Jul	1017
Huffman West	1	1	2 Aug – 23 Aug	1049
Lucich North Central	0	0	8 Aug – 29 Aug	1050
Lucich North South 1	1	1	12 Jul – 2 Aug	1050
Lucich North South2	0	0	12 Jul – 2 Aug	1050
Lucich North East	2	2	21 Jul – 13 Aug	1049
Lucich North Northeast	0	0	16 Aug – 31 Aug	748
Lucich North Northeast 2	0	0	28 Jun – 21 Jul	1048
Lucich North 4	1	2	4 Aug – 25 Aug	905
Lucich South North (rice)	2	4	16 Aug – 31 Aug	750
Lucich South South (rice)	0	0	6 May – 28 May	938
Lucich South 3	7	11	25 Jul – 15 Aug	1050
Nestor East	3	3	22 Jul – 12 Aug	1049
Ruby Ranch	0	0	15 Aug – 31 Aug	786
TNBC5	0	0	15 Aug – 31 Aug	798
TNBC6	0	0	6 Jun – 29 Jun	1050
Central Basin				
BKS North Central	5	6	3 May – 24 May	1050
BKS South Central 1	27	27	10 Aug – 31 Aug	1050
BKS Southwest Central	18	20	5 Jul – 26 Jul	1050
BKS2	11	12	2 May – 23 May	1050
BKS3	4	5	6 Aug – 27 Aug	1050
Elsie	0	0	3 Aug – 15 Aug	572
Frazer South North	9	12	7 Aug – 28 Aug	1050
Sills4	19	27	1 Jun – 24 Jun	1033
Sills5	13	17	9 May – 1 Jun	1034
Sills6	2	4	16 Jun – 11 Jul	1050
Tufts3	0	0	10 Jul – 31 Jul	1050
Fisherman's Lake				
Cummings East	0	0	13 Jul – 3 Aug	1050
Cummings East Central	0	0	1 Aug – 22 Aug	1050

Table 3-1. Continued

Reserve Area and Reserve	Number of Giant Gartersnakes: Individuals	Number of Giant Gartersnakes: Captures	Dates Trapped (2022)	Total Trap Days
Cummings West	0	0	11 Jul – 1 Aug	1047
Natomas Farms North	0	0	27 Jul – 17 Aug	1049
Natomas Farms 1	0	0	13 Jun – 8 Jul	1050
Natomas Farms 2	0	0	9 Aug – 30 Aug	1049
Rosa Central	0	0	23 May – 15 Jun	1050
Rosa Central South	0	0	12 Aug – 31 Aug	948
Total	**130**	**159**		**42,997**

Table 3-2. Prior Probabilities for Parameters of Single-Season Occupancy Models for Giant Gartersnake on Natomas Basin Conservancy Reserve Properties, 2022

Component	Model	Parameter	Uninformative priors
Detection	All	β_0	*N(0,1.648)*
	All	β_{temp}	*N(0,1.648)*
	All	β_{date}	*N(0,1.648)*
	All	σ_{site}	*U(0,10)*
Occupancy	$\psi_{habitat}$ and ψ_{basin}	β_0	*N(0,1.648)*
	$\psi_{habitat}$	β_{rice}	*N(0,1.648)*
		$\beta_{em.vegergent}$	*N(0,1.648)*
		$\beta_{fl.veg}$	*N(0,1.648)*
		$\beta_{open.water}$	*N(0,1.648)*
		$\beta_{terr.veg}$	*N(0,1.648)*
	ψ_{basin}	β_{north}	*N(0,1.648)*
		$\beta_{central}$	*N(0,1.648)*
		β_{south}	*N(0,1.648)*

Table 3-3. Posterior Distributions for Capture Parameters of Closed Abundance Model of Giant Gartersnake in the Natomas Basin, 2022

Model Component	Parameter	Median (95% CI)
Capture	p_0	0.0017 (0.0005–0.0056)
	α_{temp}	0.1959 (0.0025–0.3928)
	α_{SVL}	0.2212 (-0.2764–0.7037)
	α_{sex}	0.2800 (-0.6028–1.1758)
	α_{behav}	1.9797 (1.0637–2.7824)
	σ_{site}	0.0008 (0.0001–0.0005)
	σ_{ind}	0.0012 (0.0004–0.0028)
	σ_{day}	0.0009 (0.0002–0.0030)

Table 3-4. Summary of Giant Gartersnake Captures and Abundance Estimates, 2022

Site	Indiv	Cap	*N*	Trap Days	Shoreline Sampled (kilometers)
Bennett North	2	3	42 (19–77)	3,150	2.67
Bennett South	1	1	42 (20–77)	1,050	0.86
BKS	79	87	385 (211–681)	6,300	4.01
Huffman West	1	1	42 (20–77)	1,049	0.82
Lucich North	8	9	46 (23–83)	10,116	8.13
Lucich South	9	15	46 (22–84)	2,788	2.40
Sills	31	48	148 (76–267)	4,752	3.71
Total	**131**	**164**	**751 (402–1342)**		

Table 3-5. Posterior Summaries for Parameters from the Robust-Design CMR Model, 2018–2022

Model component	Parameter	Median (95% CI)
Recapture	p	0.007 (0.003–0.020)
	β_{wt}	0.205 (0.095–0.319)
	σ_{site}	0.572 (0.092–1.909)
	σ_{year}	0.388 (0.148–0.777)
Survival	φ_{female}	0.493 (0.338–0.678)
	φ_{male}	0.501 (0.340–0.705)
	σ_{φ}	0.759 (0.229–1.804)
Availability	γ_{female}	0.585 (0.365–0.833)
	γ_{male}	0.405 (0.139–0.886)
	σ_{γ}	0.500 (0.024–1.954)

Table 3-6. Posterior Model Probabilities for Probability of Occurrence of Giant Gartersnake Based on Habitat on Natomas Basin Conservancy Reserves, 2022

Explanatory Variable					
Rice	Emergent Vegetation	Floating Aquatic Vegetation	Open Water	Terrestrial Vegetation	Posterior Probability
0	0	0	0	0	0.097
0	1	0	0	0	0.069
1	0	0	0	0	0.062
0	0	1	0	0	0.057
1	1	0	0	0	0.050
0	0	0	0	1	0.047

Notes: “1” indicates that the variable was included in the model.
“0” indicates that the variable was left out of the model.
Only those models with posterior probability >0.05 and the null model are presented in the table.

Table 3-7. Posterior Distributions for Parameters of the Final Single-Season Occupancy Habitat Model for Giant Gartersnake on Natomas Basin Conservancy Reserve Properties, 2022

Model Component	Parameter	Posterior Probability
Detection	μ_p	0.07 (0.03 to 0.23)
	α_0	-2.34 (-3.53 to -1.13)
	α_{temp}	0.31 (0.01 to 0.61)
	α_{date}	-0.32 (-1.07 to 0.43)
	σ_{site}	2.14 (1.24 to 3.3)
Occurrence	ψ_{North}	0.91 (0.42 to 0.99)
	$\psi_{Central}$	0.95 (0.50 to 0.99)
	$\psi_{Fisherman's\_Lake}$	0.09 (0.01 to 0.82)
	β_{North}	0.96 (-1.30 to 3.40)
	$\beta_{Central}$	1.58 (-0.80 to 4.07)
	$\beta_{Fisherman's\_Lake}$	-2.06 (-4.59 to 0.53)
	β_{rice}	0.13 (-2.74 to 3.28)
	N_{occ}	30 (22 to 37)

Note: Posterior distributions are represented by the posterior median and symmetric 95% credible interval.

Table 3-8. Posterior Model Probabilities for Effects of Habitat on Dynamic Occupancy of Giant Gartersnake on Natomas Basin Conservancy Reserves, 2011–2022

Explanatory Variable					
Emergent Vegetation	Terrestrial Vegetation	Floating Aquatic Vegetation	Submerged Aquatic Vegetation	Rice	Posterior Probability
0	0	0	0	0	0.3423
0	0	0	0	1	0.1197
0	1	0	0	1	0.1104

Notes: “1” indicates that the variable was included in the model.
“0” indicates that the variable was left out of the model.
Only those models with posterior probability >0.05 are presented in the table.

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FIGURE 3-1
Giant Gartersnake (*Thamnophis gigas*)

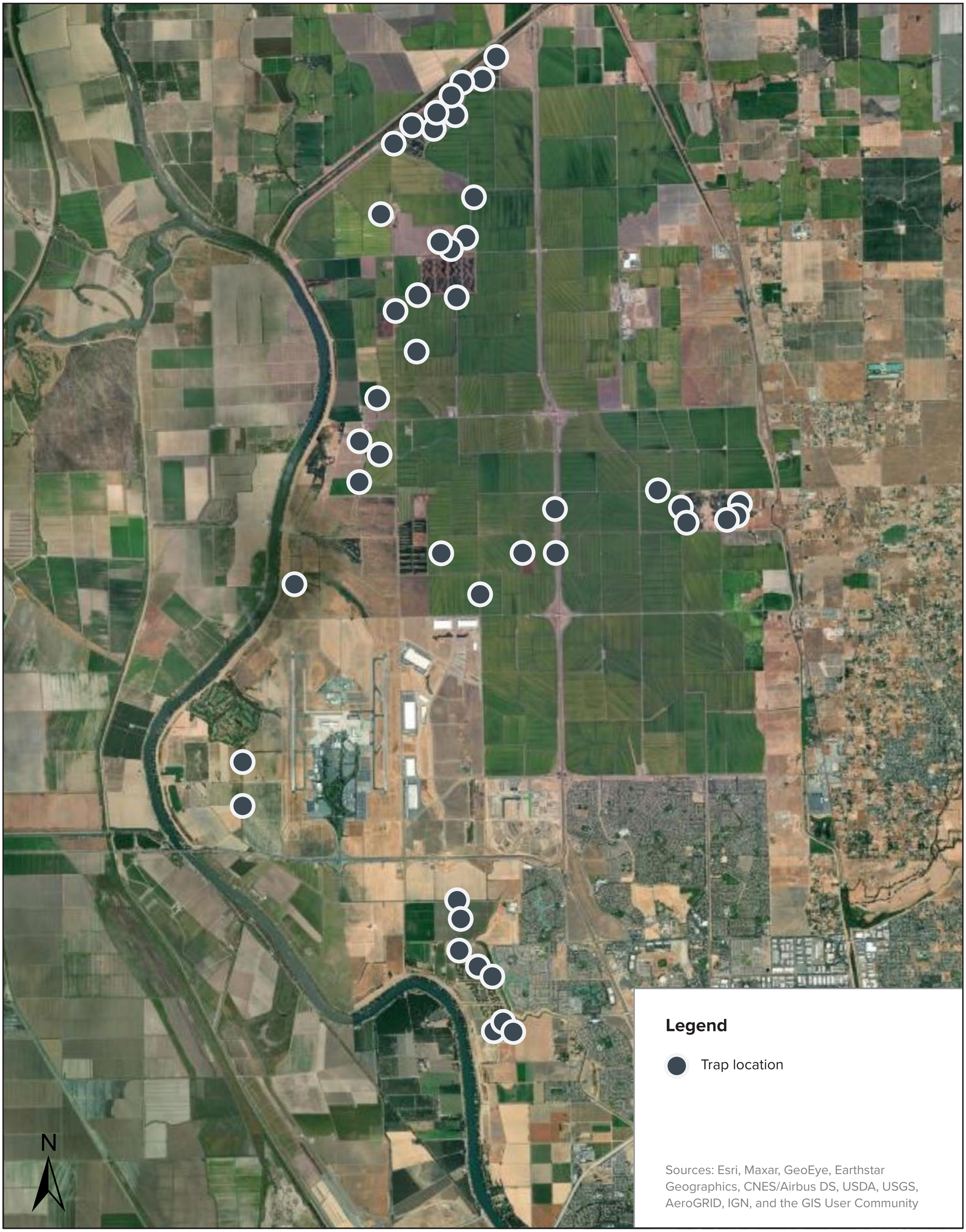

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FIGURE 3-2
Areas Sampled for Giant Gartersnake in the Natomas Basin in 2022

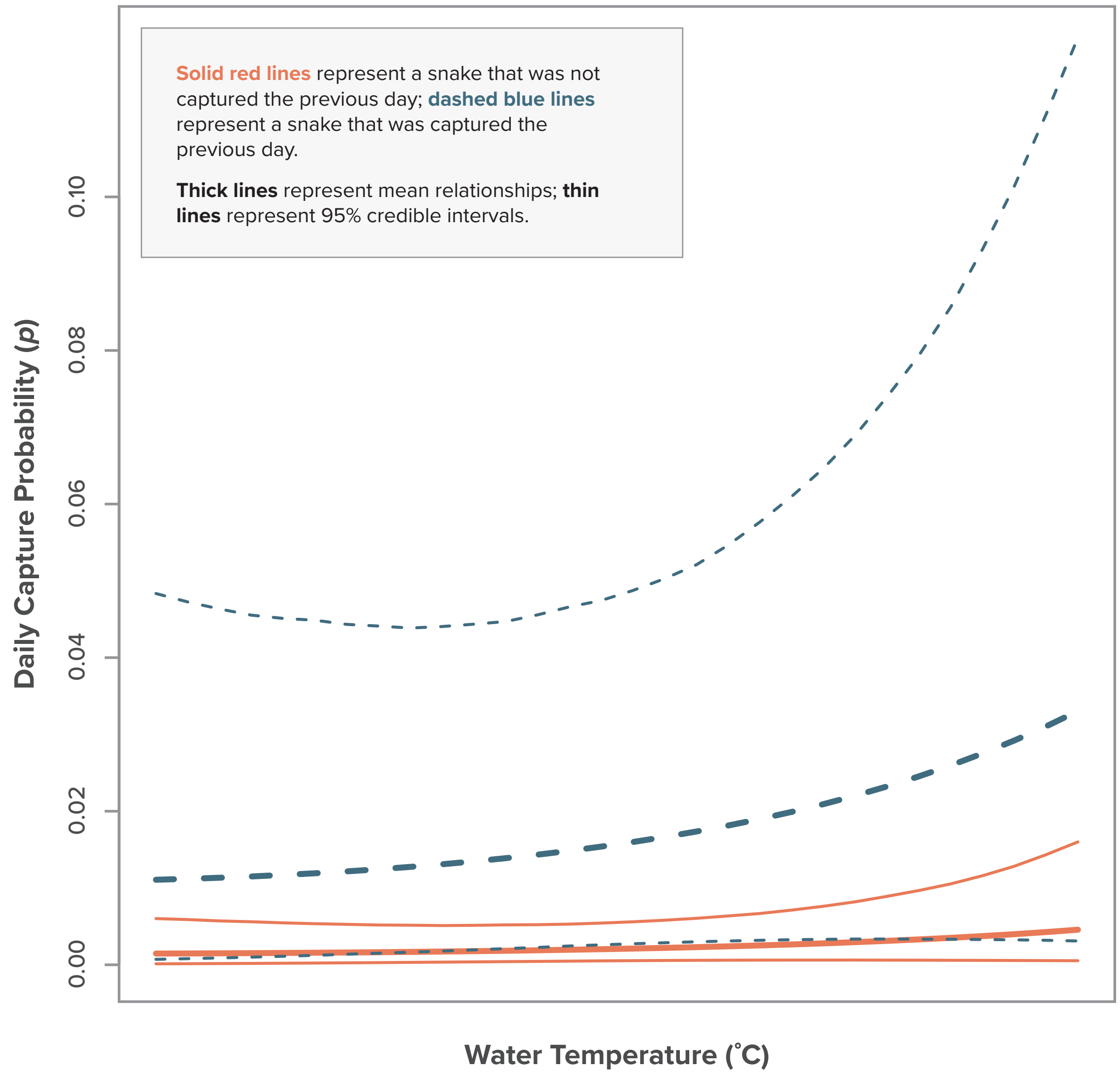

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FIGURE 3-3
Model Averaged Effect of an Ephemeral Behavioral Response and Water Temperature on Giant Gartersnake Capture Probability in the Natomas Basin in 2022

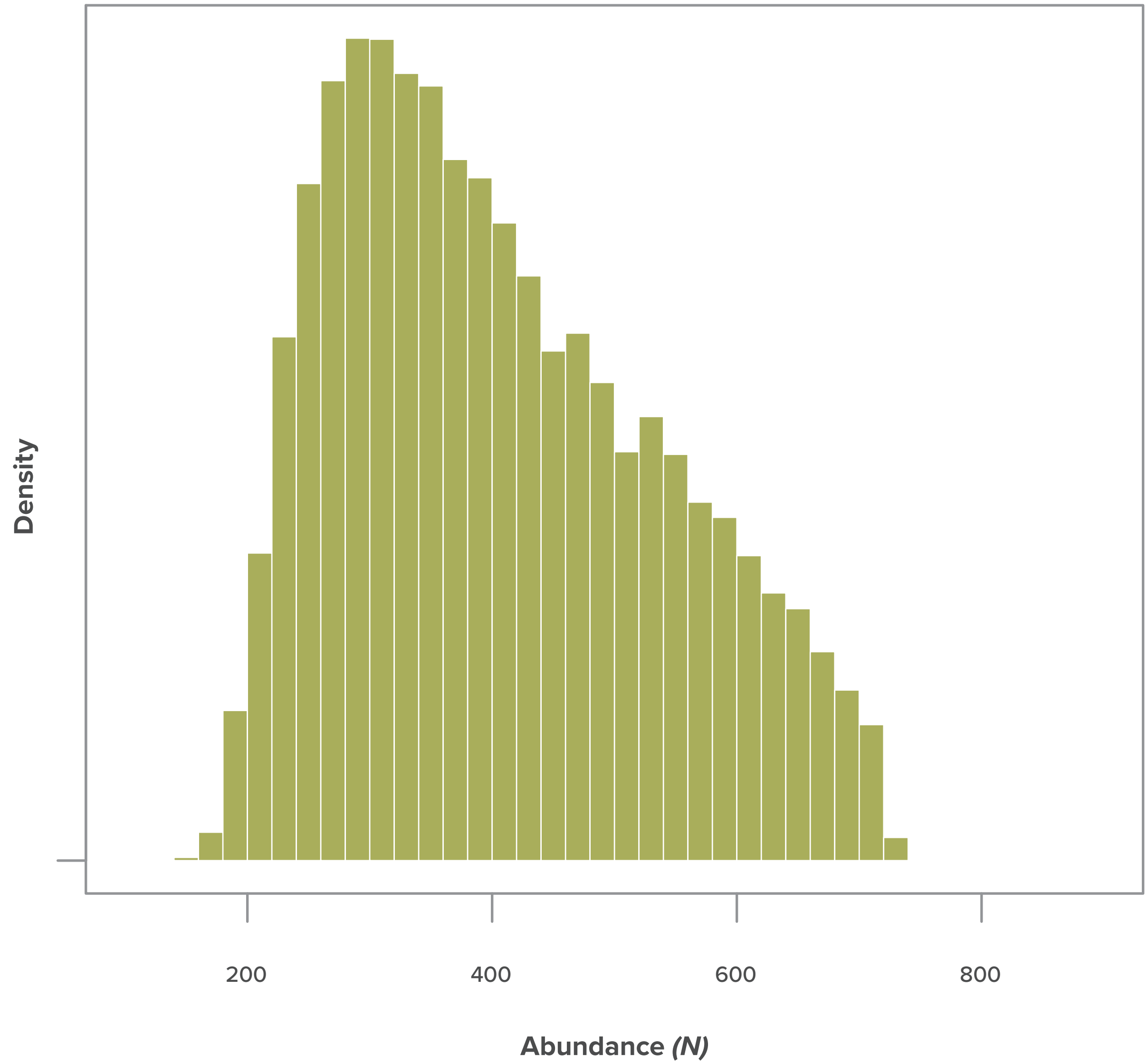

FIGURE 3-4
Posterior Distribution of Estimated Giant Gartersnake Abundance in the Sampled Area at BKS Based on Closed Population Models in 2022

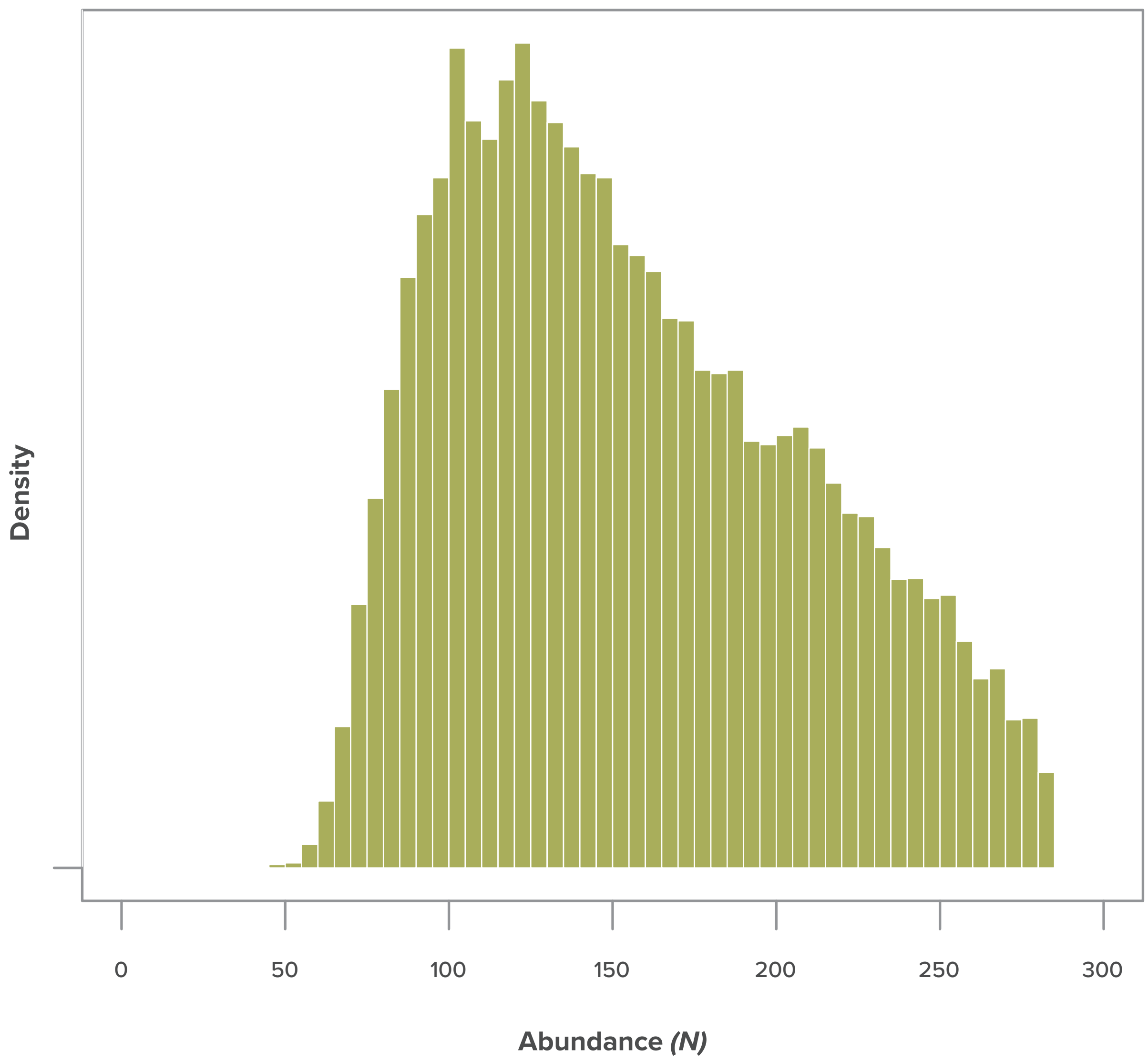

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FIGURE 3-5
Posterior Distribution of Estimated Giant Gartersnake Abundance in the Sampled Area at Sills Based on Closed Population Models in 2022

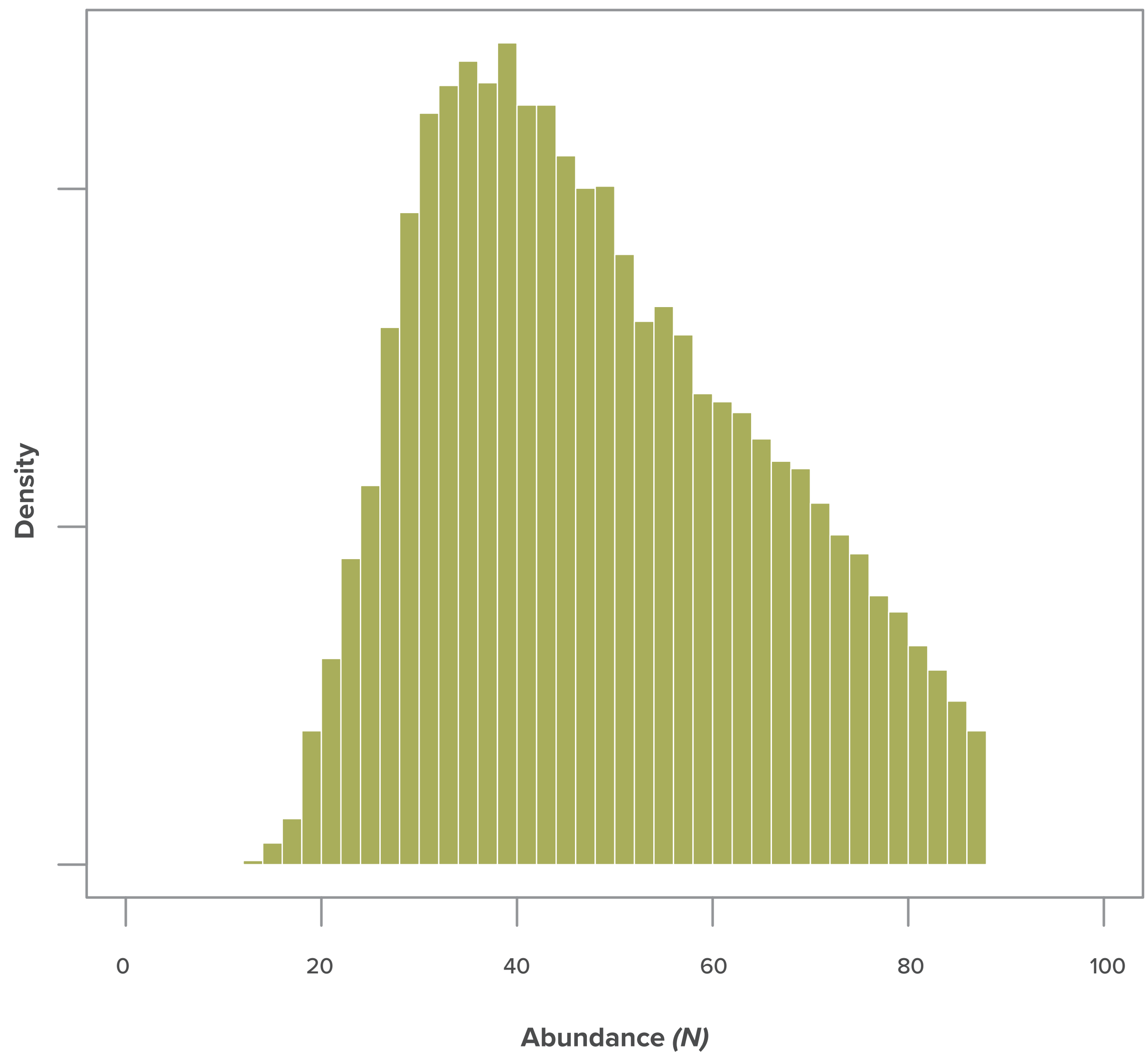

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FIGURE 3-6
Posterior Distribution of Estimated Giant Gartersnake Abundance in the Sampled Area at Lucich North Based on Closed Population Models in 2022

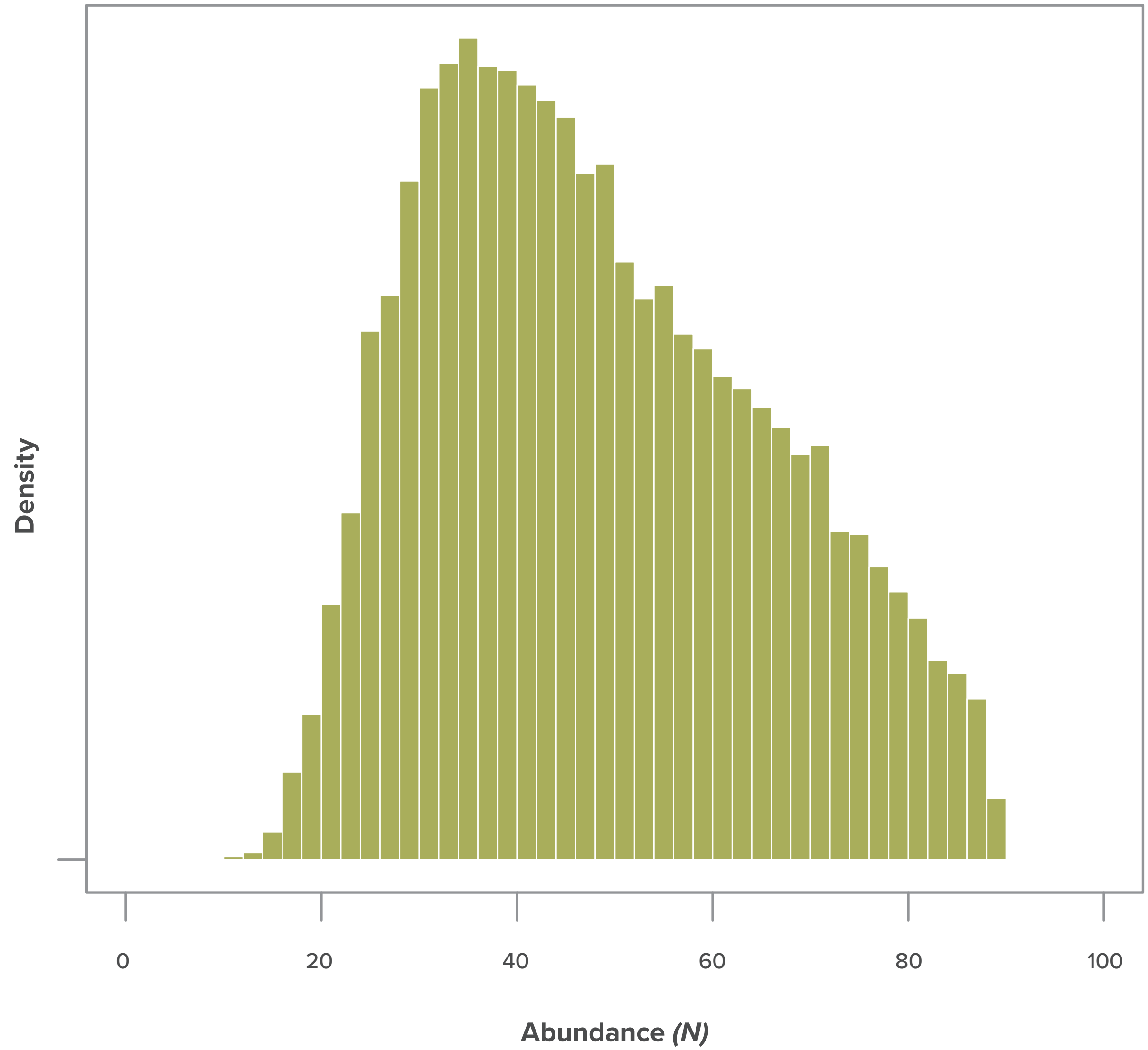

FIGURE 3-7
Posterior Distribution of Estimated Giant Gartersnake Abundance in the Sampled Area at Lucich South Based on Closed Population Models in 2022

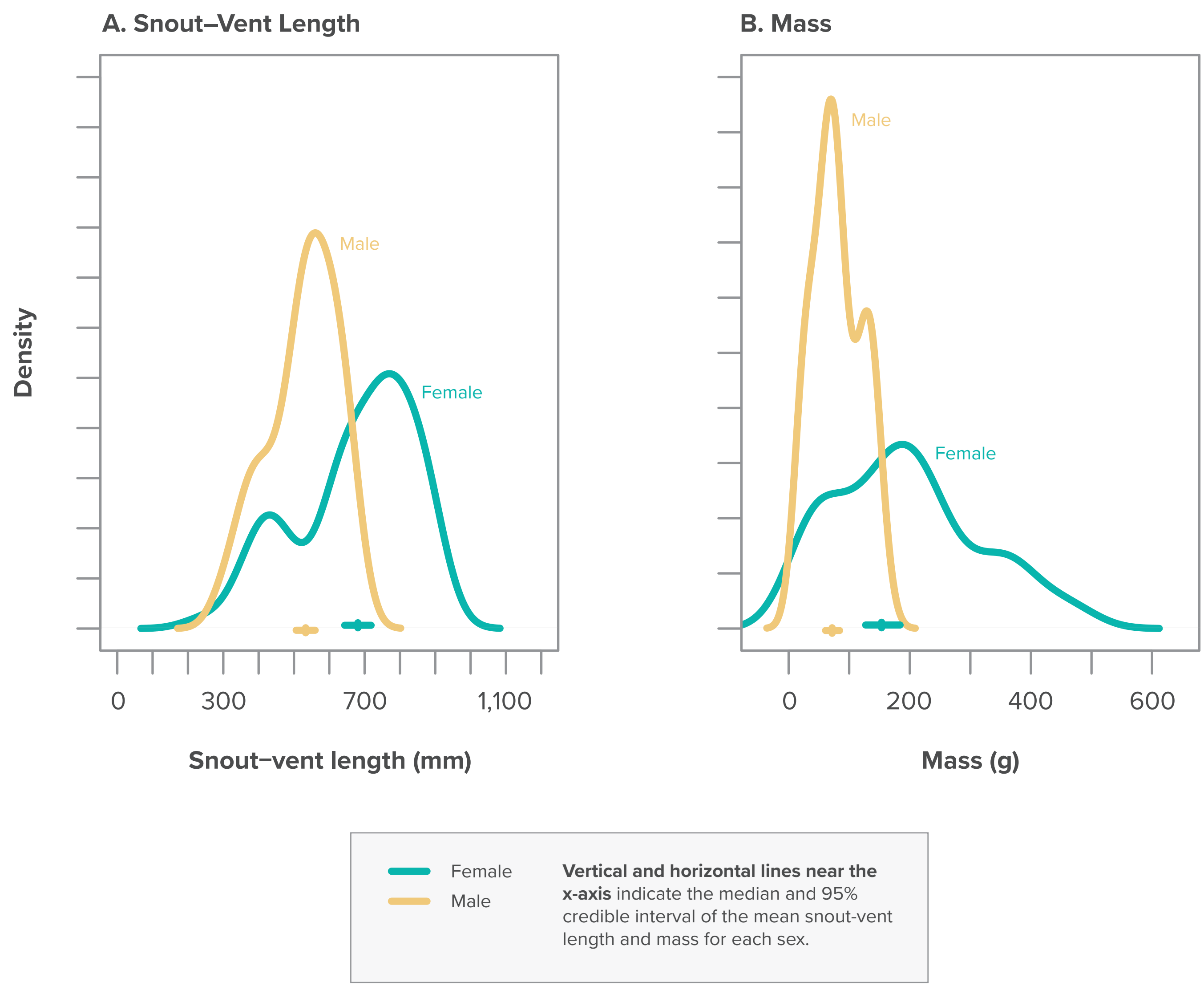

FIGURE 3-8
Distribution of Male and Female
Snout-Vent Length (A) and Mass (B) in the Natomas Basin, 2022

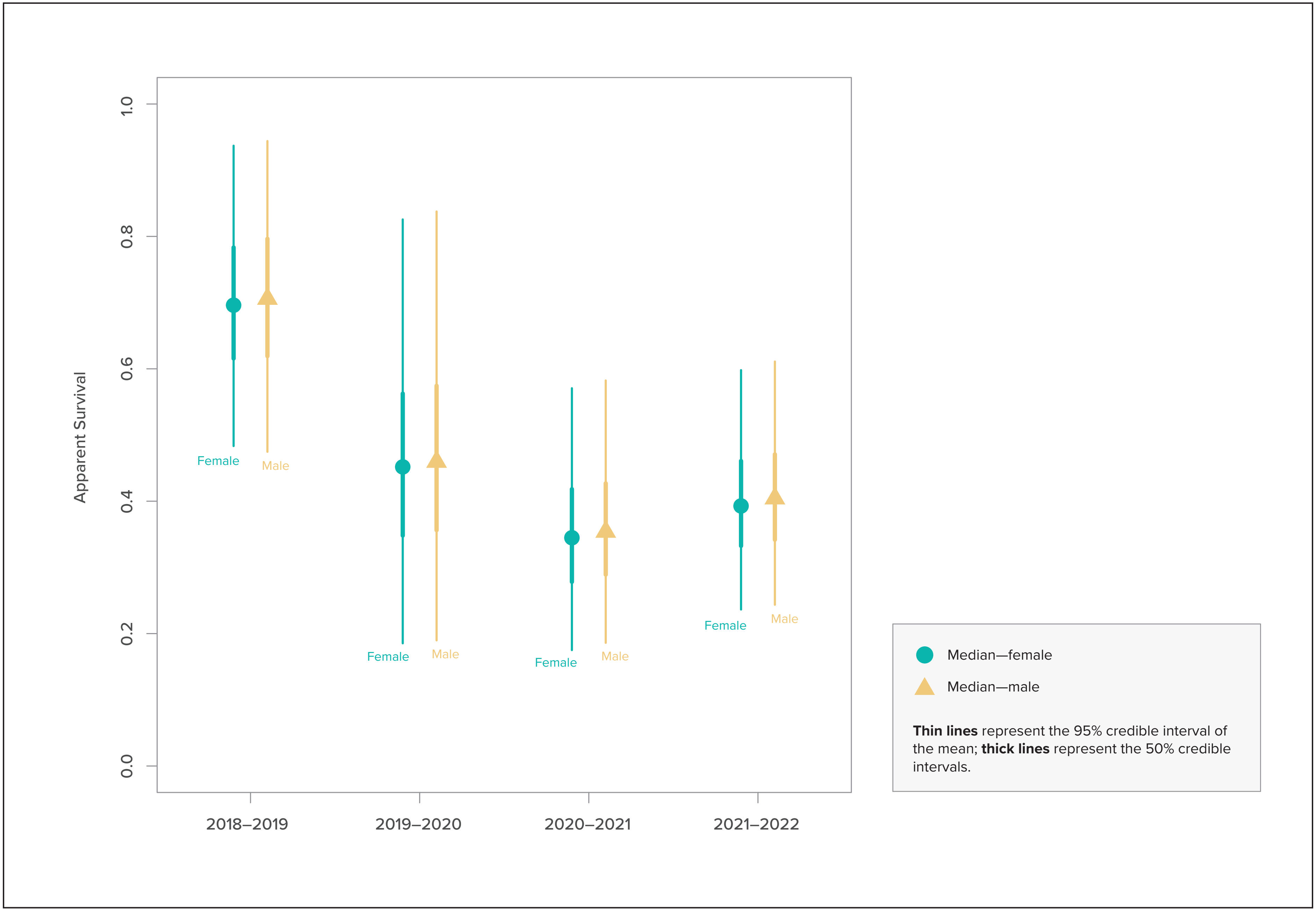

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FIGURE 3-9
Annual Apparent Survival Estimate for Giant Gartersnake in the BKS Tract, 2018–2022

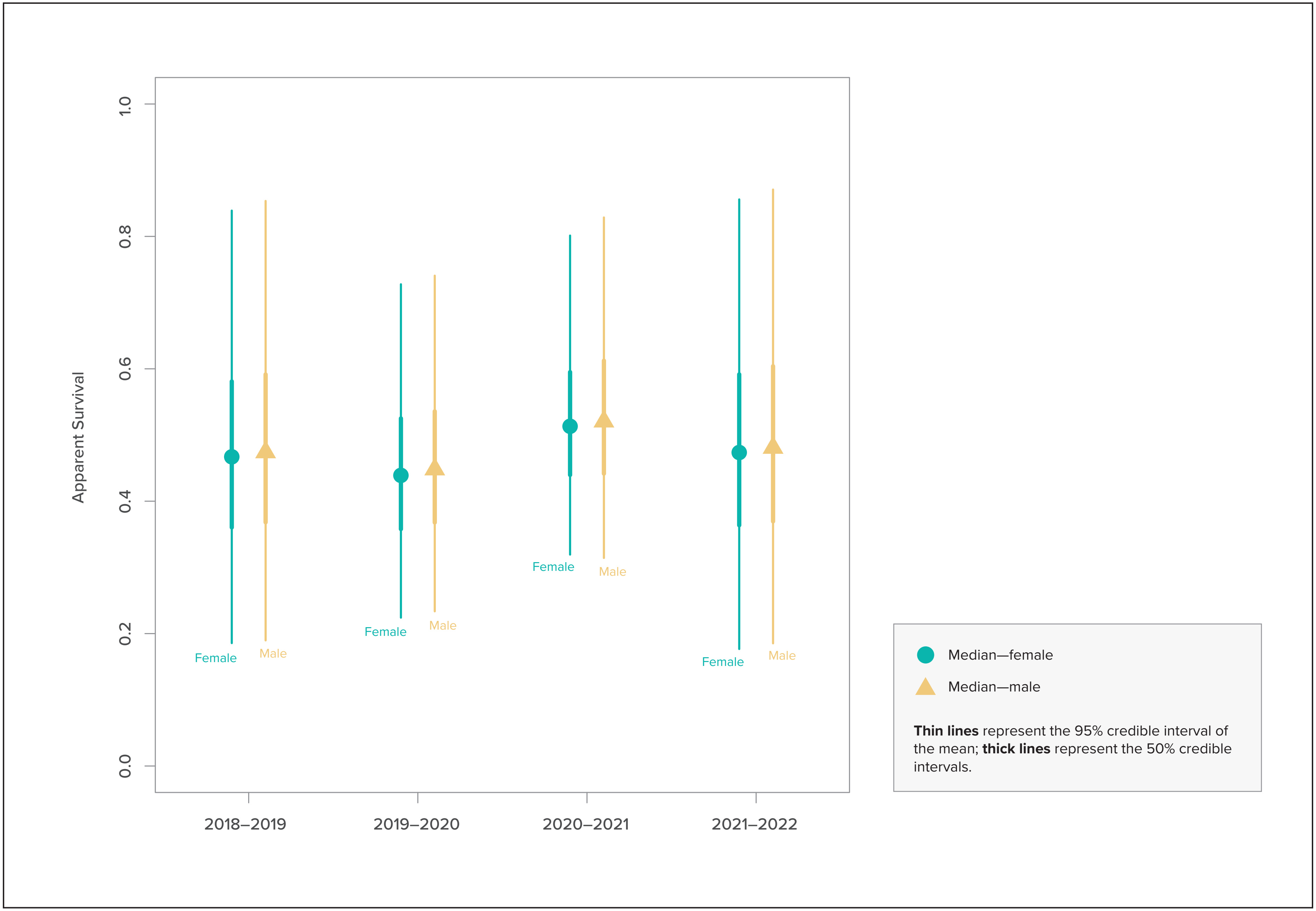

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FIGURE 3-10
Annual Apparent Survival Estimate for Giant Gartersnake in the Lucich North Tract, 2018–2022

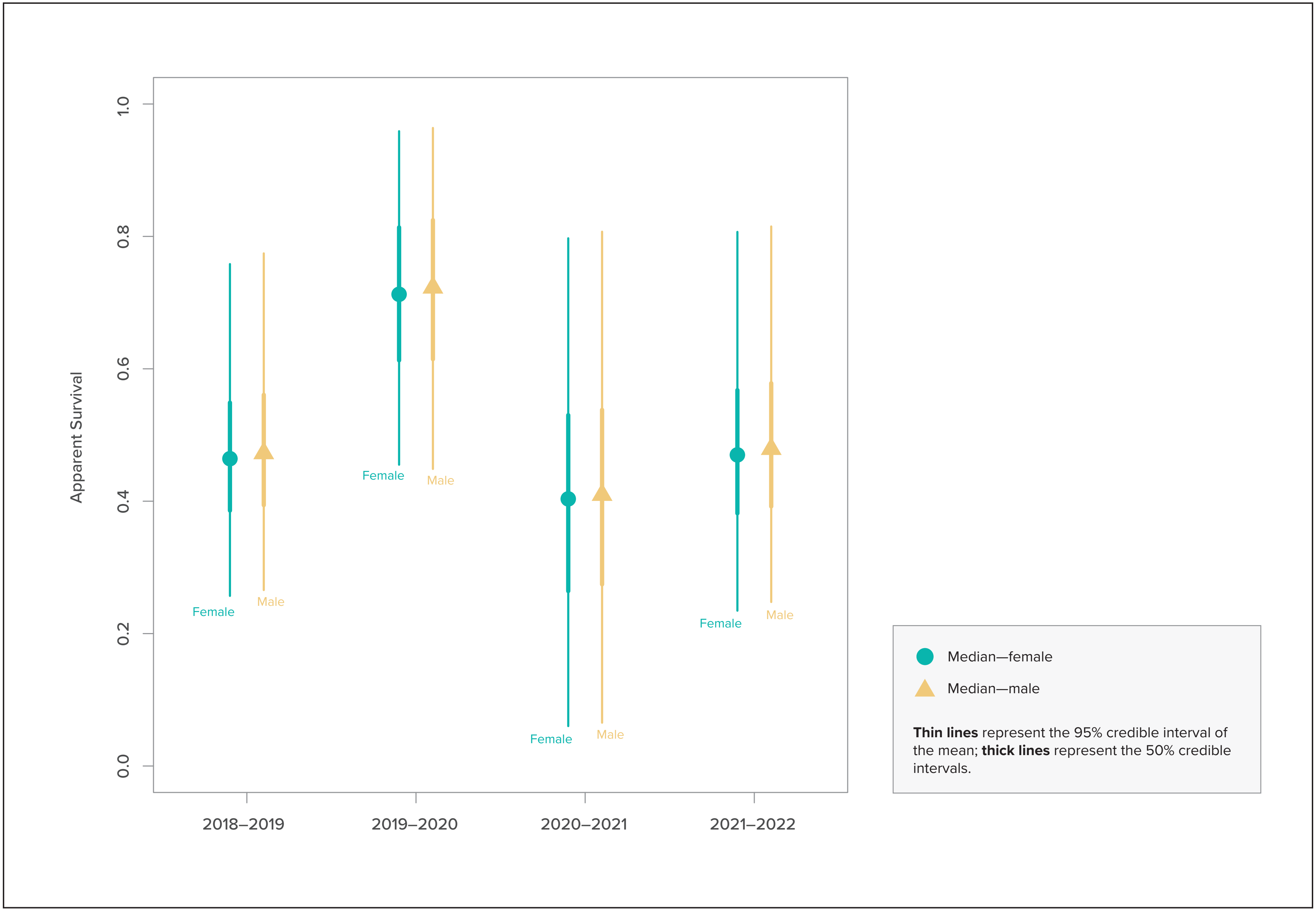

FIGURE 3-11
Annual Apparent Survival Estimate for Giant Gartersnake in the Sills Tract, 2018–2022

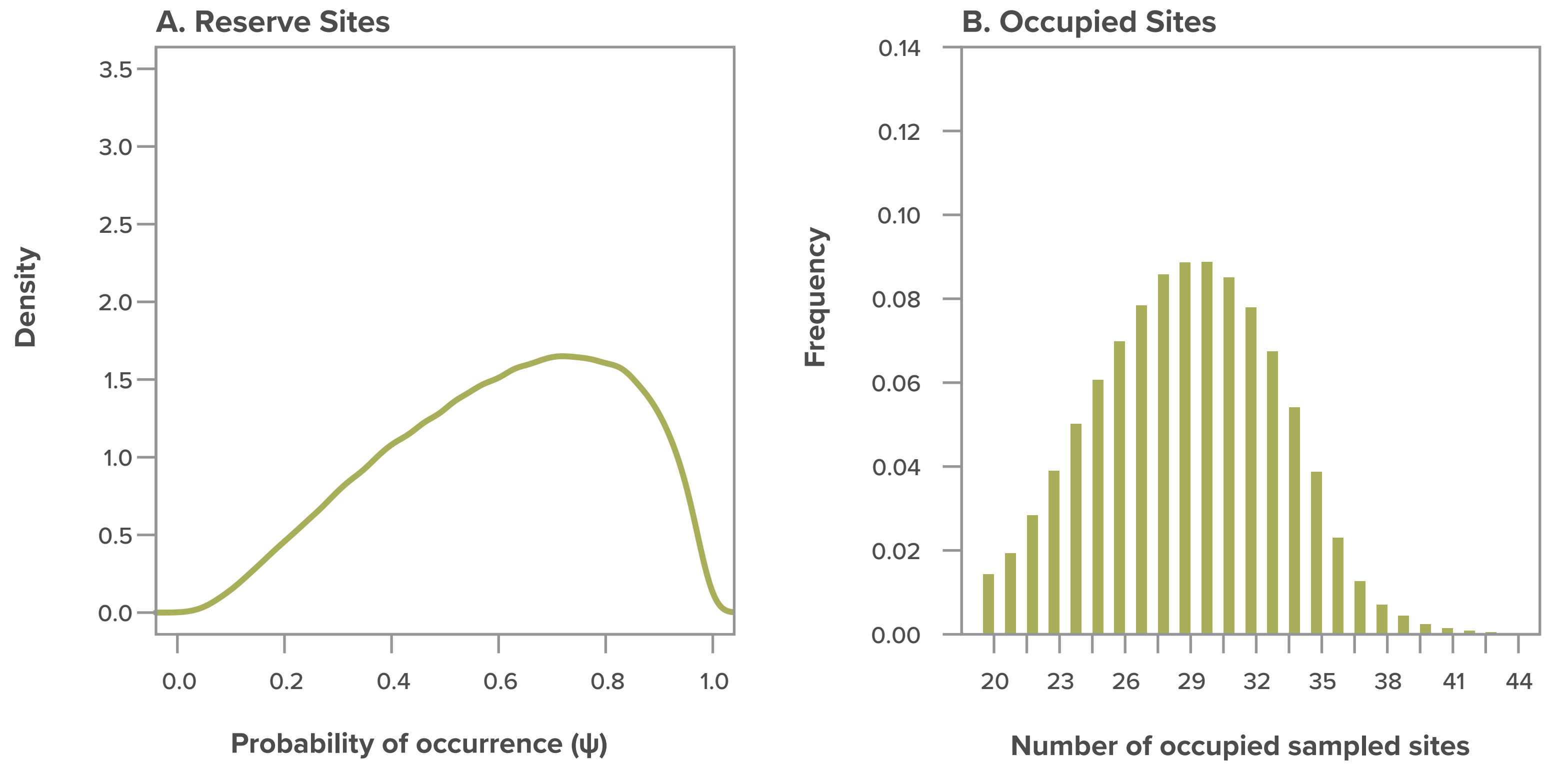

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FIGURE 3-12
Proportion of Reserve Sites Occupied (A) and Number of Occupied Sites (B) Based on Static Occupancy Models for the Natomas Basin, 2022

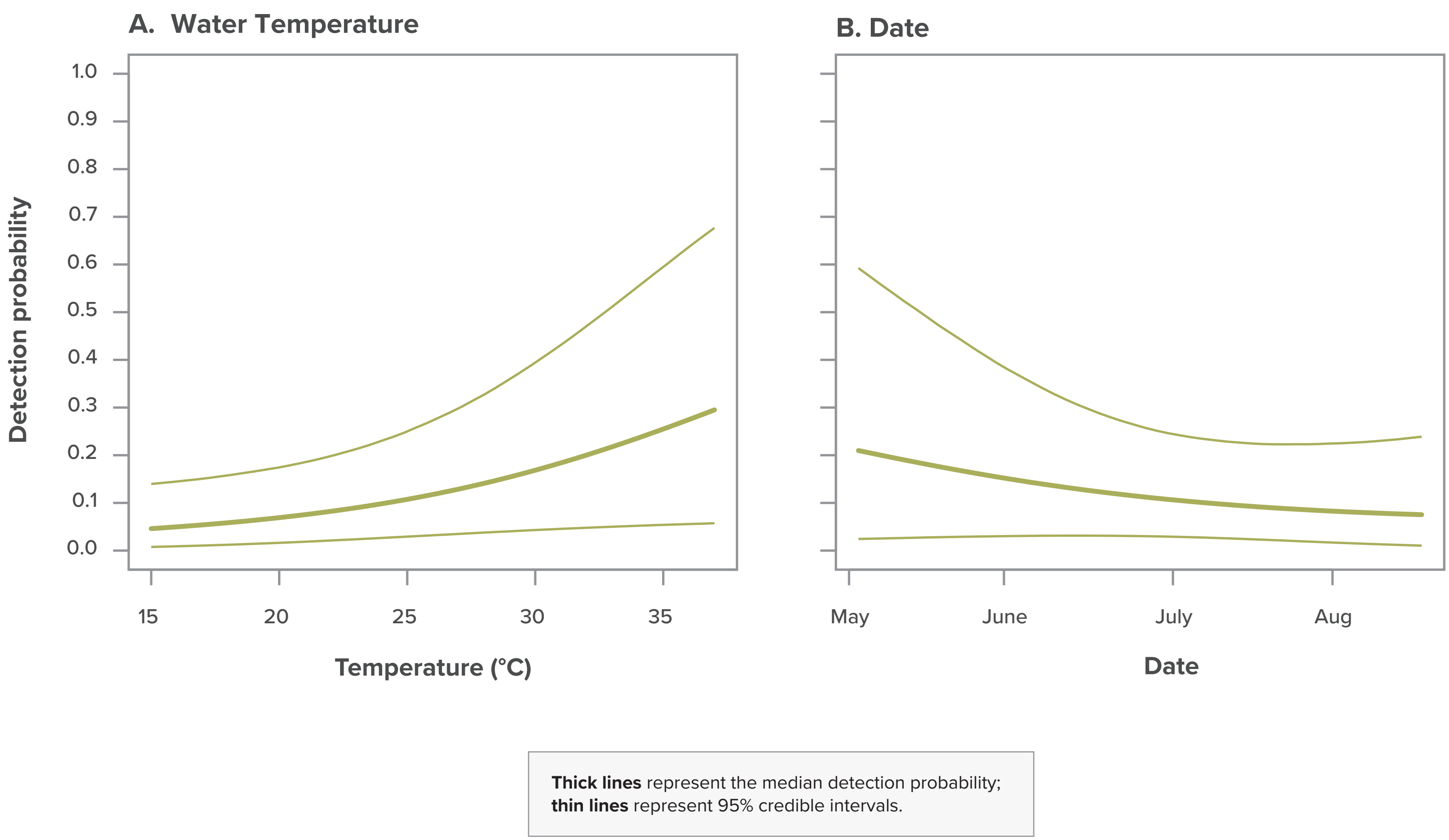

FIGURE 3-13
Effects of (A) Water Temperature and (B) Date on the Detection Probability of Giant Gartersnake in the Natomas Basin, 2022

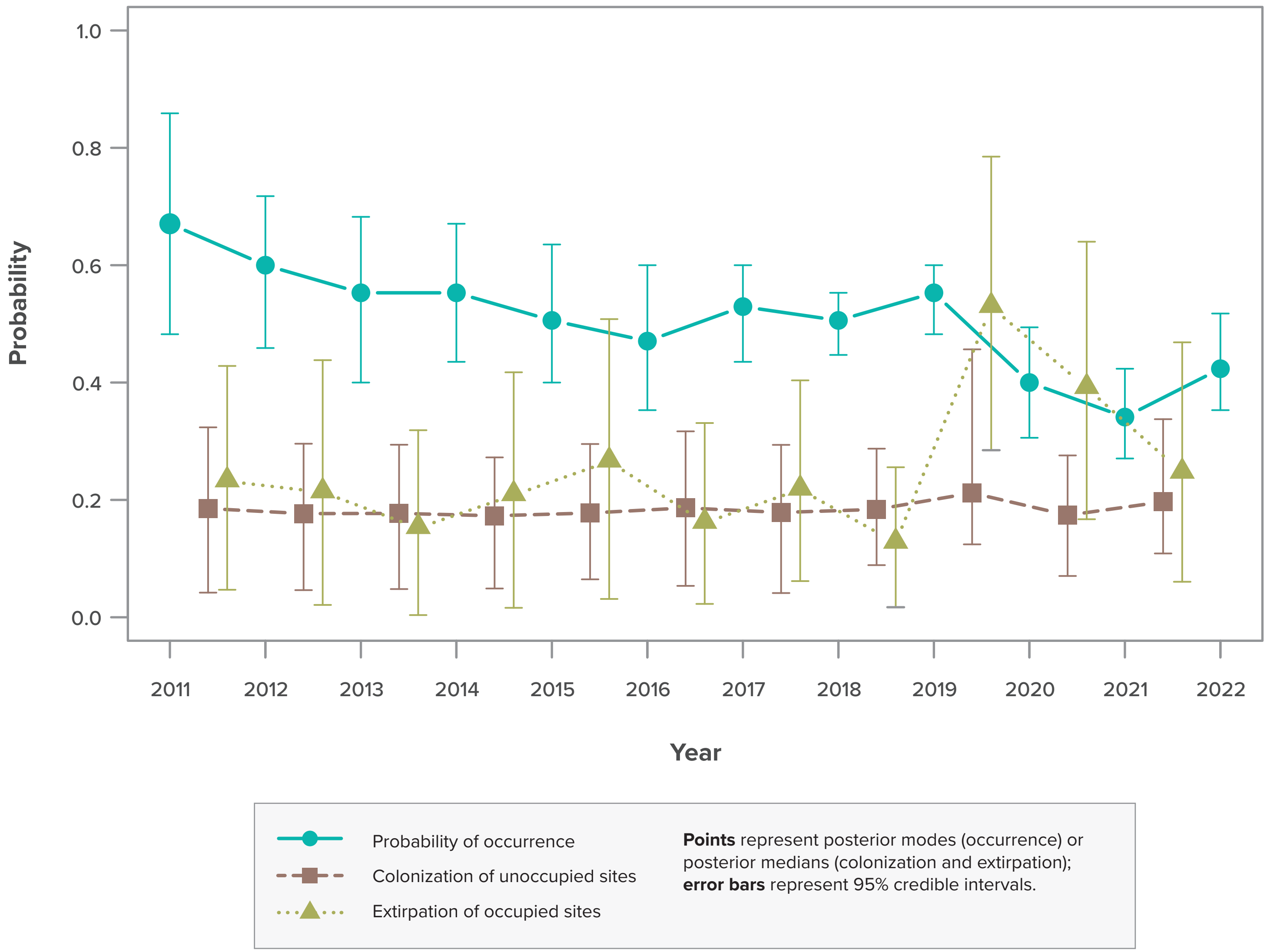

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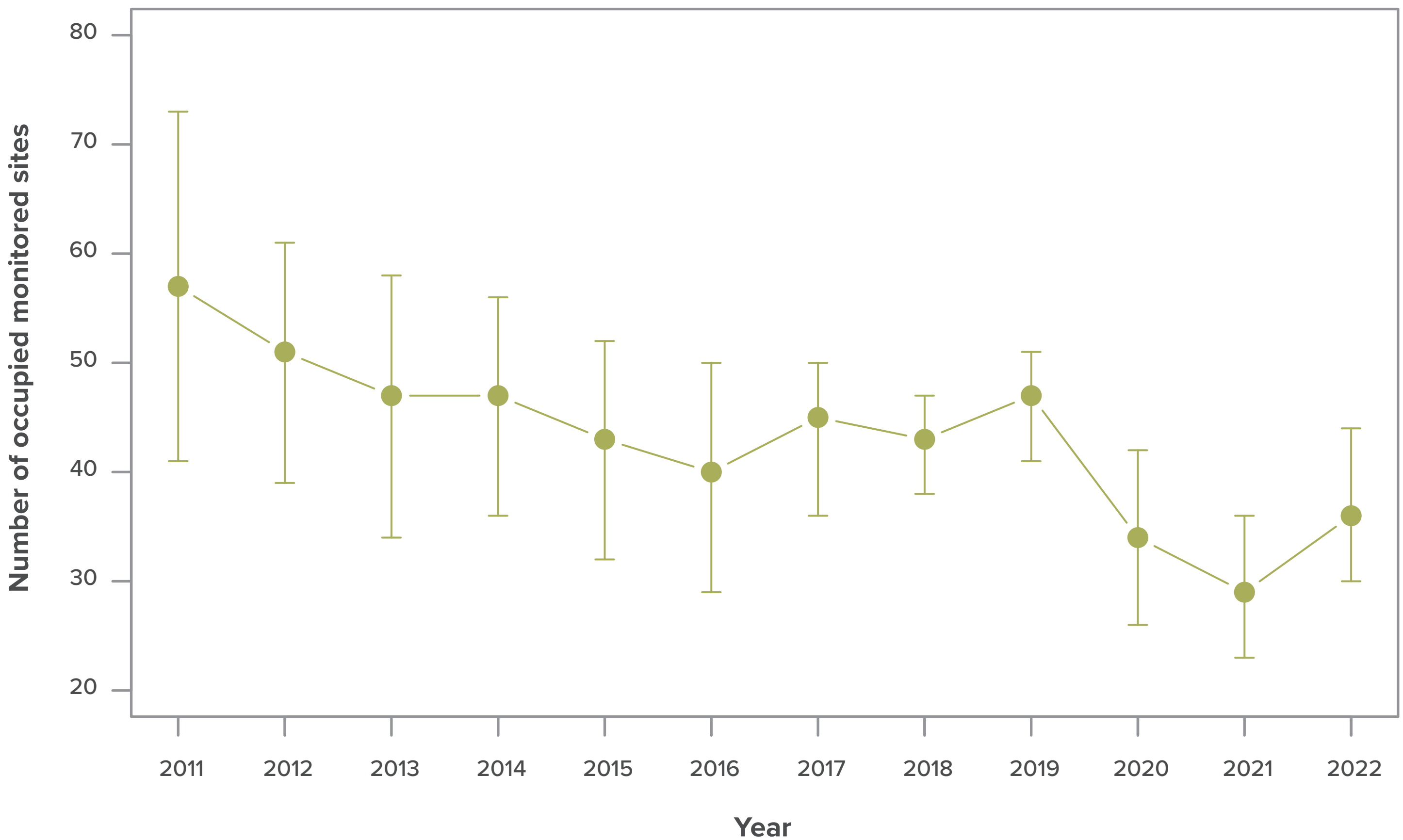
FIGURE 3-14

Annual Probability of Occurrence of Giant Gartersnake on Reserves Based on the Dynamic Occupancy Model



Points represent posterior modes; **error bars** represent 95% credible intervals. Note that 41 sites were sampled in 2022, and a total of 83 unique sites were sampled for giant gartersnake occurrence in at least 1 year from 2011 to 2022.

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FIGURE 3-15
Estimated Number of Sampled Reserve Sites Occupied by Giant Gartersnake

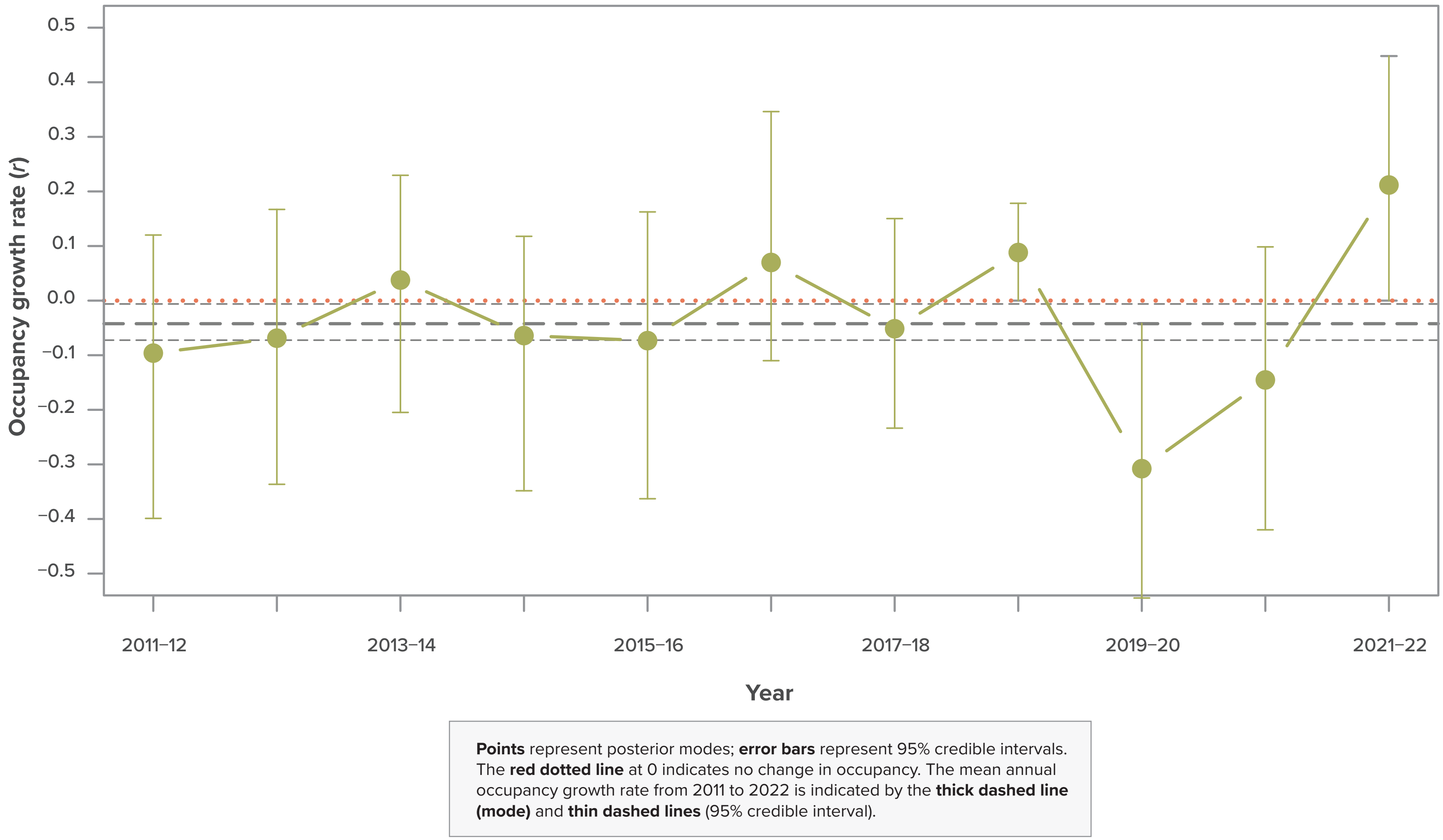

FIGURE 3-16
Annual Intrinsic Rate of Occupancy Growth for Giant Gartersnake in Reserves, 2011–2022

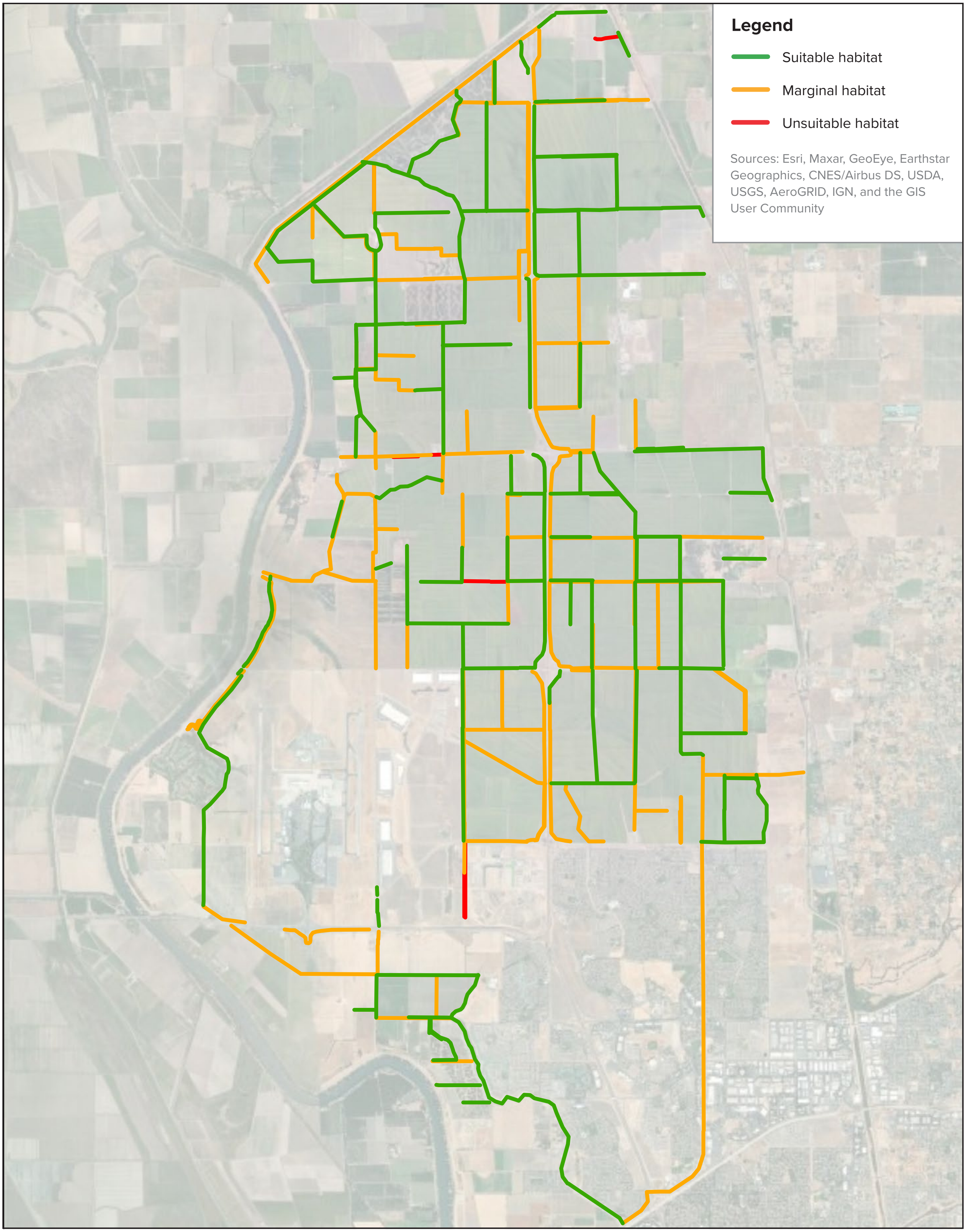

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FIGURE 3-17
Suitability of Habitat in the Canals of the Natomas Basin for Giant Gartersnake in 2022

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Chapter 4
Swainson's Hawk

CHAPTER HIGHLIGHTS

- Following a decrease in the number of occupied territories to slightly above the monitoring period average in 2021, the number of occupied territories in 2022 increased to the third highest observed during the monitoring period.
- Following a substantial decrease in all measures of reproductive success in 2021, reproductive metrics rebounded somewhat but remained relatively low in 2022. A statistically significant long-term decline in the number of young produced per successful nest was still evident in 2022, a phenomenon observed across the range of the species in California.
- Management of habitats on reserve lands continues to be better than on similar lands in the Basin outside of reserves. However, the proportion of suitable foraging habitat in the Basin composed of reserve lands is too small to determine if management of reserve lands is contributing significantly to the success of the Swainson's hawk population in the Basin.
- Provision of future nest trees, planting suitable crops (e.g., alfalfa or winter wheat followed by another row crop), and maintenance of vegetative cover on fallow rice fields are management actions most likely to contribute to the effectiveness of reserve lands in supporting the Swainson's hawk population in the Basin.

4.1 Introduction

4.1.1 Background

The NBHCP and its Implementing Agreement (City of Sacramento et al. 2003) require that an annual survey of nesting Swainson's hawks be conducted throughout the Basin (Chapter VI, Section E [2][a][1] of the 2003 NBHCP). In compliance with the conditions described in the NBHCP, this chapter describes the methods, results, and implications of the results of surveys for Swainson's hawk in the Natomas Basin from 1999 through 2022.

It should be noted that the study area for this species differs slightly from the study area used in all other monitoring efforts. For the purposes of conducting Swainson's hawk population monitoring, the study area was expanded in 2001 to include the far side of the peripheral water bodies (i.e., the Sacramento River, the Natomas Cross Canal, and Steelhead Creek) because these areas support nesting habitat for Swainson's hawks that forage within the Basin. Moreover, individual pairs may use alternate nest sites within given territories that span these water bodies. This expanded study area is referred to as *the Basin* in this chapter.

4.1.2 Goals and Objectives

Monitoring efforts for Swainson's hawk are designed to assess the progress of the NBHCP toward meeting the Plan's goals and objectives for Swainson's hawk populations and the habitats they use. The Swainson's hawk monitoring surveys are designed to achieve the following specific objectives.

- Document the numbers, distribution, density, and reproductive success of the Swainson's hawk population in the Basin.
- Conduct surveys in a systematic and repeatable manner that will ensure detection of all active Swainson's hawk nests in the Basin from year to year.
- Document changes in land use and availability of foraging habitats throughout the Basin over time.

4.1.3 Life History

4.1.3.1 Status and Range

Swainson's hawk (Figure 4-1) inhabits grassland plains and agricultural regions of western North America during the breeding season and grassland and agricultural regions from Central Mexico to southern South America during the non-breeding season (Bechard et al. 2010; Airola et al. 2019). Early accounts described Swainson's hawk as one of the most common raptors in the state, occurring throughout much of lowland California (Sharp 1902). Since the mid-1800s, the native habitats that supported the species have undergone a gradual conversion to agricultural uses. Today, native grassland habitats are virtually nonexistent in the state, and only remnants of the once-vast riparian forests and oak woodlands still exist (Katibah 1983). This habitat loss contributed to a substantial reduction in the breeding range and has reduced the estimated size of the breeding population by more than 90% in California (Bloom 1980; Bechard et al. 2010).

More recent surveys indicate a larger and possibly expanding breeding population in the Central Valley, which supports approximately 94% of the statewide population (Anderson et al. 2007). The results of the 2005–2006 statewide survey conducted by DFW and the Swainson's Hawk Technical Advisory Committee indicated the Central Valley supported an estimated 3,218 (± 947) breeding pairs (Battistone et al. 2019), or between 19% and 80% of the historical population (Bloom 1980). The most recent effort to estimate the statewide population was conducted in 2018 (Furnas et al. 2022) with results suggesting a more substantial recovery of the species in California and an estimated population of 18,810 (95% CI: 11,353–37,228) exceeding the range of the estimated historical population. However, the results are inconsistent with the continuing reduction of suitable foraging habitat in the Central Valley and the results of regional surveys and monitoring efforts, issues which are acknowledged in the Furnas et al. (2022) report. This report also identified potential survey and modeling issues that may have resulted in an overestimation of the size of the population, which led the authors to recommend changes to the protocol for subsequent survey efforts and to caution readers regarding the use of the results to address management implications.

The Central Valley population extends from Tehama County south to Kern County. Yolo, Sacramento, and San Joaquin Counties support the bulk of this Central Valley population (Estep 1989; Battistone et al. 2019) (Figure 4-2). The Central Valley population is geographically isolated from the rest of the breeding population, which extends northward into western and central Canada and eastward to northwestern Illinois (England et al. 1997). Unpublished data from banding studies conducted by R.

Anderson, P. Bloom, J. Estep, and B. Woodbridge suggest that no movement occurs between the Central Valley breeding population and other populations. However, results of satellite radio telemetry studies of migratory patterns indicate that birds outside of the Central Valley may occasionally travel through portions of the Central Valley during migration (Kochert et al. 2011).

Despite the loss of native habitats in the Central Valley, Swainson's hawks appear to have adapted relatively well to certain types of agricultural patterns in areas where suitable nesting habitat remains. However, nesting and foraging habitat for Swainson's hawks continues to decline in the Central Valley primarily due to agricultural practices and urban expansion.

4.1.3.2 Habitat Use

Swainson's hawks usually nest in large native trees, such as valley oak (*Quercus lobata*), cottonwood (*Populus fremontii*), walnut (*Juglans* spp.), and willow (*Salix* spp.), and with increasing frequency in nonnative trees, such as eucalyptus (*Eucalyptus* spp.). Nests occur in riparian woodlands, roadside trees, trees along field borders, isolated trees, small groves, and on the edges of remnant oak woodlands. Stringers of remnant riparian forest along drainages contain the majority of known nests in the Central Valley (Estep 1984; Schlorff and Bloom 1984; Kochert et al. 2011). Nests are usually constructed as high as possible in the tree, providing protection to the nest as well as visibility from it (Figure 4-3).

Nesting pairs are highly traditional in their use of nesting territories and nesting trees. Many nest territories in the Central Valley have been occupied annually since 1979, and banding studies conducted since 1986 confirm a high degree of nest site and mate fidelity (Estep unpublished data).

In the Central Valley, Swainson's hawks feed primarily on small rodents, usually in large fields that support low vegetative cover (providing access to the ground) and high densities of prey (Bechard 1982; Estep 1989, 2009). These habitats are usually hay fields, grain crops, certain row crops, and lightly grazed pasturelands. Fields lacking adequate prey populations (e.g., flooded rice fields) or those that are inaccessible to foraging birds (e.g., vineyards, orchards) are rarely used (Estep 1989, 2009; Babcock 1995; Nur et al. 2019). Urban expansion and conversion of agricultural lands to unsuitable crop types are responsible for a continuing reduction of available Swainson's hawk foraging habitat in the Central Valley.

4.1.3.3 Breeding Season Phenology

Swainson's hawks arrive at the breeding grounds from mid-March to early April (Figure 4-4). Breeding pairs immediately begin constructing new nests or repairing old ones. Eggs are usually laid in mid- to late April, and incubation continues until mid-May when young begin to hatch. The brooding period typically continues through early to mid-July when young begin to fledge (Bechard et al. 2010). Studies conducted in the Sacramento Valley indicate that one or two—and occasionally three—young typically fledge from successful nests (Estep 2007; Estep and Dinsdale 2012; ICF 2019) (Figure 4-5). After fledging, young remain near the nest and are dependent on the adults for about 4 weeks, after which they permanently leave the breeding territory (Anderson and Estep unpublished telemetry data). By mid-August, breeding territories are no longer defended, and Swainson's hawks begin to form communal groups. These groups begin their fall migration from late August to mid-September. Unlike most other Swainson's hawk populations, which migrate to southern Argentina for the winter, the Central Valley population winters from Central Mexico to central South America (Airola et al. 2019).

4.2 Methods

4.2.1 Population Assessment

Surveys were conducted by systematically driving all available roads within the Basin, including both sides of all peripheral drainages. Where roads could not be used, surveys were conducted on foot. All potential nesting trees were searched with binoculars and/or a spotting scope for nests and adult Swainson's hawks.

Surveys were conducted in three phases. Phase 1 surveys were conducted early in the breeding season (late March to mid-April) to (1) detect Swainson's hawk activity at previously known nest sites as well as in all other suitable nesting habitats and (2) to detect early nest failures that might otherwise be missed. All suitable nesting habitats were checked for the presence of adult Swainson's hawks and to note nesting activity and behavior (e.g., nest construction, courtship flights, defensive behavior). Activity was noted and mapped; locations of nests were documented using a global positioning system receiver.

Phase 2 surveys were conducted in mid-May through June to (1) determine whether potentially breeding pairs detected during Phase 1 surveys were nesting and (2) resurvey all previously unoccupied potential nesting habitat for late-nesting pairs and for active nests that may have been missed during Phase 1 surveys.

Phase 3 surveys were conducted during July to determine nest success and record the number of young fledged per nest. Incidental observations, such as foraging, roosting, and other sightings of adult Swainson's hawks, were also noted.

An *occupied territory* is defined as a nest site that was occupied by a pair of Swainson's hawks, regardless of the reproductive outcome. An *active nest* is defined as a nest in which eggs were laid. A *successful nest* is defined as a nest in which young were fledged. A *failed nest* is defined as a nest in which eggs were laid but from which no young were fledged.

4.2.2 Habitat Assessment

The distribution and abundance of land cover/crop types throughout the Basin, both on and off reserve lands, are documented annually (see Chapter 2, *Land Cover Mapping, Botanical Inventory, and Noxious Weed Monitoring*). These data are used to document any changes in the distribution and abundance of suitable Swainson's hawk foraging habitat throughout the Basin.

4.3 Results

4.3.1 Population Assessment

Swainson's hawks continued to nest primarily in the southern portion and along the far western and northern edges of the Basin during 2022. The nest sites are predominantly along the Sacramento River and within approximately 1 mile of the river. These areas support suitable habitat for both nesting and foraging: potential nesting trees are distributed along roadsides, in remnant riparian and oak woodlands, and as isolated trees; foraging habitat is present in the upland row crops that dominate this part of the Basin. Conversely, most of the Basin north of Elkhorn Boulevard and east of Powerline Road is less suitable for nesting or foraging by Swainson's hawks because it is dominated by rice production, which provides limited foraging value, and because there are relatively few potential nest trees in this area.

A total of 149 current and historical Swainson's hawk nesting territories were monitored during 2022 (Table 4-1). However, many of these territories are assumed to represent alternative nesting locations for the same breeding pairs. In instances where individual birds are marked (i.e., color banded) and can be identified, or where a new nest site occurs in proximity to a known and unoccupied nest with no other known territories in the immediate vicinity, the site is considered an alternate nest of a known territory. In the absence of either of these conditions, the site is considered a new territory. Therefore, although the number of territories may increase each year, this increase does not necessarily reflect new breeding pairs within the study area.

Changes in the number of occupied Swainson's hawk nesting territories, the number of successful nests, and the total number of young fledged from 2001 through 2022 are depicted on Figure 4-6. Although annual variation in the total number of occupied territories is large, the trend is a general increase over time ($R^2 = 0.620$, $P < 0.001$, Figure 4-7). The total number of occupied territories increased by 10 from 2021, which was the second largest increase in the number of occupied territories from year to year since comprehensive monitoring began in 2001. In total, 69 territories were occupied during 2022, well above the average of 57 occupied territories and the third highest over the 21-year monitoring period.

Measures of reproductive success continue to exhibit high annual variation. Since 2009 there have been five precipitous drops in most measures of reproductive success, including the total number of successful nests, total number of young fledged, the number of young per occupied territory and the number of young per active nest. In all cases, reproductive metrics have rebounded the following year, often dramatically (Figures 4-6 and 4-8).

All measures of reproductive success rebounded slightly in 2022 but remained below the monitoring period average. The number of young per occupied territory, which is essentially the reproductive rate of the breeding population, rebounded significantly, but remains well below 1, the approximate value of a stable population. The reproductive rate is significantly negatively correlated with the number of pairs (i.e., occupied territories) that fail to nest at all ($R^2 = 0.656$, $P < 0.001$). The relatively low reproductive rate observed in 2022 is consistent with results from other areas of the Central Valley (Estep 2020, Estep pers obs.) and not unique to—or based on conditions within—the Natomas Basin.

The number of young per successful nest (a measure of brood size) also increased substantially. However, the long-term decrease in the number of young produced per successful nest (measured since 1999) continues to be statistically significant as measured by simple linear regression ($R^2 = 0.594$, $P < 0.001$, Figure 4-9). The cause(s) and relevance of the decline in this particular parameter of reproductive success is unknown. The number of young fledged per successful nest is negatively correlated with the total number of occupied territories each year ($R^2 = 0.352$, $P = 0.004$).

Forty-nine (71%) of the 69 pairs that occupied territories nested. Thirty-five of these were successful while 14 nest attempts failed, and eight pairs did not nest at all. The reproductive outcome of 12 occupied territories was undetermined. A total of 40 fledglings were fledged within the study area in 2022, or just over one young per successful nest (Table 4-2). Five of the 35 successful nests had more than one young in 2022 (Table 4-1).

In 2022, there were 35 active nesting territories along the Sacramento River, an increase of eight from 2021, and the highest number observed since 2004 (Table 4-3, Figure 4-10). Although the total number of nesting pairs along the Sacramento River fluctuates substantially from year to year ($\bar{x}$ = 28.9; SD = 3.9), there is no discernible trend over time. This relative constancy in the mean number of pairs has persisted despite continuing home construction, ongoing tree removal, and increasing human disturbances, including disturbance associated with implementation of the SAFCA NLIP along the east side of the river. Many pairs have alternate nest sites on both sides of the river, allowing for changes in nest site location in response to local disturbances.

Swainson's hawks often use alternate nest sites within the breeding territory. Of the 69 active territories in 2022, 49 (71%) have one or more alternate nest sites. Of the 61 pairs that nested in 2022, seven pairs selected alternate nest trees that had no previously documented use, and 15 pairs selected known alternate nest trees that were different from the previous year. All the alternate nest trees were in the immediate vicinity of previously used nest trees.

Historical activity within the 69 active territories is variable but indicates the extent of territory fidelity and the tendency toward long-term occupancy. Twenty-six (38%) of the territories were first reported active during or before the first year of monitoring under the current protocols in 2001 and, although some have been inactive in some of the intervening years, most have been fairly consistently active throughout the entire 22-year monitoring period. Forty-nine (71%) of the 69 active territories were first reported active prior to 2010.

Two Swainson's hawk nest trees were removed in 2022. Although not used since 2004, the large cottonwood tree that supported the nest for NB-10 was removed; and the row of eucalyptus trees that supported the nest for NB-97, last active in 2019, was also removed. However, there are potential alternative nesting sites in the immediate vicinity of both sites. Although many potential nest trees were removed during levee construction activities associated with the SAFCA NLIP, restoration actions have established new potential replacement trees near the toe of the new levee. These trees are expected to provide new potential nesting habitat when they reach maturity. Although no Swainson's hawk nest trees were removed within the NLIP in 2022, a total of nine have been removed since implementation of the NBHCP, seven of which resulted in the apparent abandonment of the nesting territory (Table 4-1). Levee construction activities on the next phase of the NLIP began in 2019 and continued through the 2022 breeding season. Numerous mature valley oak and other native trees were removed from the land side of the existing levee south of Powerline Road. Additional tree removal is planned as the project moves southward. There are no reported nests within the project right-of-way; however, substantial suitable nesting habitat is present and will be removed to expand the levee. Construction disturbance from levee construction activities is also likely to affect nesting activity and reproductive output of active nests that occur on the water side of the levee.

Competition with other nesting raptors also influences the distribution and abundance of nesting Swainson's hawks. In 2022, 16 previously documented Swainson's hawk territories were occupied by nesting red-tailed hawks and great-horned owls.

Sources of adult or nestling mortality are usually difficult to confirm but presumably include predation by great-horned owls and direct disturbances to nests from construction or recreational activities that result in nest abandonment. Collisions with airplanes have also been documented but are difficult to quantify. In 2014, Sacramento County Airport System (SCAS) reported four adult Swainson's hawk fatalities resulting from collisions with aircraft, including the banded (i.e., identifiable) adult female from territory NB-107, immediately west of the airport perimeter fence. SCAS staff reported two Swainson's hawk fatalities from collision with aircraft in 2017, two in 2018, one in 2020, and one in 2021.

4.3.2 Habitat Assessment

Changes from 2004 through 2022 in the total acreages of three general habitat categories (upland agriculture, fallow lands, and grasslands) that provide suitable Swainson's hawk foraging habitat are listed in Table 4-4 and depicted on Figure 4-11. The distribution of suitable Swainson's hawk foraging habitat in 2022 is shown on Figure 4-12. Basin-wide foraging habitat increased over 46% (7,530 acres) from 2021 to 2022 (Table 4-4), primarily due to the substantial increase in fallow lands, particularly fallow rice lands, that occurred due to the ongoing drought in California. Similarly, suitable habitats on reserve lands also increased substantially, also due to an increase in fallow lands caused by the drought, but also by the addition of several new tracts to the reserve system.

Total Swainson's hawk foraging habitat in the Basin declined from 2006 through 2015, but has been highly variable since that time frame. There has been no significant increase or decrease over the monitoring period in upland agriculture, fallow lands, or total Swainson's hawk foraging habitat, although there has been a significant decline in grasslands ($R^2 = 0.616$, $P < 0.001$) and alfalfa throughout the Basin ($R^2 = 0.336$, $P = 0.012$). Annual fluctuations in *total* available acres of suitable Swainson's hawk foraging habitat have been driven primarily by rice farming practices in the Basin, because fallow rice fields are considered to be suitable—although low quality—foraging habitat for Swainson's hawks, and the number of acres of rice in production has varied substantially over the monitoring period.

There is no correlation between the number of occupied territories each year and the total acreage of suitable forging habitat in the Basin ($R^2 = 0.076$, $P = 0.254$), the acreage of upland row and field crops ($R^2 = 0.121$, $P = 0.145$), or the total acreage of alfalfa each year ($R^2 = 0.079$, $P = 0.258$). However, the total number of occupied territories is negatively correlated with the total acres of grassland habitat in the Basin ($R^2 = 0.337$, $P = 0.009$). No measures of reproductive success were significantly correlated with the total acreage for any of the categories of Swainson's hawk suitable foraging habitat in the Basin, including alfalfa.

Table 4-5 lists the extent and proportion of four categories of suitable Swainson's hawk foraging habitat on both reserve and non-reserve lands in 2022. These categories include both cultivated and uncultivated lands. Suitable cultivated habitats consist of alfalfa; row, grain, and other hay crops; and fallow lands. Suitable uncultivated habitats consist of irrigated pasture and grasslands (created native grasslands, nonnative annual grasslands, and ruderal habitats). The relative foraging value of the different types depends on prey density and availability, but all have foraging value; collectively, these habitat types provide an important diversity of foraging habitats in the Basin. Although other habitat types are occasionally used for foraging, their value is generally considered to be less than that of the habitat types listed above.

Alfalfa is considered one of the highest habitat-value crop types for Swainson's hawk. Alfalfa decreased Basin-wide from 2020 to 2021, but increased on reserve lands. This was due in part to the acquisition of alfalfa growing lands by TNBC from 2021 to 2022. Nevertheless, the proportion of suitable foraging habitat comprising alfalfa remains substantially higher on reserve than on non-reserve lands (Table 4-5), as it has been for several years. As a result of the establishment of a substantial number of acres of grasslands on non-reserve lands by the SAFCA NLIP, the proportion of grasslands is now substantially higher on non-reserve lands than reserve lands.

The reserve system currently accounts for approximately 15% of the suitable Swainson's hawk foraging habitat in the Basin. Consequently, the extent to which TNBC-managed land will be able to influence the trajectory of the Swainson's hawk population in the Basin is currently limited.

4.4 Discussion

Trends over time in the number of occupied territories are indicative of a stable but slightly increasing breeding population of Swainson's hawks in the Natomas Basin. Interestingly, in 2019 the lowest reproductive metrics and number of active nests occurred concurrently with the highest number of occupied breeding territories since monitoring began. In 2020, the number of active and successful nests fully recovered, and although the reproductive rate also recovered slightly, it remained low compared with past years. Occupancy declined again in 2021 along with another sharp decline in reproductive output, and increased in 2022, with only slightly increased reproductive output. However, the extreme decline in reproductive metrics in 2019 and continuing low rate from 2020 to 2022 was part of a broader condition throughout the Central Valley in these years. Similar phenomena were observed in 2011 and 2013, which may indicate that reproductive success is likely to rebound in subsequent years.

Although it remains speculative, in any given year the likely causes for this widespread lack of production among Swainson's hawks and other nesting raptor species in the Central Valley include drought, late-spring storms, changes in agricultural patterns or practices, or more subtle climate-change phenomena—which may affect prey (i.e., rodent) populations—or possibly a natural cyclical decline in microtine rodents, or a combination of both. The arrival dates of Swainson's hawks on the breeding grounds and the pattern of territory establishment was typical from 2019 to 2022, and territory occupancy was relatively high, which may indicate that the decline in reproductive performance is related to food resources.

The significant decline over the monitoring period in the number of young per successful nest, a reproductive metric influenced by clutch size and brood size, is unusual because of the intrinsic invariability in the metric (i.e., it is derived from a series of mostly 1s and 2s) but not unprecedented. The breeding population of Swainson's hawk in Saskatchewan experienced a similar long-term decline in the number of young fledged per successful nest that coincided with a decline in the principal prey species, Richardson's ground squirrel (*Urocitellus richardsonii*) (Houston and Schmutz 1995). Annual variation in clutch or brood size is common among some raptor species (including Swainson's hawk) that rely to a large extent on a single prey species, particularly if that species is subject to its own reproductive cycles, such as the California vole (*Microtus californicus*). However, a gradual and long-term decrease in average clutch or brood size may suggest a change in habitat conditions, such as the continuing conversion of row and field crop habitats to orchards or other crop types that could influence the availability of Swainson's hawk food resources. The increase in the number of occupied territories in conjunction with a decrease in the number of young per successful nest is also consistent with a density-dependent response in the reproductive rate to an increase in the size of the breeding population. Other possible but less likely factors include pesticides or disease.

The generally increasing trend in the number of occupied Swainson's hawk nesting territories is not positively correlated with the total acreage of upland agricultural crops in the Basin or any other habitat metric. This may indicate that the Basin provides only a portion of the foraging habitat required for this population, which is consistent with recent telemetry studies that demonstrated substantial use of out-of-Basin foraging habitats by Swainson's hawks nesting in the Basin (Fleishman et al. 2016).

The 2022 distribution of nest sites remained similar to past years, with the bulk of the nests occurring in trees along the perimeter drainages, primarily the Sacramento River and the Natomas Cross Canal. Most of the remaining sites are in the south Basin (i.e., south of Elkhorn Boulevard) and along the western edge of the Basin.

Nest tree removal and conversion of agricultural foraging habitat, mostly because of urbanization, have historically resulted in the removal of some nesting territories in the south Basin. The 2008 moratorium on planned and proposed urbanization because of levee-related restrictions was lifted in 2015, and development has resumed, primarily in the south Basin. As a result, suitable nesting and foraging habitat is expected to decline more rapidly within the Basin in the near future, which could result in nesting pairs being displaced. Recent urbanization in the Basin south of Elkhorn Boulevard and east of Powerline Road has and continues to cause the removal of suitable foraging habitats. Nesting territories in this area, such as NB-27 and NB-140, that are becoming increasingly surrounded by urbanization, are expected to eventually be abandoned. Others, such as NB-98 and NB-63, are subject to increasing risk due to recent urbanization within the territory. However, despite this loss, which was anticipated in the NBHCP, the management of preserves and other suitable nesting and foraging habitats in the Basin have contributed to maintaining a stable and even increasing Swainson's hawk nesting population.

The ongoing loss of trees could limit future nesting opportunities and the ability of the Swainson's hawk population to respond to habitat changes throughout the Basin. The County of Sacramento continues to allow residential development on the waterside of the Sacramento River levee, which accelerates tree loss as riparian vegetation is cleared for home sites. These projects, along with tree and brush clearing for vegetation management and a fire on the east side of the river just north of Powerline Road in 2010, have cumulatively contributed to additional tree loss along the river. This loss of potential nesting trees and the increase in human disturbance along the river could potentially result in territory abandonment and limit opportunities for relocation of displaced nesting pairs and the establishment of new nesting sites.

In addition, SCAS, citing Federal Aviation Administration regulations, has removed trees on airport lands that are considered potential hazard trees due to bird use (County of Sacramento 2006). Although these actions may have been warranted to meet federal safety regulations, they have resulted in the removal of a substantial number of mature trees, including sites known to be used by Swainson's hawks as nest sites. No active nest trees were removed by SCAS in 2022.

SCAS also implements a wildlife hazard management plan to minimize the potential for bird strikes with planes on airport lands (Sacramento County Airport System 2007). This program involves the removal of a variety of bird species, including raptors. The loss of individual Swainson's hawks through this program is inconsistent with the goals of the NBHCP with respect to the maintenance of existing Swainson's hawk population levels in the Basin. Despite implementation of the wildlife hazard management plan, airplane collision with birds at Sacramento International Airport (SMF) is a cause of mortality that could potentially affect the Natomas Basin Swainson's hawk population.

Much of the land within the SMF perimeter fence is managed as a short grassland, which is attractive to foraging Swainson's hawks and other raptors, putting them at risk of collision with planes landing or taking off. Collision mortality during the breeding season can result in the abandonment of active nests and loss of productivity and increase adult turnover in the breeding population.

Implementation of the SAFCA NLIP has resulted in impacts on the Swainson's hawk population, but effects have generally been short term and appear to be mitigated. Despite the changes in habitat value resulting from levee and canal construction activities, tree removal, restoration activities, and related disturbances that may have been responsible for some nest failures in the last several years, the distribution of nesting pairs within the area affected by levee construction remains relatively stable. In addition, the restored grassland habitats in the area of the SAFCA NLIP provide moderate- to high-value foraging habitat and may also provide potential refugia for voles and other prey populations on adjacent agricultural lands, while the restored woodland habitats are expected to provide future nesting opportunities.

The majority of major levee construction activities from the Natomas Cross Canal to Powerline Road—coordinated by SAFCA—have been completed; however, the next phase of the project, from Powerline Road southward, which began in 2019, has been ongoing through 2022 and has largely been completed south to San Juan Road. Levee work will continue through at least 2023 south of San Juan Road. The landside levee construction is coordinated by USACE, including the removal of trees along the remaining portion of the Sacramento River and along Steelhead Creek, could affect nesting activity in those areas.

4.5 Effectiveness

Biological effectiveness as it pertains to Swainson's hawk is measured on the basis of acquisition of reserve lands and management activities that meet the goals for Swainson's hawk habitat, as well as the population's response to these actions. Effectiveness is also measured through successful implementation of management recommendations designed to further benefit Swainson's hawk through targeted land acquisition or specific land management activities.

As discussed above, the status of the Swainson's hawk population in the Basin remains stable to slightly increasing. Evidence to date thus indicates that implementation of the NBHCP and Metro Airpark HCP has been effective in conserving the nesting population of Swainson's hawks in the Natomas Basin. However, additional population effects could become evident as urbanization of the Basin continues following the lifting of the building moratorium and actions unforeseen by the NBHCP continue, such as the continuation of the SAFCA NLIP south of Powerline Road, bird control actions by SCAS, bird–aircraft collision mortality, continued disturbance and habitat removal along the east side of the Sacramento River, future urbanization of county lands, or possibly factors affecting hawks outside the breeding season (i.e., on wintering habitats).

Swainson's hawk habitat goals continue to be met through establishment and management of suitable upland habitat, including the planting of potential future nesting trees, on reserve lands. The first documented active nest on an NBHCP Reserve tract was a nest on the BKS tract in 2005. 2019 marked the second year Swainson's hawks occupied a nest on an NBHCP Reserve tract. A nesting pair established a new nest within a small group of trees planted in 2007 between the Huffman East and Huffman West tracts in the North Basin Reserve. In 2020, a third Swainson's hawk nest site was found on the Atkinson tract of the North Basin Reserve. The nest was near the southern end of the cottonwood grove, where the nesting pair successfully fledged two young.

As discussed in Section 4.3, *Results*, reserve lands managed for Swainson's hawk foraging habitat continue to provide a higher proportion of high-value cover types (i.e., alfalfa) than other comparable lands in the Basin. Swainson's hawk habitat has been a key consideration in reserve land acquisition. Acquisitions have generally been consistent with recommendations in the *Biological Effectiveness Monitoring Report* for the last several years. In 2022, a significant portion of fallow rice on reserve lands was managed to provide higher quality foraging habitat for Swainson's hawk, in keeping with past recommendations. This effort is expected to continue in 2023.

4.6 Recommendations

- Although TNBC is currently ahead of NBHCP requirements for acquiring lands within 1 mile of the Sacramento River, it should continue to focus on those areas, where the majority of nesting pairs occur and where soils are more conducive to long-term sustainability of suitable upland foraging habitats, and on lands that consolidate ownership into larger contiguous habitat reserves.
- Continue efforts to create new nesting and foraging habitat in protected areas.
- Continue to coordinate with SAFCA, USACE, or other responsible agencies to minimize the effects of the remaining segments of the NLIP on TNBC reserves and other lands in the Basin. To the extent feasible, coordinate with agencies regarding mitigation and compensation for impacts that may be compatible with TNBC goals such as tree replacement activities, restoration activities, and other management opportunities.
- Continue efforts to inform, educate, and share information with Sacramento County to raise awareness of the importance of native trees along the Sacramento River to provide current and future nesting habitat for Swainson's hawks.
- Continue to meet habitat goals for Swainson's hawk through acquisition and restoration of upland habitats as necessary. Non-rice agricultural fields, grasslands, and pastures provide the highest value foraging habitat.
- Continue to experiment with Swainson's hawk-friendly crops and crop rotations on marginal soils to improve foraging opportunities.
- Manage fallow lands with cover crops or other techniques to increase prey production for Swainson's hawk.
- Give preference to utilizing simple management techniques and existing farm resources for the Swainson's hawk components of the reserve lands. Efforts should be made to integrate surrounding farmlands with reserve lands.
- Consideration of installation of uncultivated field borders composed of native grasses (and forbs used by pollinator species) to provide refugia for prey populations has been a long-standing recommendation. However, with the development and maturation of SAFCA NLIP mitigation lands along the Sacramento River levee that currently appear to provide this refugia, this recommendation may be dropped in the future if these habitats continue to function adequately.

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Table 4-1. Results of 2022 Swainson's Hawk Surveys, NBHCP Area

Territory Number	Status[a]	Number of Young	Nesting Habitat	Nest Tree Species[b]
NB-1	I		Urban	Valley oak
NB-2	I		Urban	Cottonwood
NB-3	NLE		Isolated tree—removed in 2003	Valley oak
NB-4	I		Riparian	Cottonwood
NB-5	I		Riparian	Willow
NB-6	I		Ornamental grove	Eucalyptus
NB-7	NLE		Isolated trees—removed in 2002	Willow
NB-8	I		Roadside tree row—ornamental	Cottonwood
NB-9	I		Channelized riparian	Cottonwood
NB-10	I		Isolated tree – removed in 2021	Cottonwood
NB-11	I		Riparian	Valley oak
NB-12	A-S	1	Riparian	Cottonwood
NB-13	A-S	1	Riparian	Oregon ash
NB-14	A-S	1	Tree row—ornamental	Eucalyptus
NB-15	NLE		Isolated tree—removed in 2002	Valley oak
NB-16	A-S	1	Oak grove	Cottonwood
NB-17	NLE		Isolated tree—removed in 1998	Valley oak
NB-18	I		Isolated tree	Cottonwood
NB-19	A-F	0	Tree along irrigation canal	Cottonwood
NB-20	NLE		Isolated tree—removed in 2002	Cottonwood
NB-21	A-F	0	Riparian	Cottonwood
NB-22	A-F	0	Isolated tree	Willow
NB-23	I		Riparian	Willow
NB-24	A-U		Riparian	Valley oak
NB-25	I		Riparian	Walnut
NB-26	NLE		Roadside tree—removed in 2002	Valley oak
NB-27	I		Riparian	Cottonwood
NB-28	I		Riparian	Cottonwood
NB-29	A-X	0	Riparian	Willow
NB-30	A-X	0	Riparian	Cottonwood
NB-31	I		Riparian	Willow
NB-32	A-S	1	Riparian	Cottonwood
NB-33	I		Riparian	Cottonwood
NB-34	I		Riparian	Cottonwood
NB-35	I		Riparian	Cottonwood
NB-36	A-S	1	Riparian	Cottonwood
NB-37	A-X	0	Riparian	Cottonwood
NB-38	A-F	0	Riparian	Cottonwood
NB-39	A-F	0	Riparian	Willow
NB-40	A-S	1	Riparian	Cottonwood
NB-41	I		Riparian	Willow

Table 4-1 Continued

Territory Number	Status[a]	Number of Young	Nesting Habitat	Nest Tree Species[b]
NB-42	I		Riparian	Cottonwood
NB-43	A-S	2	Riparian	Cottonwood
NB-44	A-S	1	Riparian	Cottonwood
NB-45	I		Riparian	Cottonwood
NB-46	I		Riparian	Cottonwood
NB-47	A-S	2	Riparian	Cottonwood
NB-48	I		Riparian	Cottonwood
NB-49	I		Riparian	Cottonwood
NB-50	I		Riparian	Sycamore
NB-51	I		Riparian	Cottonwood
NB-52	A-S	1	Riparian	Cottonwood
NB-53	A-X	0	Riparian	Cottonwood
NB-54	I		Riparian	Cottonwood
NB-55	A-X	0	Riparian	Cottonwood
NB-56	I		Riparian	Cottonwood
NB-57	A-U		Riparian	Cottonwood
NB-58	I		Riparian	Cottonwood
NB-59	A-U		Riparian	Cottonwood
NB-60	A-S	1	Riparian	Cottonwood
NB-61	I		Riparian	Cottonwood
NB-62	A-F	0	Riparian	Cottonwood
NB-63	I		Isolated tree	Willow
NB-64	A-S	2	Riparian	Valley oak
NB-65	A-S	1	Cottonwood grove	Cottonwood
NB-66	A-S	1	Riparian	Cottonwood
NB-67	I		Riparian	Cottonwood
NB-68	A-S	1	Riparian	Sycamore
NB-69	I		Urban ornamental	Willow
NB-70	A-U		Riparian	Valley oak
NB-71	A-S	1	Riparian	Willow
NB-72	I		Riparian	Cottonwood
NB-73	NLE		Tree row – removed in 2019	Ornamental conifer
NB-74	A-F	0	Roadside tree	Willow
NB-75	A-U		Riparian	Cottonwood
NB-76	NLE		Tree row—removed in 2004	Cottonwood
NB-77	A-S	1	Riparian	Cottonwood
NB-78	I		Riparian	Cottonwood
NB-79	I		Riparian	Sycamore
NB-80	I		Riparian	Cottonwood
NB-81	I		Isolated tree	Cottonwood
NB-82	I		Riparian	Willow

Table 4-1 Continued

Territory Number	Status[a]	Number of Young	Nesting Habitat	Nest Tree Species[b]
NB-83	I		Riparian	Willow
NB-84	I		Riparian	Cottonwood
NB-85	A-U		Riparian	Cottonwood
NB-86	A-U		Riparian	Cottonwood
NB-87	A-S	1	Riparian	Cottonwood
NB-88	A-S	1	Riparian	Cottonwood
NB-89	A-S	1	Riparian	Valley oak
NB-90	I		Riparian	Willow
NB-91	A-S	1	Riparian	Cottonwood
NB-92	I		Riparian	Cottonwood
NB-93	I		Riparian	Cottonwood
NB-94	A-S	1	Riparian	Cottonwood
NB-95	A-U		Riparian	Valley oak
NB-96	A-S	1	Riparian	Cottonwood
NB-97	I		Tree row	Eucalyptus
NB-98	A-S	1	Tree row	Eucalyptus
NB-99	I		Urban	Ornamental pine
NB-100	I		Riparian	Walnut
NB-101	A-U		Riparian	Cottonwood
NB-102	I		Riparian	Cottonwood
NB-103	I		Riparian	Cottonwood
NB-104	A-S	1	Riparian	Black locust
NB-105	A-F	0	Riparian	Cottonwood
NB-106	I		Roadside	Cottonwood
NB-107	I		Riparian	Cottonwood
NB-108	A-F	0	Ornamental (freeway rest stop)	Cottonwood
NB-109	A-X	0	Tree row	Valley oak
NB-110	I		Riparian	Cottonwood
NB-111	I		Tree Row	Cottonwood
NB-112	I		Riparian	Valley oak
NB-113	I		Riparian	Cottonwood
NB-114	A-F	0	Channelized riparian/tree row	Valley oak
NB-115	I		Riparian	Willow
NB-116	A-U		Cottonwood grove	Cottonwood
NB-117	I		Riparian	Cottonwood
NB-118	A-F	0	Tree row	Valley oak
NB-119	A-U		Channelized riparian/tree row	Cottonwood
NB-120	A-F	0	Channelized riparian/tree row	Valley oak
NB-121	A-S	1	Rural residential	Walnut
NB-122	I		Tree row	Valley oak
NB-123	I		Isolated tree	Cottonwood

Table 4-1 Continued

Territory Number	Status[a]	Number of Young	Nesting Habitat	Nest Tree Species[b]
NB-124	A-S	2	Riparian	Valley oak
NB-125	A-S	1	Riparian	Cottonwood
NB-126	I		Riparian	Cottonwood
NB-127	A-S	1	Riparian	Oregon ash
NB-128	I		Riparian	Alder
NB-129	A-S	1	Roadside tree row	Willow
NB-130	I		Isolated tree	Locust
NB-131	I		Riparian	Cottonwood
NB-132	A-S	2	Cottonwood grove	Cottonwood
NB-133	I		Isolated roadside tree	Valley oak
NB-134	I		Channelized riparian/tree row	Valley oak
NB-135	A-F	0	Isolated roadside tree	Sycamore
NB-136	A-U		Cottonwood grove	Cottonwood
NB-137	I		Riparian	Valley oak
NB-138	A-S	1	Tree row	Valley oak
NB-139	A-X	0	Isolated roadside tree	Eucalyptus
NB-140	A-X	0	Roadside tree row	Redwood
NB-141	A-S	1	Riparian	Cottonwood
NB-142	I		Riparian	Valley oak
NB-143	I		Tree row	Willow
NB-144	I		Tree row	Ornamental conifer
NB-145	A-S	1	Grove	Cottonwood
NB-146	I		Rural residential	Eucalyptus
NB-147	I		Riparian	Willow
NB-148	A-F	0	Isolated roadside tree	Willow
NB-149	A-S	1	Riparian	Oregon ash

[a] A = active; I = inactive; NLE = no longer extant; S = successful; F = failed; X = did not nest; U = undetermined.
[b] For territories designated as I or X, tree species shown reflects last active nest tree.

Table 4-2. Reproductive Data for Active Swainson's Hawk Territories in the NBHCP Area, 1999–2022

Year	Occupied Territories[b]	Successful Nests	Unsuccessful Nests	Occupied but Not Nesting	Un-confirmed Nesting Status	Number Young Reared to Fledging	Number Young per Occupied Territory[c]	Number Young per Active Nest[c, d]	Number Young per Successful Nest[c]
1999[a]	15	14	1	0	0	25	1.67	1.67	1.79
2000[a]	18	10	4	4	0	20	1.11	1.43	2.00
2001	46	24	15	7	0	40	0.87	1.03	1.67
2002	43	24	11	7	1	38	0.90	1.09	1.58
2003	54	34	15	4	1	53	1.00	1.08	1.56
2004	59	39	12	4	4	54	0.98	1.06	1.38
2005	45	31	11	1	2	48	1.12	1.14	1.55
2006	45	32	9	4	0	48	1.07	1.17	1.50
2007	44	34	9	1	0	48	1.09	1.12	1.41
2008	51	42	8	1	0	64	1.25	1.28	1.52
2009	59	51	2	1	5	83	1.54	1.57	1.63
2010	52	42	4	3	3	70	1.43	1.52	1.67
2011	62	23	27	6	6	30	0.54	0.60	1.30
2012	65	42	14	3	6	59	1.00	1.05	1.40
2013	56	11	26	16	3	12	0.23	0.32	1.09
2014	59	34	11	7	7	39	0.75	0.87	1.15
2015	61	44	6	4	7	69	1.28	1.38	1.57
2016	56	43	3	6	4	63	1.21	1.37	1.47
2017	58	49	4	3	2	68	1.21	1.28	1.39
2018	69	48	9	5	7	70	1.13	1.23	1.46
2019	71	5	33	26	7	5	0.08	0.13	1.00
2020	70	50	8	3	9	54	0.89	0.93	1.08
2021	59	24	25	7	3	24	0.43	0.49	1.00
2022	69	35	14	8	12	40	0.70	0.81	1.14

[a] Years 1999 and 2000 do not include the Sacramento River territories.

[b] An occupied territory is a nesting area that was occupied by a breeding pair of raptors throughout all or a significant portion of the breeding season. Includes successful nests, unsuccessful nests, pairs with unconfirmed nesting status, and pairs not nesting.

[c] Does not include pairs with unconfirmed nesting status.

[d] Active nest = number of successful nests + number of unsuccessful nests.

Table 4-3. Number of Active Territories on the Sacramento River, 2001–2022

River Side	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
West	14	12	12	20	11	14	8	8	8	12	11	11	11	10	12	13	15	20	19	18	11	16
East	13	12	20	18	13	15	12	21	23	15	17	20	14	19	17	13	14	13	13	13	16	19
Total	**27**	**24**	**32**	**38**	**24**	**29**	**20**	**29**	**31**	**27**	**28**	**31**	**25**	**29**	**29**	**26**	**29**	**33**	**32**	**31**	**27**	**35**

Table 4-4. Swainson's Hawk Foraging Habitat in the NBHCP Area (acres), 2004–2022

Habitat Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Upland agriculture	8,251	7,566	6,462	7,919	8,293	11,692	13,863	15,100	14,019	12,096	11,601	11,771	11,890	11,089	11,782	10,488	8,837	8,784	8,396
Fallow lands	823	1,625	10,101	10,033	10,076	5,869	2,912	2,323	2,282	2,160	1,604	1,893	1,712	6,442	3,307	4,667	3,234	3,414	9,955
Grasslands[a]	7,847	7,766	7,263	5,669	5,461	5,794	4,853	4,608	4,491	4,832	4,961	4,344	4,157	4,359	4,252	4,193	4,043	4,041	5,418
Total	**16,921**	**16,957**	**23,826**	**23,621**	**23,830**	**23,355**	**21,628**	**22,031**	**20,792**	**19,088**	**18,166**	**18,007**	**17,759**	**21,890**	**19,341**	**19,348**	**16,114**	**16,239**	**23,769**

[a] Grasslands include the grasslands (created), nonnative annual grassland, and ruderal land cover types.

Table 4-5. Extent and Proportion of Suitable Swainson's Hawk Foraging Habitat on and off TNBC Reserve Lands, 2022

	Alfalfa	Row, Grain, and Other Hay Crops[a]	Grasslands[b]	Fallow	Total
On-reserve acreage (acres)	437	873	290	1,674	**3,532**
On-reserve percentage of cover type (%)	12%	25%	8%	47%	
Off-reserve acreage (acres)	695	8,396	5,418	9,955	**23,769**
Off-reserve percentage of cover type (%)	3%	35%	23%	42%	
Total					

[a] Row, grain, and other hay crops includes the grass hay and irrigated grassland land cover type.
[b] Grasslands include the grasslands (created), nonnative annual grassland, and ruderal land cover types.

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FIGURE 4-1
Swainson's Hawk

NBC 104332 (2-27-2023)

FIGURE 4-2
Swainson's Hawk Range

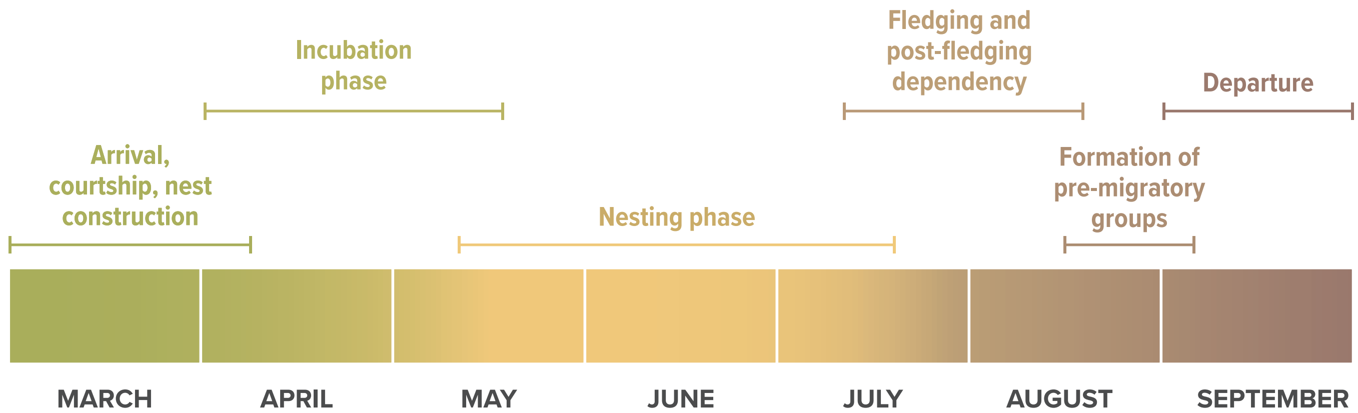
Typical Swainson's hawk nesting and foraging habitat
in the Central Valley

Typical Swainson's hawk nest

NBC 104332 (2-27-2023)

ICF

FIGURE 4-3
Swainson's Hawk Nesting and Foraging Habitat



NBC 104332 (2-27-2023)

ICF

FIGURE 4-4
General Representation of Swainson's Hawk Breeding Cycle in the Central Valley


Swainson's hawk nest with eggs


Nestling Swainson's hawks


Nearly fledged Swainson's hawks

NBC 104332 (2-27-2023)

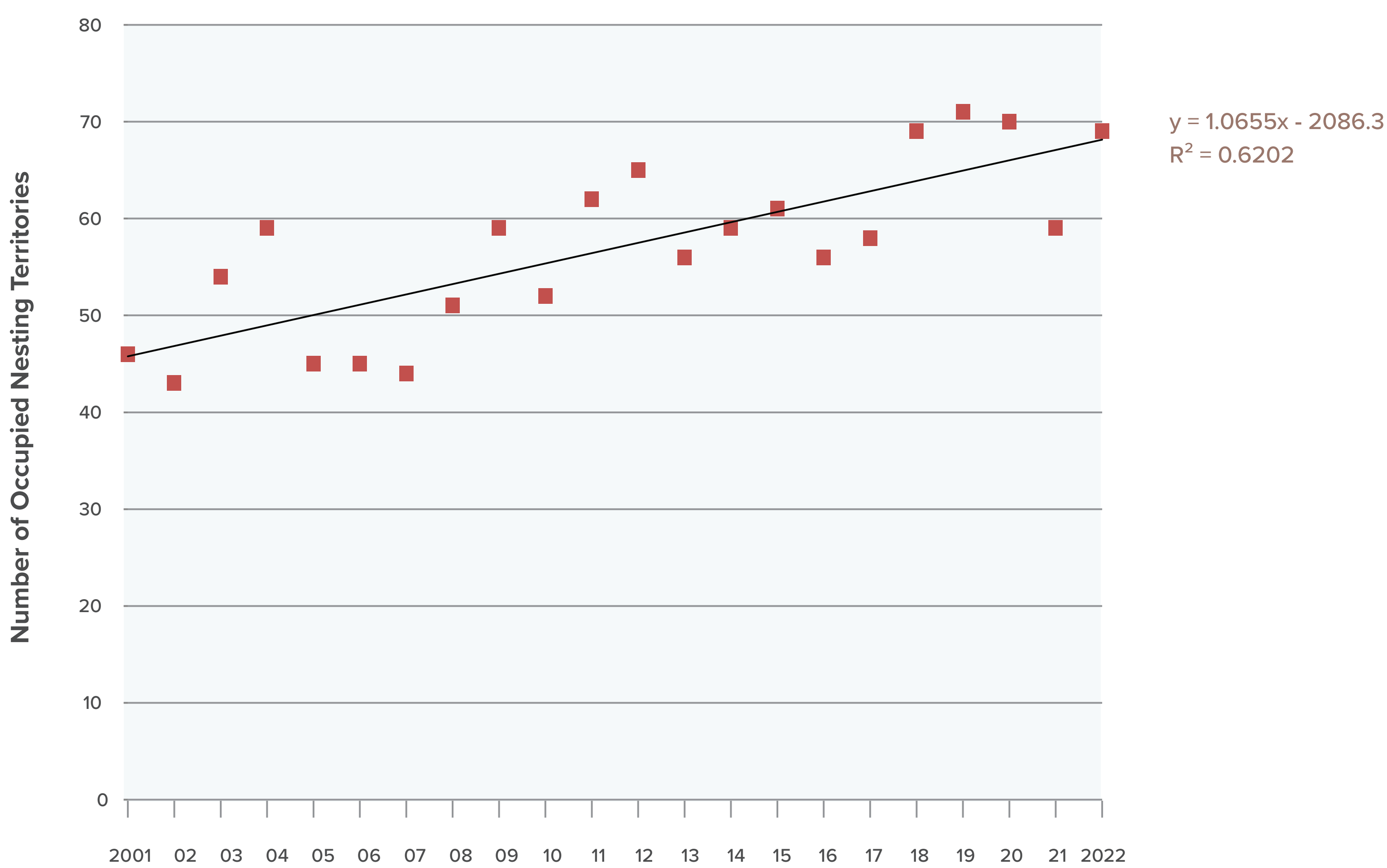
FIGURE 4-5
Swainson's Hawk in the Nest

NBC 104332 (2-28-2023)

ICF

FIGURE 4-6

Number of Occupied Swainson's Hawk Nesting Territories, Successful Nests, and Total Young Fledged in the Natomas Basin, 2001–2022



ICF

FIGURE 4-7
Trends in the Number of Occupied Territories in the Natomas Basin Nesting Population, 2001–2022

FIGURE 4-8
Various Measures of Swainson's Hawk Reproductive Success in the Natomas Basin, 1999–2022

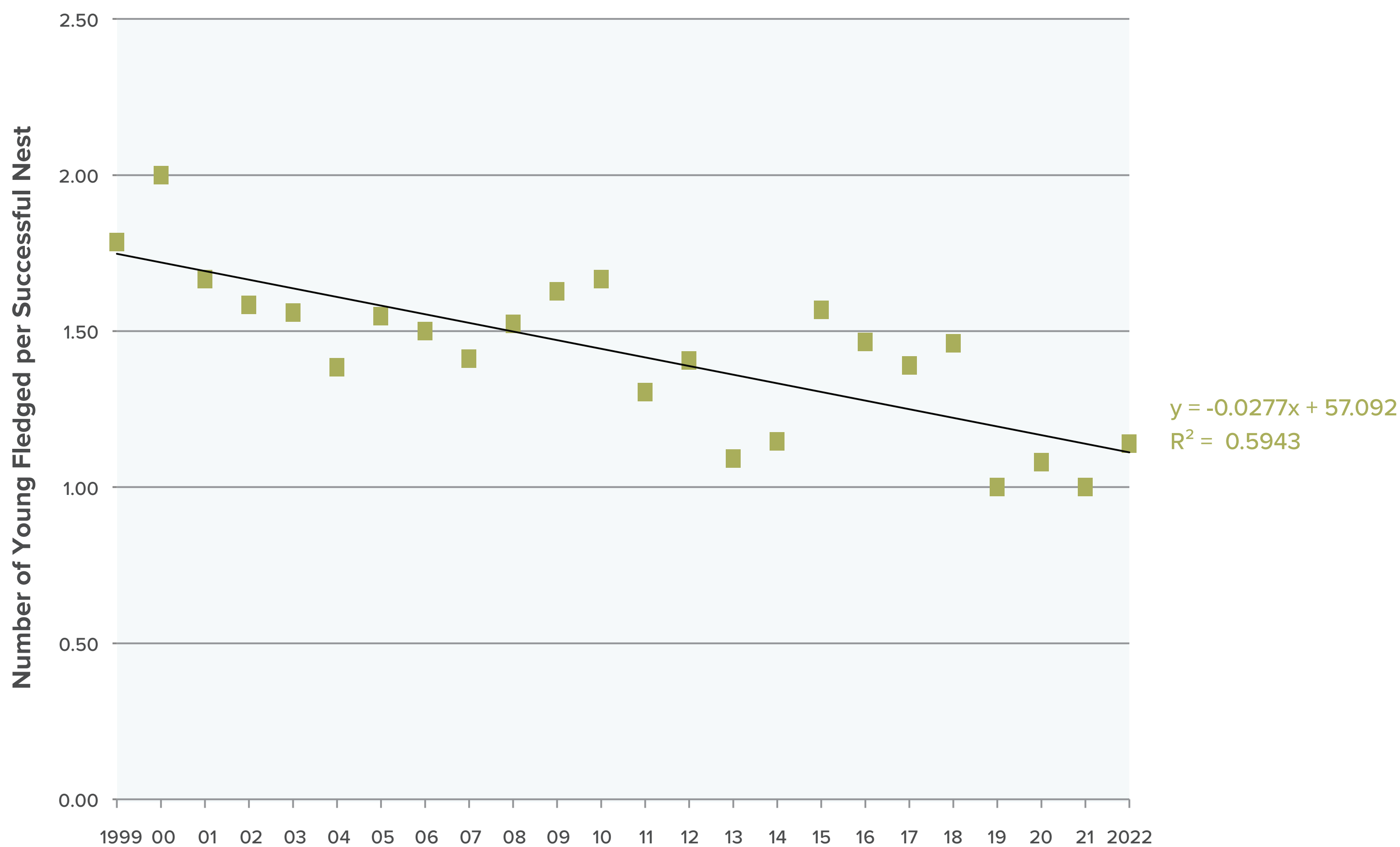


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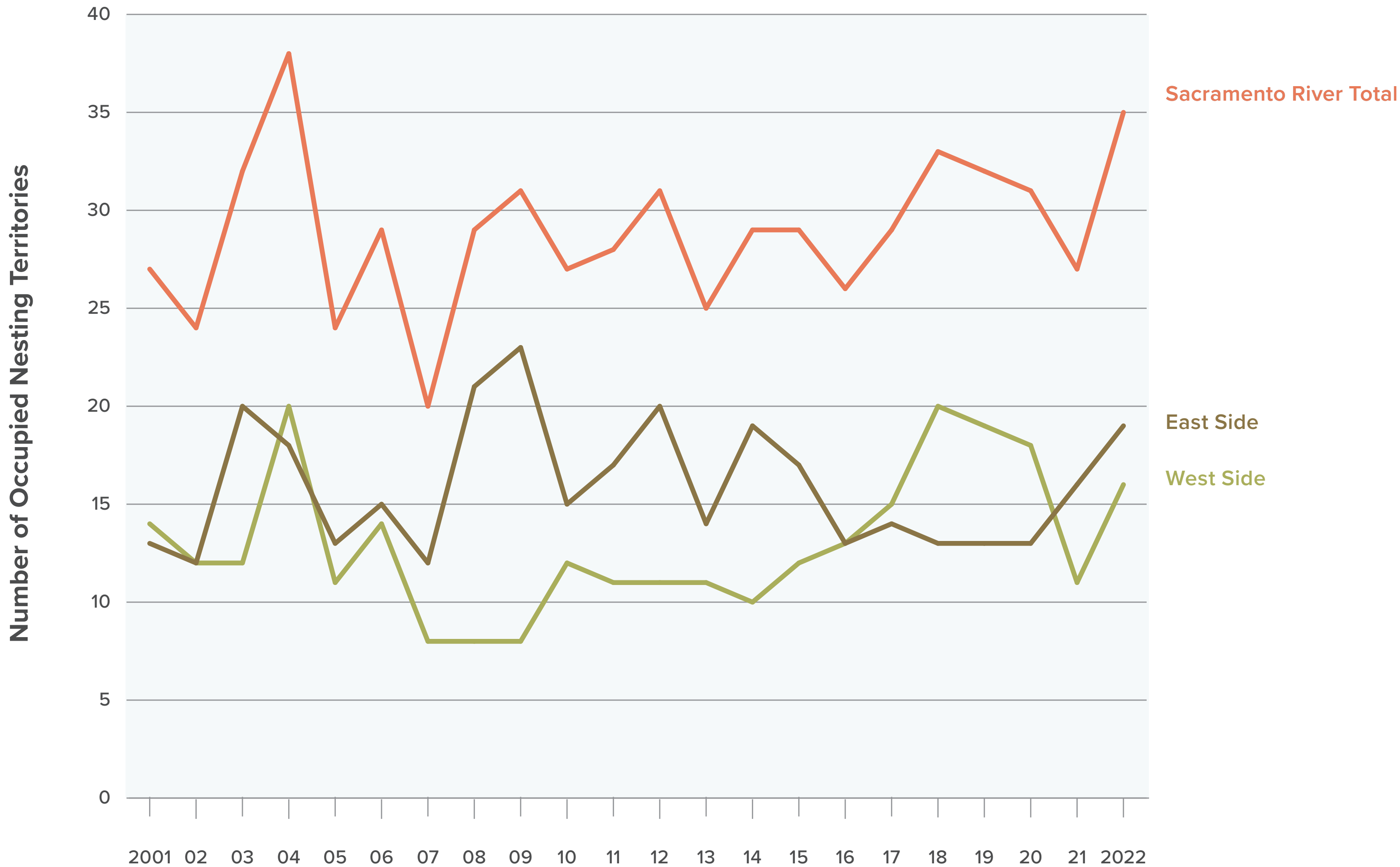
FIGURE 4-9

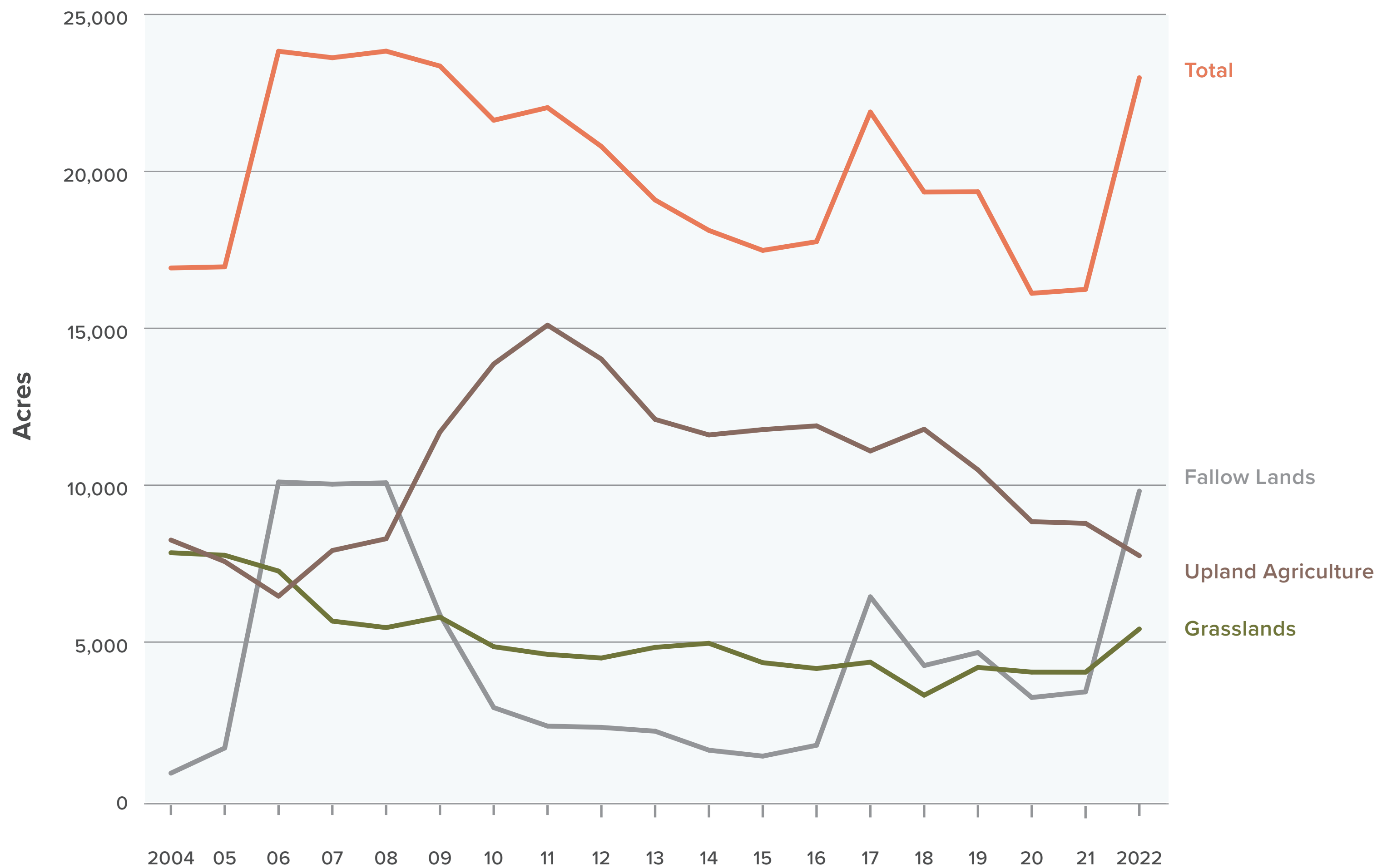
Trends in the Number of Young Fledged per Successful Nest in the Breeding Population of Swainson's Hawk in the Natomas Basin, 1999–2022



NBC 104332 (2-28-2023)

FIGURE 4-10

Number of Occupied Swainson's Hawk Nesting Territories along the Sacramento River in the Natomas Basin, 2001–2022



NBC 104332 (2-28-2023)

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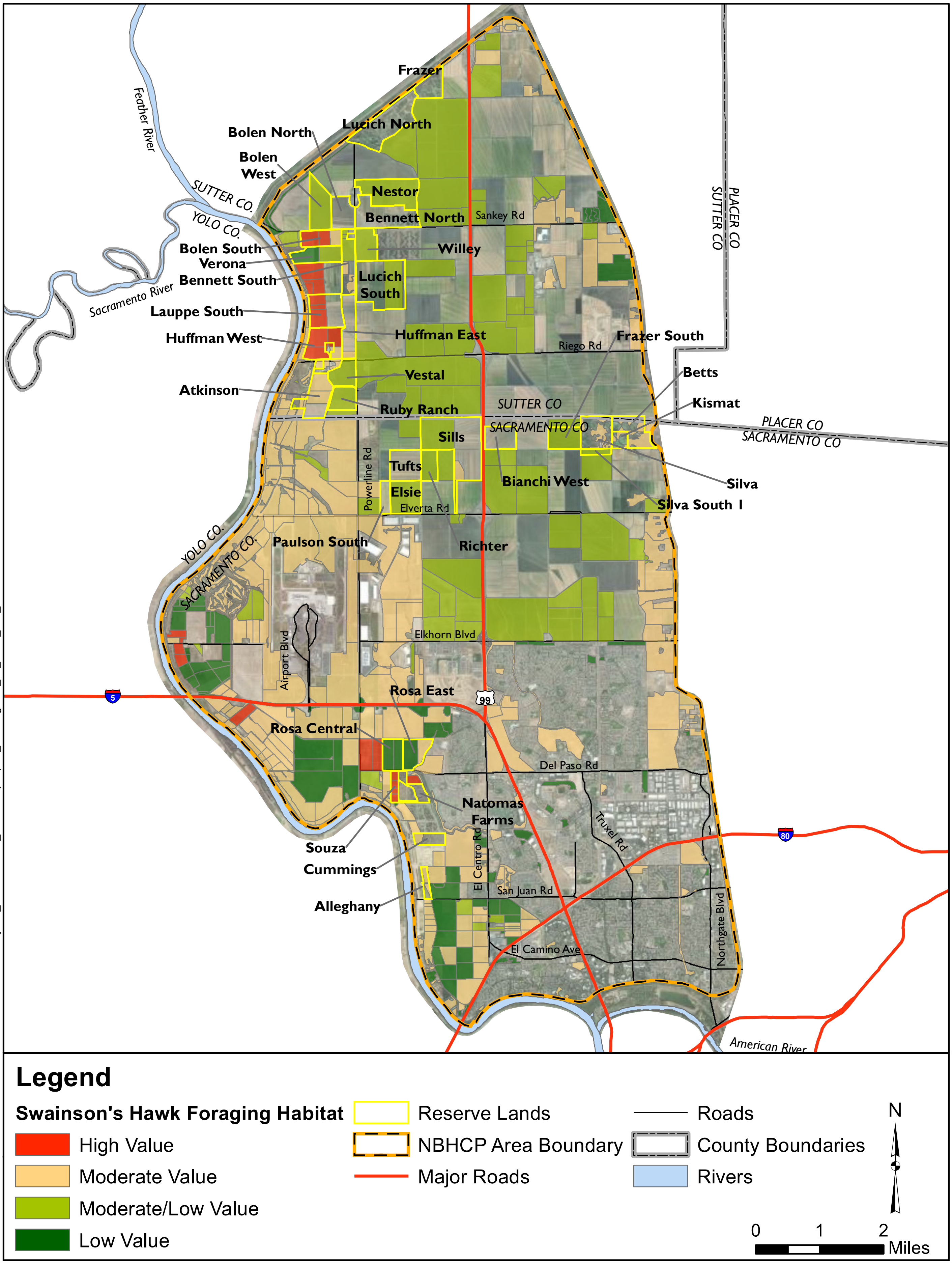
FIGURE 4-11

Changes in the Abundance of Three Categories of Swainson's Hawk Foraging Habitat in the Natomas Basin, 2004–2022



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ICF

Figure 4-12
Suitable Swainson's Hawk
Foraging Habitat in the Natomas Basin in 2022

Chapter 5
Other Covered Wildlife Species

CHAPTER HIGHLIGHTS

- Burrowing owls continue to use reserve lands in the winter, but nesting on reserve lands has not been documented since 2014. Maintenance and enhancement of California ground squirrel populations on reserve lands and provision of an experimental berm to provide nesting habitat on the Sills tract grassland are management actions most likely to contribute to the effectiveness of reserve lands in supporting the burrowing owl population in the Basin.
- Loggerhead shrikes have declined throughout the Basin and now rarely occur, despite significant increases in potential habitat. Providing potential nesting habitat in areas with little to no disturbance and implementing management actions that could increase insect prey are likely to contribute to the effectiveness of reserve lands in supporting loggerhead shrikes in the Basin.
- White-faced ibises continue to use reserve lands and non-reserve lands in the Basin extensively. No additional management actions are warranted.
- Pacific pond turtles now occur on most if not all reserve lands with a wetland component. Population trends are challenging to determine due to the ubiquity of nonnative turtle species that also inhabit the Basin but are difficult to distinguish in the field. Investigating the proportion of native to nonnative turtles and the associated trends over time is recommended.
- Reserve lands continue to provide critical habitats for a wide variety of species, including shorebirds, neotropical migrants, raptors, and waterfowl.

5.1 Introduction

5.1.1 Background

Other Covered Species are those species other than giant gartersnake and Swainson's hawk that are addressed in the NBHCP and covered by its associated permits (Table 1-2). Monitoring efforts for Other Covered Species, like those for Swainson's hawk and giant gartersnake, are designed to evaluate the progress of the NBHCP toward meeting the Plan's goals and objectives for Covered Species and their habitats. Monitoring populations of Other Covered Species is accomplished using a variety of techniques, including a generalized avian survey on reserves. Two general types of monitoring were conducted to meet the NBHCP goals and objectives: monitoring on reserve lands and Basin-wide monitoring on non-reserve lands.

5.1.2 Goals and Objectives

The objectives of monitoring efforts on reserves are listed below.

- Document the presence/absence and use of reserves by all wildlife species in general and Other Covered Species in particular.

- Compare the relative success of Other Covered Species on and off reserves.
- Evaluate the extent to which the NBHCP is meeting its objectives to provide open space to benefit all native wildlife species.

Secondary objectives of monitoring on reserve lands include providing information on the effects of management actions and monitoring populations of indicator species that may be useful in assessing the health of managed habitats.

Monitoring on non-reserve lands is limited to surveys for Other Covered Species. The objectives of this monitoring effort are listed below.

- Document the presence/absence of Other Covered Species within the Basin.
- Compare the relative success of Other Covered Species on and off TNBC reserve lands.

5.2 Methods

5.2.1 Surveys on Reserves

Surveys for Other Covered Species include surveys for covered avian species and Pacific pond turtles. These surveys are conducted using a generalized avian monitoring protocol that is a modified area search (Ralph et al. 1993). The survey technique consists of slowly driving roads or walking trails and recording the numbers of each species (both Covered and non-Covered Species) seen or heard on each reserve tract. Areas of dense vegetation, linear tree rows, and areas inaccessible by vehicle are surveyed on foot using the area search technique to ensure complete coverage. The exact route and the time allotted for the survey is specific to each tract and is constrained to ensure consistency in effort and technique through time. The numbers of each bird species seen or heard during the search are recorded. Species observed outside each tract are not counted unless they are clearly associated with the tract in some way (e.g., swallows flying overhead hawking insects, or a raptor perched outside the tract and scanning the ground inside the tract, would be counted). The specific routes taken and time allotted for each tract are described in the *Natomas Basin Habitat Conservation Plan Area Biological Effectiveness Monitoring Program* (ICF Jones & Stokes 2009).

From 2005 through 2017, surveys were conducted once on each tract monthly. Beginning in 2018, the frequency of surveys was changed from one survey per month to two surveys per month from April through June and one survey per month in July and August. Surveys in September through November were dropped. Surveys from December through February were limited to reserves composed of rice fields and emergent wetland habitats (ICF 2017).

The tracts acquired in 2021 included the Willey, Verona, and Lauppe South tracts in the North Basin Reserve, and the Paulsen South, Elverta, and Richter tracts in the Central Basin Reserve. Surveys on the Willey, Paulsen South, and Richter tracts began in January 2021. Surveys on the Verona and Lauppe South tracts began in May 2021. Surveys on the Elverta tract began in January 2022. Surveys on the Lauppe North tract, which was acquired in January 2022, also began in January. Observations of Covered Species on non-reserve lands or outside of formal survey periods were recorded separately as incidental observations. Pacific pond turtle detections were recorded during avian surveys, in particular along marsh shorelines with suitable basking habitat and other areas where turtles congregate to bask.

5.2.2 Non-Reserve Land Surveys

Surveys for Other Covered Species throughout the Basin on non-reserve lands are specifically designed to obtain maximum geographic coverage of the Basin and to ensure repeatability and consistency. These surveys were conducted monthly from 2005–2017. Since 2018, the survey effort has consisted of one survey per month from April through July.

The Basin is divided into three regions for the purposes of these surveys (Figure 5-1). The North Basin is the area between the Natomas Cross Canal and Elverta Road, the Central Basin is the area between Elverta Road and Del Paso Road, and the South Basin is the area between Del Paso Road and Garden Highway. A road transect has been established in each region. Each road transect covers 48–51 kilometers (30–32 miles) and is surveyed in approximately 1.5 hours. Survey times were assigned to road segments in each transect to minimize variation in effort. A single observer drives slowly (when possible) and scans the area for Other Covered Species, occasionally stopping at pullouts or backtracking where appropriate. Stops occur frequently to scan large fields for Other Covered Species, but the duration and number of stops are constrained by the time allotted for each segment and transect. Each survey route is depicted in Figure 5-1. Surveys in the South Basin reserve were discontinued at the end of 2017.

5.2.3 Analytical Methods

The average number of detections per survey (i.e., total number of individuals counted divided by the number of surveys) and the proportion of surveys in which at least one individual was counted are the two metrics or indices used to assess relative abundance between years, seasons, and reserves. Trends over time in the relative abundance were evaluated using simple linear regression.

5.3 Results

A complete list of all wildlife species detected on reserves since comprehensive monitoring began is provided in Appendix C-1. The numbers of each bird species detected by tract and reserve during surveys for Other Covered Species in 2022 are provided in Appendix C-2.

5.3.1 Generalized Avian Surveys

In 2022, 116 avian species were detected on reserves, compared to 123 in 2021, and 118 in 2020. The number of species observed each monitoring year has ranged from a low of 114 in 2019 to a high of 139 in 2009. Two new species were detected on reserves in 2022. Two mountain plovers (*Charadrius montanus*) were detected in January on the Lucich South tract. One Phainopepla (*Phainopepla nitens)* was detected in January and two were detected in February on the Atkinson tract. Table 5-1 summarizes the total number of individuals and number of avian species recorded from 2020 through 2022 on each tract (by reserve) for selected taxonomic groups (raptors, waterfowl, neotropical migrants, and shorebirds) and all birds.

5.3.1.1 Raptors

The raptor group consists of hawks and owls, a category of predatory birds that predominantly occupy the top of the food web and are generally less abundant than other groups, making them good indicators of ecosystem health. Although Swainson's hawk and burrowing owl are the only two Covered Species that are raptors, 17 other raptor species have been recorded during avian surveys in the Basin since 2004.

Many raptors are migratory, changing the composition of the raptor community across seasons. For example, Swainson's hawks occur in the Basin only during the breeding season, spending the winter in Central and South America, while large numbers of red-tailed hawks and other species move into the Basin from other areas during the winter.

Across all years and all seasons, red-tailed hawk continues to be the most abundant raptor on reserve lands, followed by northern harrier, American kestrel, red-shouldered hawk, and white-tailed kite. The annual average number of raptors detected per survey on reserve lands fluctuated from a high of 1.44 in 2009 to a low of 0.063 in 2019 and 2020 (Figure 5-2). The modest overall decline in raptor detections over the course of the monitoring period is no longer evident due to the increase in raptor detections in 2022 (R^2=0.204, P=0.060). However, declines in the number of detections of northern harrier (R^2=0.609, P<0.001) and American kestrel (R^2=0.637, P<0.001) are still evident and statistically significant.

The largest mean numbers of raptors detected per survey across all years were observed on the BKS (0.335 raptor per survey) and Atkinson tracts (0.223 raptor per survey), followed by Lucich South (0.133 raptor per survey) and Lucich North (0.127 raptor per survey). Raptors are most abundant on reserves from October through February when large numbers of them come into the Central Valley to spend the winter.

5.3.1.2 Waterfowl

The waterfowl group—comprising geese, swans, and ducks—is an important aesthetic and sporting resource in the Basin. About 60% of the ducks and geese that migrate along the Pacific Flyway use the wetlands, flooded agricultural fields, and wildlife refuges in the Central Valley during winter. The waterfowl population wintering in the Central Valley comprises 20% of all waterfowl in North America (Heitmeyer et al. 1989). Because less than 10% of the wetlands that historically covered the Central Valley still exist today, this group is of high management concern in the region. Drought and the fallowing of rice fields in 2022 have enhanced that concern.

Across all years, greater white-fronted goose continues to be the most abundant species of waterfowl on reserve lands, followed by snow goose, mallard, northern shoveler, and pintail. The average number of waterfowl detected per survey on reserve lands exhibits a great deal of variation over the monitoring period, as would be expected for migratory species that occur in very large flocks (Figure 5-3). However, there is no evidence of a significant increase or decrease in waterfowl numbers as a group over the monitoring period (R^2=0.112, P=0.175). Of the four most abundant species, only the mallard has exhibited a significant decline over the monitoring period (R^2=0.702, P=0.001) (Figure 5-3).

The largest numbers of waterfowl averaged over the course of the monitoring period were found on the BKS tract, followed by Lucich South, Lucich North, and Bennett North. BKS and Lucich North are composed almost entirely of wetlands; the other tracts with high numbers of waterfowl are composed of rice fields. Waterfowl numbers are highest from December through February when large numbers of geese and other waterfowl begin to arrive in the Central Valley to spend the winter.

5.3.1.3 Neotropical Migrants

Neotropical migrants are defined here as passerine (perching) birds (e.g., flycatchers, swallows, warblers) that breed in North America in the summer and migrate in fall to the Neotropics (southern United States, Mexico, Central America, and South America) to spend the winter. Populations of neotropical migrants are generally declining, due in part to loss of habitats such as riparian woodlands in both their breeding and wintering ranges, as well as habitat loss along migration routes. The riparian woodlands on the western and northern edges of the Natomas Basin are an important resource for breeding and migrating neotropical migrants. This habitat type has recently increased substantially in the Basin as a result of mitigation associated with the NLIP. Many species such as kingbirds and swallows also make extensive use of the wetlands, grasslands, and agricultural habitats on reserve lands for foraging.

Across all years, cliff swallows continue to be the most abundant neotropical migrant on reserve lands, followed by barn swallows, tree swallows, and western kingbirds (Figure 5-4). As of 2022, there has been no significant increase or decrease in the numbers of neotropical migrant detections over the monitoring period (R^2=0.014, P=0.645). Detections of neotropical migrants have been driven primarily by cliff swallows, which began nesting in large numbers under the carport on the BKS tracts in the Central Basin Reserve in 2012. In 2015, cliff swallows arrived on the BKS tract in April and May, but the colony collapsed and no young were fledged. The cliff swallow nesting colony did not return in 2016 or 2017, although large numbers of birds continue to congregate on the BKS tracts, possibly nesting in smaller groups throughout the tracts. In 2018, cliff swallows nested on both the BKS tracts and under the drainage canal between the AKT and Sharma SAFCA tracts. A similar pattern was repeated in 2019. In 2020, cliff swallows again nested in the culvert draining the SAFCA marshes into Fisherman's Lake, but in small numbers, and were not detected nesting anywhere else on reserve lands. No nesting colonies of cliff swallows were detected in 2021 or 2022.

Although there has been no significant decrease in neotropical migrants as a whole, there have been significant declines in the numbers of detections of barn swallows and tree swallows over the monitoring period (R^2=0.395, P<0.005 and R^2=0.254, P=0.033, respectively), No significant declines are evident for either cliff swallows (R^2=0.004, P=0.799) or western kingbirds (R^2=0.071, P=0.286) (Figure 5-4).

5.3.1.4 Shorebirds

Shorebirds are a diverse taxonomic group that includes sandpipers, plovers, stilts, avocets, snipes, and phalaropes. They are closely associated with wetland areas; the majority of species migrate long distances between breeding and wintering areas. The shallow wetlands and flooded agricultural fields of the Central Valley constitute one of the most important foraging areas in western North America for migrating and wintering shorebirds (Shuford et al. 1998). The post-harvest rice fields and marsh complexes of TNBC's reserve system provide important habitats for shorebirds during spring and fall migration. Management of these habitats can have a strong influence on the number of shorebirds stopping over in the Basin. Like waterfowl, shorebirds are a group of high management concern in the region.

Some shorebird species have been documented breeding on reserve lands, including American avocet, black-necked stilt, and killdeer. These species tend to be most abundant during June through August, the period after young have fledged. Conversely, the non-resident shorebirds tend to be most abundant in winter.

Long-billed dowitcher, killdeer, dunlin, and least sandpipers are the most abundant shorebirds on reserve lands. Shorebird detections have decreased significantly over the monitoring period (R^2=0.432, P=0.003). Long-billed dowitcher, killdeer, and dunlin all exhibit significant declines in the number of detections over the monitoring period (R^2=0.269, P=0.027, R^2=0.770, P<0.001, and R^2=0.253, P=0.033, respectively), while least and western sandpiper numbers show no evidence of an increase or decrease over the monitoring period (R^2=0.006, P=0.758) (Figure 5-5).

The largest numbers of shorebirds averaged over the course of the monitoring period are found on the BKS tract, followed by the Lucich South, Lucich North, and Nestor tracts.

5.3.1.5 Other Species and Observations of Interest

Yellow-billed magpie is endemic to California, and its range is restricted to the Central Valley, southern Coast Ranges, and Sierra Nevada foothills. Numbers of this species have declined rapidly in the Central Valley in association with the introduction and spread of West Nile virus, first detected in this species in 2004 (Ernest et al. 2010). Yellow-billed magpie appears to be more susceptible to West Nile virus than most species (Wheeler et al. 2009), and the impacts of West Nile virus on avian populations is of increasing concern because populations of many species have not recovered after initial contact with the disease, contrary to predictions (George et al. 2015).

The mean number of detections per survey has declined drastically and significantly over the monitoring period (R^2=0.809, P<0.001). With the exception of a slight increase in 2021, the number of detections has continued to decline to values significantly below the levels detected prior to the West Nile virus epidemic (Figure 5-6). Although yellow-billed magpies have been detected on most reserve tracts over the monitoring period, they began to disappear from tracts that did not contain nesting habitat after 2008. Not surprisingly, this species is most common on tracts with significant woodlands such as Alleghany 50, Atkinson, BKS, and Huffman West. However, even on these tracts, there has been a significant decline in the number of detections per survey over the monitoring period (R^2=0.562, P<0.001).

The distribution and abundance of the Canada geese has been increasing in the United States for several decades. Populations in some areas have grown substantially, so much so that they are considered pests for their droppings, bacteria in their droppings, noise, and damage they do to some grasslands.

Although California is outside the historical breeding range of Canada geese, numerous resident populations have become established. Because they are herbivorous, they can present management problems in natural landscapes where the management goal is establishment of native grasses. There has been a significant increase in the numbers of Canada geese detected on reserves during the monitoring period (R^2=0.824, P<0.001), although the numbers appear to have stabilized since 2018 (Figure 5-6). Canada geese now regularly nest on several reserve tracts, including the BKS, Lucich North, Lucich South, Frazer, Bennett North, and Bennet South tracts.

5.3.2 Other Covered Species

Of the 20 Other Covered Species, five have been detected in the Basin: white-faced ibis, loggerhead shrike, tricolored blackbird, burrowing owl, and Pacific pond turtle. Although suitable foraging habitat for Aleutian cackling goose (formerly Aleutian Canada goose) is present, this species has not been detected in the Basin since comprehensive monitoring began in 2004. Suitable nesting habitat for bank swallow is not present in the Basin. Suitable habitat for the vernal pool species—vernal pool fairy shrimp, mid-valley fairy shrimp, vernal pool tadpole shrimp, California tiger salamander, and western spadefoot—has not been reported in the Basin except for the 11 vernal pools (1 acre) created on the BKS tract and a few potentially suitable wetlands on private property along the extreme eastern edge of the Basin. To date, no evidence of occupancy of the 11 pools at BKS by any Covered Species has been observed. Several blue elderberry shrubs, the host plant for valley elderberry longhorn beetle, have been documented in the Basin, but the beetle itself has not been found there and no surveys have been conducted. None of the covered plant species have been detected in the Basin (see Chapter 2, *Land Cover Mapping, Botanical Inventory, and Noxious Weed Monitoring*). Several Sanford's arrowhead (*Sagittaria sanfordii*) plants were transplanted to the BKS tract in 2021 but did not survive.

All five Other Covered Species known to occur in the Basin have been documented on reserves, and all have been documented or are suspected of breeding on reserves at some point since comprehensive monitoring began (Tables 5-2 and 5-3). Pacific pond turtles of varying size are now routinely documented on reserves, and thus breeding on reserves is almost certain.

The average number of individuals detected per survey of avian Other Covered Species recorded during surveys on reserves is summarized in Table 5-3. The average numbers of avian Other Covered Species detected per survey during non-reserve land surveys are summarized in Table 5-4.

5.3.2.1 Loggerhead Shrike

Loggerhead shrike has been a year-round resident in the Natomas Basin and has been detected throughout the year (Figure 5-7). The mean number of detections per survey on reserve lands has been cyclic over the course of the monitoring period, peaking in 2009 and 2012, followed by a substantial decline after 2013 (Table 5-3, Figure 5-7). Shrike detections have remained low since 2014 and declined to zero in 2022. The decline in shrike detections on reserve lands over the monitoring period have been significant (R^2=0.272, P=0.032).

In 2020, a single shrike was detected twice on the Atkinson tract of the Central Basin Reserve on the south side adjacent to the buffer lands surrounding SMF. A single shrike was also identified once on the adjacent Ruby Ranch tract in 2021. No shrikes were detected on reserve lands in 2022, and none have been detected during Basin-wide surveys in since 2017.

The decline in the shrike population in the Basin is more pronounced on non-reserve lands. Both the mean number of loggerhead shrikes detected per survey on non-reserve lands and the proportion of surveys with shrike detections have declined significantly over the course of the monitoring period (R^2=0.831, P<0.001 and R^2=0.907, P<0.001, respectively; Table 5-4; Figure 5-7).

5.3.2.2 White-Faced Ibis

White-faced ibis was regularly detected in small numbers on reserve lands from June through September when comprehensive monitoring began in 2005. However, from 2007 through 2010 white-faced ibis established a large nesting colony on the BKS tract in the Central Basin Reserve (Table 5-2). In 2011, the BKS nesting colony was abandoned and ibis did not nest in the Basin. In 2012, a new nesting colony was established on the Willey Wetlands Preserve, a wetland constructed and owned by SCAS as mitigation for the loss of wetlands associated with airport expansion. The Willey Wetlands Preserve nesting colony was active again in 2013, and ibis from this colony foraged extensively in the rice fields of the adjacent Lucich South and Bennett South tracts. This nesting colony was active again in 2021, with 400 to 600 nesting pairs. White-faced ibis did not nest in the Basin in 2022.

Over the monitoring period, white-faced ibis typically occur in very low numbers outside the breeding season and move into the Basin in large numbers from May through September (Figure 5-8).

Neither the mean number of ibis detected per survey or the proportion of surveys on which ibis were detected on reserve lands exhibits a significant increase or decrease over the monitoring period. The mean number of ibis detected per survey has remained relatively volatile over the monitoring period, and 2022 was no exception, with detections dropping significantly after a substantial increase in 2021. Conversely, the proportion of surveys in which white-faced ibis are detected has remained relatively constant (Table 5-3, Figure 5-8).

There appears to be a slight increase in the mean number of white-faced ibis detected per survey on non-reserve lands, although it is not statistically significant (R^2=0.198, P=0.064), and the proportion of surveys on which ibis was detected exhibits a significant increase over the monitoring period (R^2=0.503, P<0.001) (Figure 5-8).

5.3.2.3 Tricolored Blackbird

Tricolored blackbirds are detected in the Basin throughout the year (Figure 5-9), although numbers are impossible to estimate outside the breeding season when they primarily occur in large, mixed-species flocks. During the breeding season, tricolored blackbirds occur in single-species flocks that are more detectable, even when they are not breeding.

Nesting tricolored blackbirds were first documented nesting in the Basin in 2005 on the BKS tract in a small patch of Himalayan blackberry. The species nested in this same spot in 2007, and a second colony was documented in 2007 in a large patch of Himalayan blackberry along the north edge of the Basin on private property. In 2008, the BKS colony moved to the marshes, while the colony along the north edge of the Basin moved to the marshes on the Frazer tract. Tricolored blackbirds continued nesting on the BKS tract through 2010 (Table 5-2). In 2011, a new colony was established on the Willey Wetlands Preserve. In 2012, no tricolored blackbirds nested in the Basin for the first time since 2006. In 2013, tricolored blackbirds began to establish a nesting colony on the Willey Wetlands Preserve but subsequently abandoned the nesting attempt. In 2020, tricolored blackbirds again nested on the Willey Wetlands Preserve adjacent to the Lucich South tract in the North Basin Preserve. Tricolored blackbirds have not nested in the Basin since 2020.

Tricolored blackbirds have historically occurred in the Basin throughout the year, although the numbers detected show a marked increase in May through August (Figure 5-9). However, in the last several years, there have been fewer detections of tricolored blackbirds outside the breeding season.

The mean number of tricolored blackbirds detected per survey on reserve lands exhibits a significant decrease over the monitoring period, primarily due to the presence of nesting colonies on the BKS and Frazer tracts in 2005, 2007, 2008, and 2009 (R^2=0.308, P=0.017), while the proportion of surveys on which tricolored blackbirds were detected on reserve lands does not exhibit any significant increase or decrease over time (R^2=0.001, P=0.948) (Figure 5-9).

Conversely, the mean number of tricolored blackbirds detected per survey on non-reserve lands exhibits no significant increase or decrease over time (Figure 5-9), while the proportion of surveys on which tricolored blackbirds were detected on non-reserve lands has increased significantly over the monitoring period (R^2=0.424, P=0.005) (Figure 5-9), primarily due to the establishment of a new nesting colony on the airport mitigation lands.

5.3.2.4 Western Burrowing Owl

Burrowing owls are known to breed and winter in low densities in the Basin, and are regularly detected throughout the year (Figure 5-10). A single pair resided at the BKS tract in 2004 and 2005 but disappeared after one member of the pair was found dead in 2006, apparently killed by a great horned owl. No burrowing owls have subsequently been detected on the BKS tract (Table 5-2).

In 2008, a pair of owls nested in a ground squirrel burrow in the northeastern corner of the Elsie tract along the Highline Canal that separates the Elsie and Tufts tracts in the Central Basin Reserve. In 2009, three pairs of owls nested in this area. In 2010, a nesting pair was documented on both the Elsie and Tufts tracts, and each produced at least three young. A single owl was observed during the breeding season on the Sills tract and on one survey was observed to be paired, although no evidence of nesting was subsequently observed. In 2011, there were three pairs documented on the Elsie and Tufts tracts, but no evidence of breeding was observed. In 2012, the pair on the Elsie tract produced a single fledgling, and the Tufts tract contained a single owl. Single owls were observed once in November on the Bolen West tract and the Sills tract. Breeding owls were absent from reserve lands in 2013. The pairs from the Elsie and Tufts tracts abandoned the site after October 2012. Owls returned to the Elsie and Tufts tracts in August 2013, although they subsequently moved to new locations on these tracts. In 2014, a pair was observed on the Tufts tract in a new location during March and April but subsequently disappeared and was not observed again until October. In 2015, a single owl was detected once on the Tufts tract in January. In 2016, a single owl was detected once on the Tufts tract in February. Owls were not detected again until November, when a single owl was detected on the Elsie and Tufts tracts, and again in December on the Elsie tract. No breeding owls were detected on reserve lands in 2016. In 2017, a single owl was detected on the Tufts tract in May but was not detected again until October. No other owls were detected on reserve lands in 2017. In 2018, a pair was detected in February on the Tufts tract, but no owls were detected again until December, when three owls were detected on the Elsie and Tufts tracts. A similar pattern was observed in 2019, when owls were detected on the Elsie, Tufts, and Sills tracts in January, February, and December, with only a single siting in May on the Tufts tract. In 2020, burrowing owls were detected on the Elsie, Tufts, and Nestor tracts in January. Owls were detected on the Elsie tract in February and March as well, but no owls were detected after May on reserve lands in 2020.

In 2021, owls were detected on the Tufts tract in January and February but were not detected again on reserve lands until December, when a single owl was detected on the Elsie tract. In 2022, a single owl was detected once in December on the Elsie tract. Nesting does not appear to be occurring on reserve tracts any longer, although wintering birds still use the area regularly.

Three burrowing owl colonies have been documented in the Basin on non-reserve lands. The largest occupied the tree planters in the parking lot of Sleep Train Arena (formerly Arco Arena). Six pairs were observed in this colony in April 2012. At least three of these pairs produced two, three, and five fledglings by June. In 2013, four pairs were present from May through July with at least one pair producing young. However, in August a large recreational vehicle show created a great deal of disturbance near the nesting colony, and only a single pair was observed until December, when five individuals were detected. In 2014, there was one pair and a single bird. The pair eventually fledged two young. In September, a large number of recreational vehicles were parked in the part of the parking lot where the burrowing owls reside, creating a large disturbance that lasted for at least a month. A single owl was observed each month for the remainder of the year. In 2015, a single bird was detected in February, July, August, November, and December. In 2016, the colony at Sleep Train Arena consisted of a single owl that was detected in nine of the 12 surveys throughout the year. In 2017, a single bird was detected in January, but no owls were subsequently detected. Use of the area once occupied by the owls for parking large recreational and commercial trucking vehicles has resulted in a level of disturbance that is apparently too great for the owls to tolerate. No owls were detected at this colony in 2018 and monitoring in the southern part of the Basin was abandoned in 2019. The demolition of Sleep Train Arena was initiated in August 2022 and completed in October of that year.

The second colony occurs near the eastern edge of the Basin just north of Del Paso Boulevard near Aimwell Road along a dirt road bordering an agricultural field. Two pairs produced four young in this colony in 2010. In 2011, three pairs were observed in April. However, by June there were only two pairs remaining and a maximum of three juveniles were observed at any one time. In 2012, three pairs occupied the site that fledged a minimum of one, two, and four juveniles. In 2013, four pairs occupied the site but only two fledged young were confirmed. In 2014, up to 11 birds were observed on the site, constituting at least three pairs. The maximum number of fledglings detected at one time was three, although the actual number is probably much higher. In October, the field on the north side of the berm was plowed and the berm itself was “fixed,” resulting in the collapse of most of the burrows that had been occupied by the burrowing owls in the colony. A single bird was observed on the site through the rest of 2014. That number increased to two pairs by April 2015. A maximum of 11 individuals were observed in May 2015, probably representing two breeding pairs and seven fledged juveniles. For the remainder of the year, the number of individuals detected ranged from one to three. In 2016, no more than two adults were observed throughout most of the year, with the exception of the September survey, when six birds were observed, indicating a single pair that successfully fledged four young. In 2017, three owls were detected in this colony in January. Subsequently, the area around the dirt road where the owl colony occurred was allowed to become completely overgrown with 3-foot-tall grasses and 6-foot-tall thistle (*Cirsium* spp.), rendering the habitat largely unsuitable for occupation by burrowing owls. As a result, only a single owl was detected in this colony through the remainder of the year. No owls were detected at this site in 2018 and monitoring of the southern part of the Basin was abandoned in 2019.

The third colony occurs just north of Elkhorn Boulevard near the eastern edge of the Basin in an elevated area between two agricultural fields that historically contained several buildings that have since been removed. Two pairs occupied this site in 2011 and fledged at least six young. In 2012, at least four pairs occupied the site and produced at least eight fledglings. In 2013, at least four pairs occupied the site and produced a minimum of five young. However, by the end of the year only a single owl occupied the site. In 2014, at least three pairs occupied the site and produced a minimum of three young. By the end of June, the site had become so overgrown that it was no longer suitable burrowing owl habitat. However, owls continued to occupy the site through August, after which owls were no longer detected. In 2015, a single pair occupied the site and fledged two young. In 2016, a single pair was observed in June, and a single fledgling was observed in August. Similarly, in 2017 a single pair fledged two young. In 2018, there was a single pair that probably fledged one young. No owls were observed at this site in 2019 or 2020.

Four owls were observed on private property on the north side of Elkhorn Boulevard directly across the street from the old Elkhorn Boulevard colony in 2018. A single owl was detected in June 2019, and one adult and three fledglings were observed in 2020. In 2021, a single pair was detected that fledged at least one young, and in 2022, a single owl was detected in May and again in July.

Burrowing owl use of other locations in the Basin has been documented over the years. A nesting pair was discovered in 2012 nesting at the base of the Steelhead Creek levee just north of the BKS tract. This pair successfully fledged at least two young but have not returned to the site over the last 4 years. Burrowing owls were also detected in a Natomas development just south of Del Paso Road in 2015, and on the east side of the Elverta Road overpass during construction in 2012. A single bird occupied the storm drain in the northeast corner of Del Paso and El Centro Road for a few months, and a breeding pair occupied the SR 99 off-ramp at Elkhorn Boulevard in 2011.

Neither the mean number of burrowing owls detected per survey nor the proportion of surveys on which owls were detected on reserve lands exhibit a statistically significant increase or decrease over the monitoring period (R^2=0.170, P=0.089 and R^2=0.183, P=0.077, respectively) (Table 5-3, Figure 5-10).

Similarly, neither the mean number of burrowing owls detected per survey nor the proportion of surveys on which owls were detected exhibits a statistically significant increase or decrease over the monitoring period (R^2=0.043, P=0.407 and R^2=0.005, P=0.788, respectively) (Table 5-4, Figure 5-10).

It is clear that burrowing owls are occupying fewer places in the Basin and are no longer resident in some areas where they historically have been, both on and off reserve lands.

5.3.2.5 Pacific Pond Turtle

Pacific pond turtles were known to occur in several areas of the Basin prior to the onset of comprehensive monitoring in 2005, including Fisherman's Lake and near the Prichard Lake and Elkhorn pumping stations. Red-eared sliders, a naturalized but nonnative species that superficially resembles Pacific pond turtle, can be difficult to distinguish from Pacific pond turtles before they slip into the water and disappear. Since 2013, large adult Pacific pond turtles have been observed regularly in Fisherman's Lake adjacent to the Rosa and Natomas Farms tracts during the summer months. Pacific pond turtles have also been documented on the Cummings, Natomas Farms, and Rosa Central tracts of the Fisherman's Lake Reserve, the BKS and Sills tracts of the Central Basin Reserve, and the Lucich North, Lucich South, Bennet North, Bennet South, and Frazer tracts of the North Basin Reserve.

Both the mean number of pond turtles and unidentified turtles detected per survey and the proportion of surveys on which pond turtles were detected on reserve lands exhibit a significant increase over the monitoring period (R^2=0.766, P<0.001 and R^2=0.865, P<0.001), respectively) (Table 5-3, Figure 5-11). It should be noted that small events can strongly influence these results, such as when a tree fell across one of the marshes on the BKS tract and was subsequently used extensively for basking by turtles, which greatly increased the probability of detecting them. In most years during the monitoring period, pond turtles have rarely been detected on non-reserve land surveys, with detections confined to the Del Paso Road crossing of Fisherman's Lake and sighting of a large female on Metro Air Parkway.

The number of unidentified turtles detected on surveys is increasing. Due to the difficulty in determining species when turtles of all species dive at the first sign of disturbance, it is impossible to tell if the increase is due to an increasing number of Pacific pond turtles or if the increase is due to increased numbers of nonnative turtles.

5.4 Discussion

TNBC reserves provide important wildlife habitats in the Central Valley. On average, 125 species of birds are recorded on reserves each year—most of which are typical of the Central Valley and are associated with open agricultural habitats, aquatic habitats, and oak woodlands. Diversity is lowest on small tracts dedicated to rice or upland agriculture and slightly higher on tracts with row crops where remnant patches of riparian scrub or valley oak woodland occur. Higher diversity is found on tracts with a managed marsh component and on tracts with a diversity of habitat types. Diversity is highest on the BKS tract, where managed marsh, annual grassland, and riparian scrub occur in close association over a large area. Monitoring results to date clearly indicate that TNBC reserves meet the objective outlined in the NBHCP to provide open space to benefit wildlife species.

The number of loggerhead shrike detections has been declining on reserves since 2012, and the situation on non-reserve lands is worse, with the number of detections on Basin-wide surveys remaining at zero for the sixth year in row. The seasonal pattern in loggerhead shrike detections indicates that little reproduction has occurred in the Basin over the past several years.

Despite trends in the numbers of shrike detections, habitat for shrikes has been expanding. The creation of extensive grasslands adjacent to the stands of oak woodland along the western side of the Basin as mitigation for the NLIP, along with the establishment of additional riparian and wetland habitats in this area should prove beneficial to shrike populations in the Basin. However, the effects of the extended and severe drought may be adversely affecting shrike populations and delaying colonization of these new habitats. Another hypothesis concerns declines in insect prey upon which shrikes depend, which has been bolstered recently by studies in Europe showing dramatic declines in insect abundance even in wilderness areas (Hallmann et al. 2017).

The white-faced ibis population has been generally increasing in the Basin since comprehensive monitoring began in 2005. Prior to establishment of the nesting colony on the BKS tract in 2007, ibis were known to nest in only a few scattered locations in the Central Valley (Ryder and Manry 1994). Ibis now appear to nest in the Basin intermittently, and the pattern of detections indicates that they continue to make greater use of the habitats in the Basin than they did in the period prior to the establishment of a nesting colony. In fact, ibis are now regularly using the rice fields and marshes for foraging.

Assessment of the health and trends in the tricolored blackbird population in the Basin is difficult because these birds are itinerant breeders that often change nesting locations and frequently fail to breed (Beedy and Hamilton 1999). Tricolored blackbirds occur in mixed-species flocks in the Basin throughout the winter, so it is unknown if new birds come into the Basin during the breeding season or if the existing birds simply flock together and become more detectable beginning in late May. Tricolored blackbird populations have experienced significant declines throughout their range and were listed as threatened under the CESA and are currently being considered for listing under the federal ESA. Despite the volatility in detections of tricolored blackbirds in the Basin, the created marsh habitats on TNBC reserves and elsewhere have undoubtedly contributed to the conservation of the species.

Prior to the establishment of TNBC's reserve system, nesting habitat for tricolored blackbirds was extremely limited in the Basin. Although there has been an expansion of nesting habitat as a result of establishment of the TNBC reserve system, it is possible that nesting habitat is not the limiting factor for this species in the Basin, but rather a lack of appropriate foraging habitat and/or insect prey. Tricolored blackbirds continue to use habitats on both reserve and non-reserve lands each year, even when breeding does not occur.

The mean number of burrowing owls detected per survey on reserve lands has remained at the same low level that began in 2015 after birds occupying the Elsie and Tufts tracts abandoned their nesting burrows (but continued to occupy these burrows in the winter time). The number of available burrows in this area is limited, and it might be expected that abandonment of some of these burrows—at least temporarily—would be necessary after so many years of use. The Highline Canal, where burrows occupied by the owls occur, is both higher and wider than other levees in the Basin with less extensive vegetation, perhaps due to higher compaction. Although these conditions are relatively rare in the Basin, the limited number of observations of owls in rice growing portions of the Basin suggest that raising and widening berms along the larger drainage canals may provide additional burrowing owl habitat.

The mean number of burrowing owls detected per survey at the three breeding colonies on non-reserve lands have all been declining over the last few years, and all three have now been completely abandoned, although a single nesting pair occurs across the street from the Elkhorn colony. Habitat suitability at Sleep Train Arena colony site declined drastically due to increased disturbance in the area where owls were historically most abundant. Habitat values at the Elkhorn Boulevard colony has probably also declined due to excessive vegetation growth and accumulation of tumbleweeds. Although the tumbleweeds were partially removed in 2017, owl numbers have not rebounded. Finally, the owl colony at the end of Aimwell Road also suffered from a major disturbance when the road separating two fields underwent maintenance that resulted in the collapse of nearly all the burrows, followed by a lack of maintenance the following year that allowed the road to become overgrown with vegetation.

Pacific pond turtle detections on reserve lands have continued to increase and it is now clear that they occupy and breed within most, if not all, of the TNBC marsh complexes. The creation and management of marsh habitats by TNBC have provided substantial benefits for Pacific pond turtle populations.

No valley elderberry longhorn beetles or evidence of occupancy of shrubs in the Basin were observed, nor were any new shrubs found. Suitable riparian habitats are generally limited to the north, west, and south Basin margins along the Sacramento River and the Natomas Cross Canal.

Habitats for Other Covered Species associated with vernal pools (e.g., vernal pool invertebrates, western spadefoot, and California tiger salamander) are generally lacking in the Basin. There have been no detections of vernal pool Covered Species in the vernal pools created on the BKS tract. No vernal pool associated species have been detected and little habitat capable of supporting them has been reported since implementation of the NBHCP began.

5.5 Effectiveness

Biological effectiveness as it pertains to Other Covered Species is measured primarily on the basis of land management activities that promote the development and enhancement of habitats for these species and the response of populations to these management actions.

White-faced ibis, tricolored blackbird, western burrowing owl, Pacific pond turtle, and loggerhead shrike have all been documented using reserve lands within the Basin. The first nesting of ibis and tricolored blackbirds in the Basin occurred on reserve lands. The persistence of burrowing owls along the Highline Canal between the Elsie and Tufts tracts of the Central Basin Reserve has resulted from careful avoidance of significant disturbance to these sites by maintenance crews maintaining the canal levee. It is clear that the establishment and management of habitats by TNBC have provided substantial conservation benefits to these species. However, declines in populations of these species, all of which are dependent to some extent on the abundance of larger insect prey, indicate that additional management actions are warranted.

5.6 Recommendations

Burrowing owl populations in the Basin have likely always been small. Efforts to protect crops and levee roads in agricultural areas have typically included intensive ground squirrel control, further reducing potential habitat for this species. TNBC should consider the following actions to augment burrowing owl populations on reserves.

- Limit the use of insecticides to the maximum extent practicable on all reserve lands to allow insect prey populations to recover.
- Allow natural colonization of new habitats by California ground squirrels in suitable upland habitats, or consider translocation of ground squirrels to suitable sites.
- Look for opportunities to create burrowing owl nesting habitat by creating raised earthen berms in grassland habitat away from trees and power poles where California ground squirrels can occur without substantially interfering with crop production or levee safety.
- Consider maintaining an unplowed/unfarmed (but mowed or grazed as necessary) strip of land on upland agricultural fields away from trees and power poles, above grade where possible, to provide potential burrowing owl nesting habitat.
- Allow development projects where burrowing owls occur to actively relocate their burrowing owls onto TNBC reserves, using nest boxes where appropriate.

Tricolored blackbird nesting colonies have become established in managed marsh habitats at the BKS and Frazer tracts, and these habitats constitute an extremely rare and important resource for this species. However, it is possible that foraging habitat and adequate prey resources at the right time of year—rather than nesting habitat—is the limiting factor for this species in the Basin. TNBC should consider the following actions to provide additional resources for the nesting tricolored blackbird population in the Basin. Many of these recommendations would also improve conditions for loggerhead shrike.

- Continue to manage some created marsh habitats to further promote the development of dense tule stands. This action will also benefit white-faced ibis.
- To the extent possible, conduct necessary management activities (i.e., grazing, mowing, weed spraying, etc.) outside the breeding season (May through August) to minimize disturbance and human presence and the potential for nest disturbance, destruction, or abandonment.
- Conduct channel clearing and marsh maintenance activities in a way that maintains the vegetation and vegetation structure used by nesting white-faced ibis and tricolored blackbird to the maximum extent possible.
- Attempt to create and maintain, where appropriate, irrigated pasture, open grasslands, and alfalfa for foraging tricolored blackbirds that minimizes the use of insecticides that would reduce insect prey populations.
- Limit the use of insecticides to the maximum extent practicable on all reserve lands to allow insect prey populations to recover.

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Table 5-1. Summary of Results of Monthly Avian Surveys by Reserve and Tract,[a] 2020–2022

	Waterfowl			Raptors			Neotropical Migrants			Shorebirds			All Bird Species		
Reserve	2020	2021	2022	2020	2021	2022	2020	2021	2022	2020	2021	2022	2020	2021	2022
North Basin Reserve															
Atkinson	- (-)	179 (4)	73 (3)	52 (9)	41 (8)	42 (6)	158 (9)	116 (9)	136 (9)	2 (1)	6 (2)	8 (2)	1,881 (56)	2,405 (65)	1,609 (59)
Bennett North	2,601 (17)	3,414 (12)	748 (11)	17 (5)	29 (6)	8 (4)	23 (4)	15 (3)	47 (3)	103 (2)	8 (2)	20 (1)	4,284 (50)	5,087 (41)	1,550 (38)
Bennett South	133 (6)	627 (4)	33 (8)	17 (6)	28 (7)	14 (6)	18 (3)	16 (5)	20 (4)	177 (6)	34 (4)	4 (1)	5,302 (42)	3,702 (42)	4,846 (35)
Bolen North	390 (3)	2,483 (3)	12 (1)	6 (2)	5 (2)	8 (3)	1 (1)	2 (1)	1 (1)	111 (4)	48 (3)	9 (2)	1,118 (22)	3,793 (24)	744 (23)
Bolen South[b]	- (-)	- (-)	- (-)	6 (3)	5 (2)	6 (2)	49 (3)	55 (4)	45 (5)	- (-)	- (-)	- (-)	323 (25)	1,911 (26)	408 (29)
Bolen West	21 (2)	676 (5)	- (-)	11 (3)	7 (4)	8 (4)	11 (3)	11 (3)	16 (2)	8 (3)	413 (4)	- (-)	732 (24)	5,092 (37)	348 (15)
Frazer	1,720 (11)	1,078 (9)	548 (11)	8 (4)	9 (4)	9 (3)	64 (4)	8 (1)	22 (3)	22 (2)	15 (1)	20 (2)	3,145 (44)	2,669 (38)	1,865 (40)
Huffman East	43 (2)	173 (3)	16 (1)	12 (5)	13 (4)	5 (4)	4 (2)	4 (2)	3 (2)	516 (6)	8 (2)	14 (1)	1,893 (31)	2,341 (24)	1,737 (28)
Huffman West[b]	- (-)	- (-)	- (-)	35 (3)	25 (5)	12 (4)	20 (3)	32 (4)	25 (5)	22 (2)	13 (2)	8 (1)	897 (24)	1,163 (28)	590 (24)
Lauppe North	n/a	n/a	- (-)	n/a	n/a	15 (5)	n/a	n/a	15 (2)	n/a	n/a	44 (3)	n/a	n/a	1,842 (29)
Lauppe South	n/a	2 (1)	128 (3)	n/a	1 (1)	3 (3)	n/a	12 (4)	17 (4)	n/a	61 (2)	156 (4)	n/a	399 (25)	1,195 (28)
Lucich North	5,948 (15)	2,608 (17)	1,338 (19)	21 (6)	26 (5)	15 (5)	51 (3)	32 (3)	46 (4)	159 (4)	429 (4)	180 (5)	12,645 (56)	6,010 (55)	2,542 (52)
Lucich South	1,401 (9)	5,630 (13)	265 (6)	30 (5)	32 (7)	22 (4)	4 (3)	2 (1)	12 (2)	370 (7)	99 (7)	158 (4)	6,413 (48)	8,055 (49)	11,463 (41)
Nestor	20 (4)	30 (3)	2 (1)	20 (6)	9 (2)	13 (4)	10 (4)	3 (2)	- (-)	19 (2)	43 (5)	4 (1)	764 (29)	1,452 (28)	440 (19)
Ruby Ranch	25 (1)	28 (2)	60 (1)	4 (3)	7 (3)	10 (2)	100 (3)	18 (4)	14 (2)	18 (2)	20 (3)	9 (2)	1,108 (31)	3,525 (34)	413 (18)
Verona	n/a	2,507 (3)	- (-)	n/a	1 (1)	4 (4)	n/a	19 (4)	6 (2)	n/a	5 (1)	3 (1)	n/a	2,780 (26)	276 (19)
Vestal	9 (1)	20 (2)	270 (1)	5 (4)	6 (5)	12 (3)	23 (5)	19 (4)	15 (3)	4 (1)	15 (1)	4 (1)	936 (35)	887 (32)	1,106 (28)
Willey	n/a	756 (5)	3 (1)	n/a	5 (3)	4 (2)	n/a	3 (2)	2 (2)	n/a	- (-)	81 (2)	n/a	1,088 (21)	1,411(19)
Central Basin Reserve															
BKS	8.913 (18)	8,342 (19)	2,386 (21)	56 (8)	58 (8)	70 (8)	339 (5)	143 (5)	283 (5)	150 (5)	105 (5)	78 (4)	17,517 (72)	15,771 (72)	7,632 (74)
Bianchi West	6 (1)	676 (5)	363 (5)	5 (3)	4 (2)	6 (1)	- (-)	3 (1)	2 (1)	79 (5)	57 (4)	65 (6)	732 (24)	1,167 (26)	1,084 (25)
Elsie	8 (2)	108 (3)	90 (1)	15 (5)	25 (4)	9 (4)	13 (1)	2 (1)	7 (1)	11 (2)	18 (2)	9 (1)	335 (20)	1,932 (26)	1,813 (19)
Elverta/Silva S.	n/a	n/a	979 (2)	n/a	n/a	20 (4)	n/a	n/a	20 (2)	n/a	n/a	5 (1)	n/a	n/a	1,693 (27)
Frazer South	1,949 (9)	603 (10)	122 (3)	7 (2)	8 (3)	14 (3)	3 (2)	6 (3)	13 (2)	214 (5)	102 (4)	48 (4)	1,819 (37)	1,308 (37)	666 (26)
Paulsen South	n/a	196 (6)	196 (5)	n/a	1 (1)	1 (1)	n/a	6 (1)	- (-)	n/a	9 (2)	26 (4)	n/a	374 (20)	454 (21)
Richter	n/a	2 (1)	15 (1)	n/a	7 (3)	4 (2)	n/a	1 (1)	2 (2)	n/a	10 (2)	- (-)	n/a	236 (15)	85 (12)
Sills	324 (4)	54 (5)	356 (4)	23 (4)	29 (4)	18 (3)	23 (2)	8 (2)	29 (4)	100 (4)	76 (5)	10 (2)	2,727 (29)	2,048 (33)	1,615 (31)
Tufts	18 (1)	20 (3)	79 (2)	3 (3)	18 (3)	8 (2)	12 (3)	2 (1)	4 (1)	119 (3)	14 (2)	2 (1)	701 (20)	759 (22)	667 (20)
Fisherman's Lake Reserve															
Allegheny[b]	- (-)	- (-)	- (-)	2 (2)	- (-)	3 (1)	43 (5)	9 (2)	5 (2)	1 (1)	- (-)	1 (1)	226 (27)	107 (11)	101 (15)
Cummings	111 (6)	162 (5)	56 (7)	18 (6)	11 (4)	4 (3)	76 (5)	33 (4)	26 (3)	2 (1)	5 (1)	3 (1)	999 (50)	626 (34)	593 (35)
Natomas Farms	322 (8)	323 (5)	201 (11)	14 (6)	17 (8)	6 (2)	47 (4)	8 (3)	54 (3)	- (-)	7 (1)	5 (1)	825 (43)	1,038 (43)	636 (45)

Table 5-1 Continued

	Waterfowl			Raptors			Neotropical Migrants			Shorebirds			All Bird Species		
Reserve	2020	2021	2022	2020	2021	2022	2020	2021	2022	2020	2021	2022	2020	2021	2022
Rosas[b]	11 (3)	24 (4)	6 (1)	7 (3)	11 (2)	8 (3)	37 (5)	32 (4)	41 (5)	2 (1)	2 (1)	9 (1)	924 (35)	405 (31)	280 (29)
Souza[b]	6 (1)	5 (1)	79 (2)	5 (2)	6 (3)	1 (1)	13 (3)	29 (2)	3 (1)	- (-)	1 (1)	1 (1)	164 (19)	164 (20)	185 (19)

[a] Numbers in this table reflect the total number of individuals of each group observed followed by the number of species observed (in parentheses).

[b] These reserves were surveyed only from May through August and therefore would be expected to have a lower number of observations and species.

Table 5-2. Number of Pairs of Other Covered Species on TNBC Mitigation Lands, 2004–2022

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Burrowing owl	1 (BKS)	1 (BKS)	1 (BKS, pair failed)	0	1 (Elsie)	3 (2 Tufts, 1 Elsie)	4 (1 Tufts, 1 Elsie, 1 Sills, 1 BKS)	3 (2 Elsie, 1 Tufts)	1 (Elsie)	2 (Elsie)	1 (Tufts)	0	0	0	0	0	0	0	0
Loggerhead shrike	4 (3 BKS, 1 Brennan)	3 (2 BKS, 1 Brennan)	3 (1 BKS, 1 Alleghany, 1 Brennan)	3 (1 BKS, 1 Alleghany, 1 Huffman West)	1 (Alleghany)	1 (Atkinson)	1 (Atkinson)	1 (Atkinson)	3[a]	3[a] (1 Lucich North, 1 Rosa, 1 Souza)	4[a] (Lucich North, Bennett North, Atkinson, Rosa)	1[a] (Rosa)	0	1 (Rosa)	1 (Rosa)	0	0	0	0
Tricolored blackbird	0	~900 (BKS)	0	~1,200 (BKS)	~4,900 (~900 BKS, ~4,000 Frazer)	~1,500 (BKS)	~700 (BKS)	0	0	0	0	0	0	0	0	0	0	0	0
White-faced ibis	0	0	0	~750 (BKS)	~1,500 (BKS)	~2,500 (BKS)	~2,500 (BKS)	0	0	0	0	0	0	0	0	0	0	0	0

[a] Presumed nesting on/or immediately adjacent to reserve lands.

Table 5-3. Average Number of Observations per Survey of Other Covered Species Recorded during Monthly Avian Surveys on Reserves, 2005–2022

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
White-faced ibis[a]	0.268	0.989	14.791	48.812	79.329	53.486	4.424	8.093	6.809	4.464	5.271	7.333	1.049	4.949	9.410	4.404	16.051	4.471
Burrowing owl	0.028	0.039	0.000	0.098	0.196	0.175	0.138	0.058	0.022	0.036	0.004	0.009	0.004	0.020	0.043	0.029	0.018	0.006
Loggerhead shrike	0.085	0.033	0.067	0.223	0.253	0.047	0.116	0.164	0.164	0.054	0.044	0.036	0.013	0.051	0.020	0.007	0.003	0.000
Tricolored blackbird	24.169	2.039	26.836	50.031	15.760	2.401	3.763	1.604	6.236	5.000	4.071	0.982	0.391	3.336	0.602	5.211	3.405	3.006
Pacific pond turtle and Unidentified Turtle	0.000	0.000	0.000	0.004	0.000	0.000	0.004	0.027	0.033	0.065	0.047	0.044	0.018	0.099	0.082	0.082	0.071	0.142

[a] To account for variation in effort in documenting total numbers during Basin-wide surveys and to account for numbers inflated by large counts at nesting colonies, this metric is the proportion of surveys on which the species was detected.

Table 5-4. Average Number of Observations per Survey of Other Covered Species Recorded during Monthly Basin-Wide Surveys, 2005–2022

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
White-faced ibis[a]	5.385	36.269	33.077	867.348	84.778	7.389	9.444	37.333	104.77	34.273	43.577	114.59	2.773	32.667	105.62	24.286	472.62	124.40
Burrowing owl	0.385	0.385	0.038	1.826	3.519	4.000	4.852	7.292	5.682	4.364	1.855	1.471	1.136	1.222	0.125	0.857	0.625	0.200
Loggerhead shrike	3.269	2.769	2.346	1.565	3.519	2.167	2.111	2.042	1.273	0.545	0.500	0.059	0.045	0.000	0.000	0.000	0.000	0.000
Tricolored blackbird	6.385	1.154	1.885	261.739	287.222	0.000	18.519	5.000	7.364	37.773	56.154	5.294	12.364	28.333	25.625	53.857	13.75	80.000

[a] To account for variation in effort in documenting total numbers during Basin-wide surveys and to account for numbers inflated by large counts at nesting colonies, this metric is the proportion of surveys on which the species was detected.

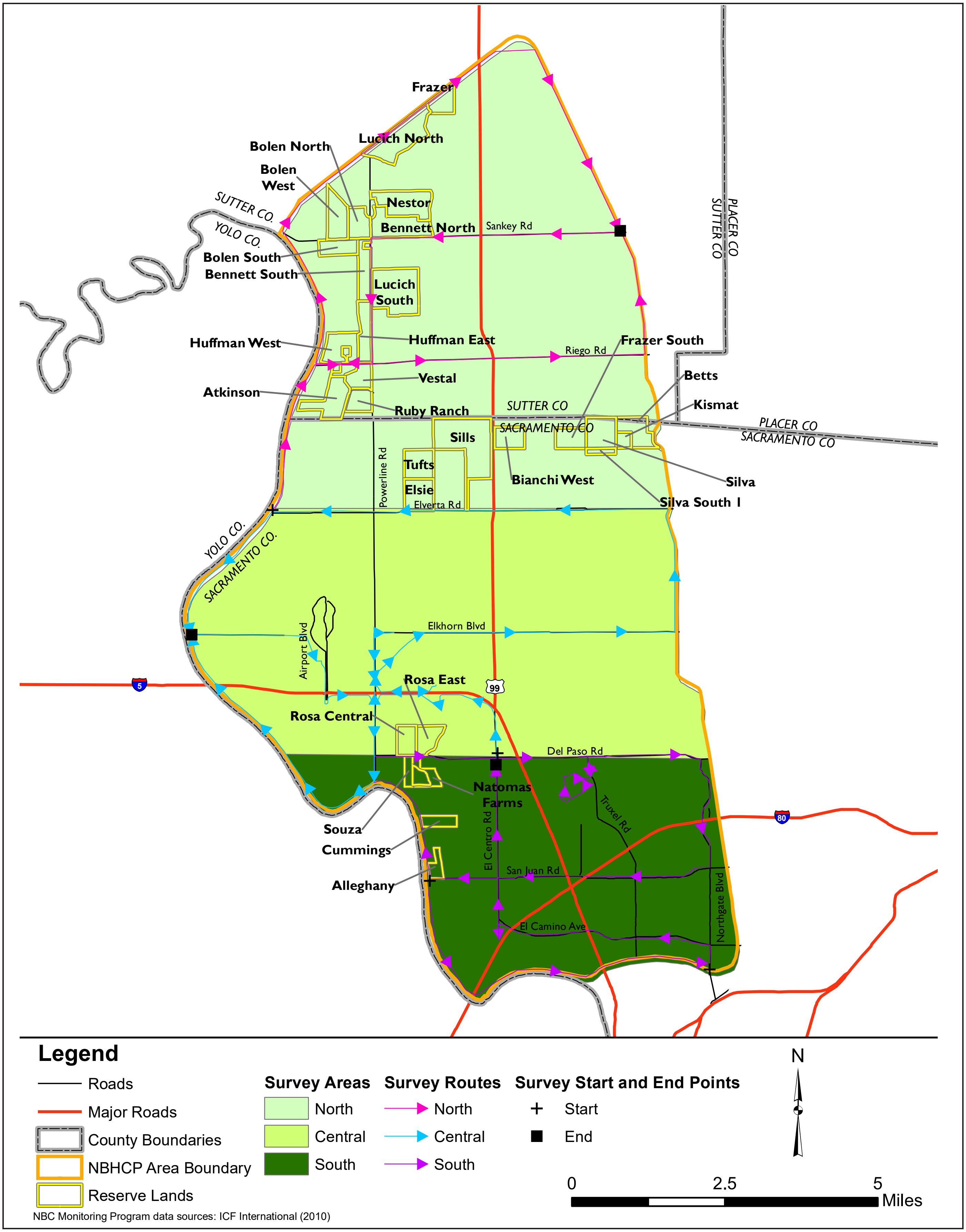

FIGURE 5-1
Monthly Basin-Wide Survey Routes

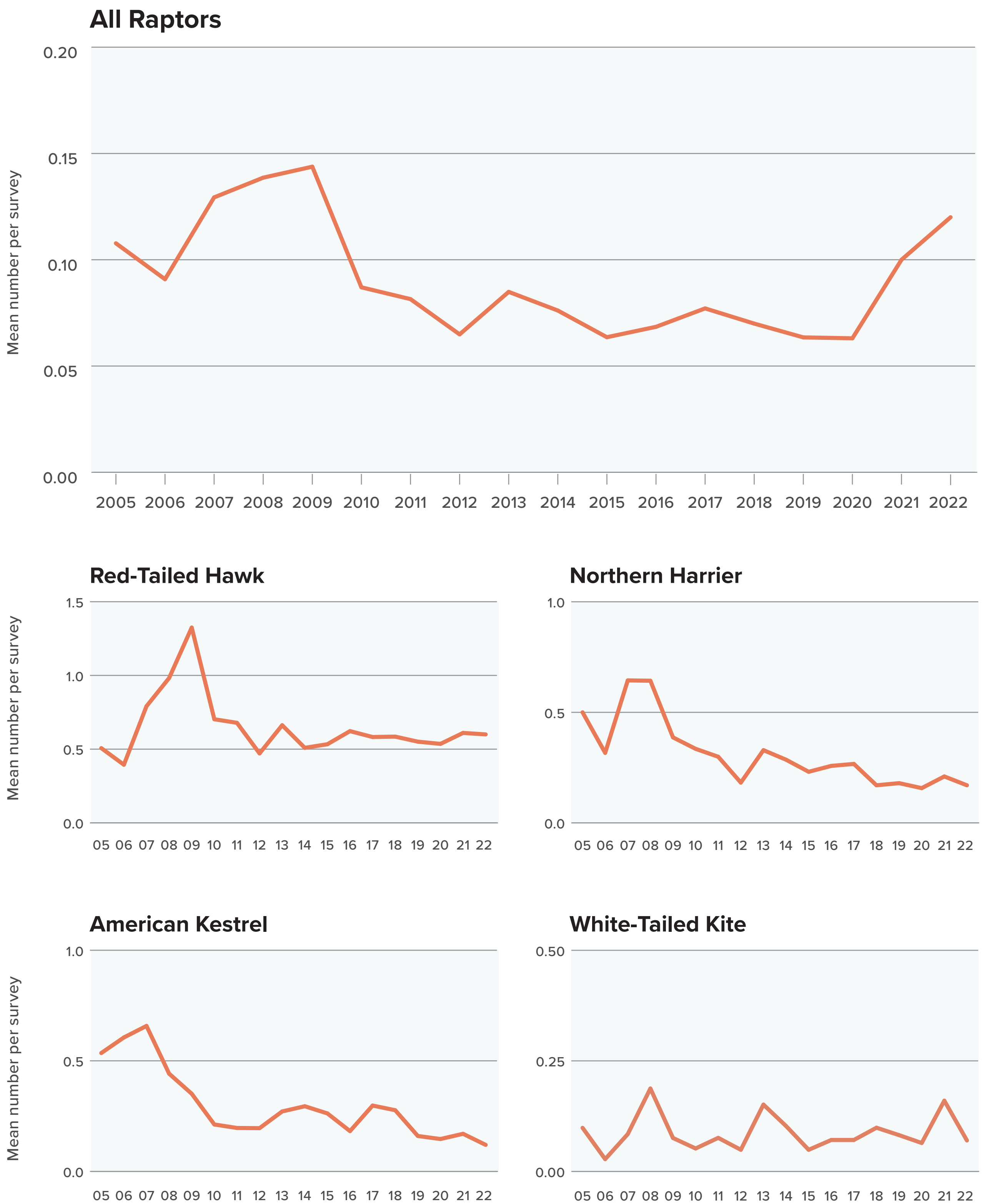

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FIGURE 5-2
Mean Number of Raptors Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2022

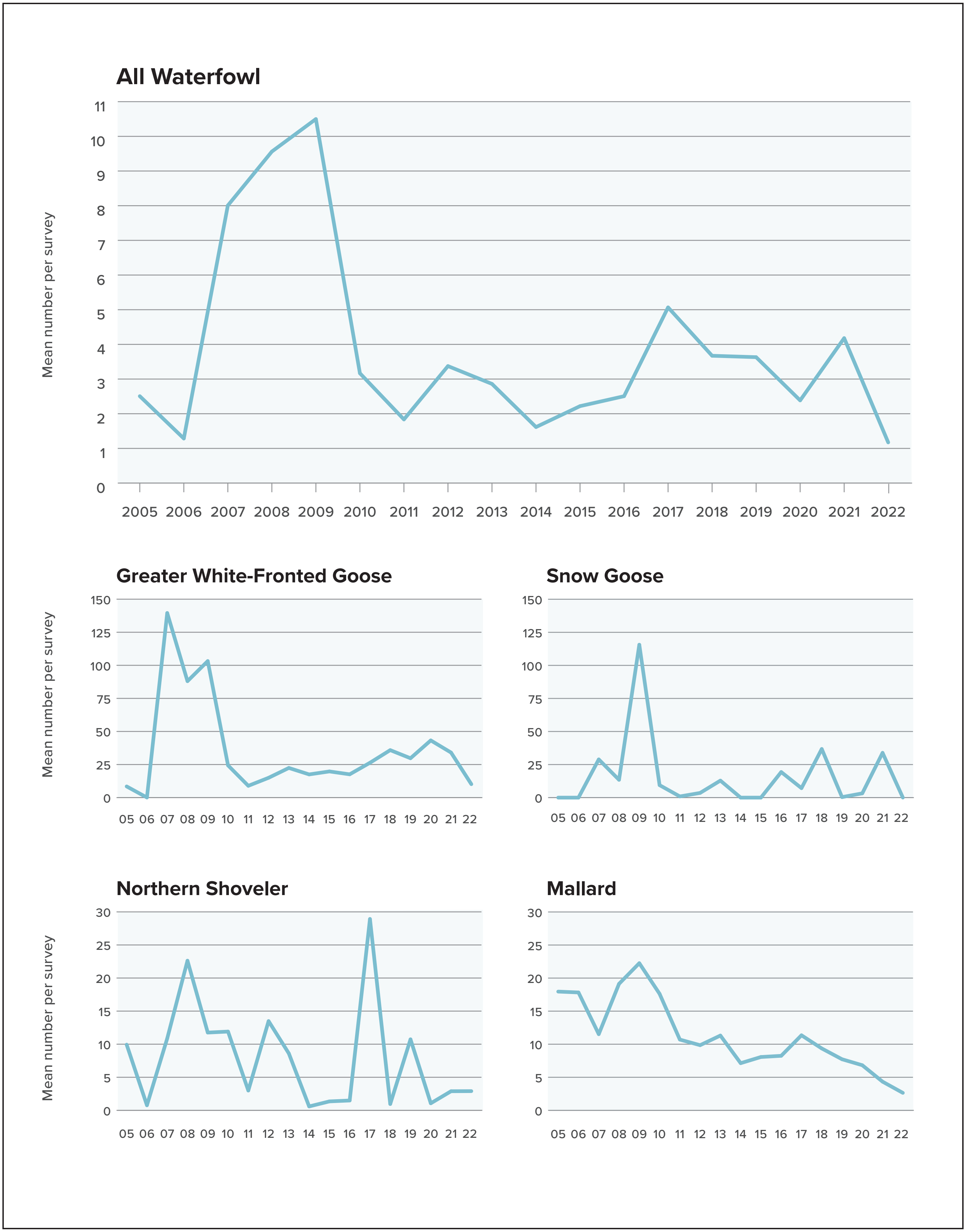


FIGURE 5-3
Mean Number of Waterfowl Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2022

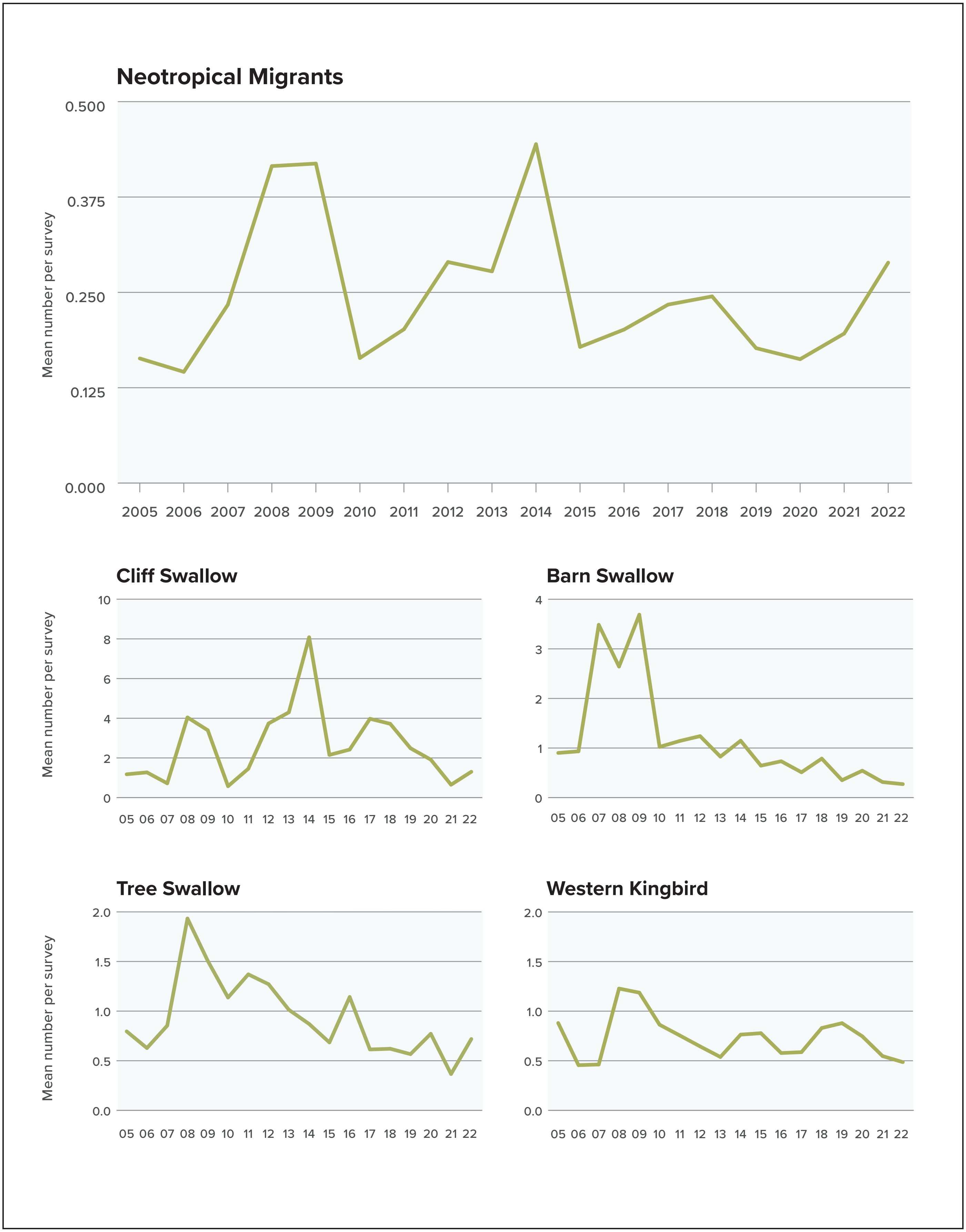


FIGURE 5-4
Mean Number of Neotropical Migrants Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2022

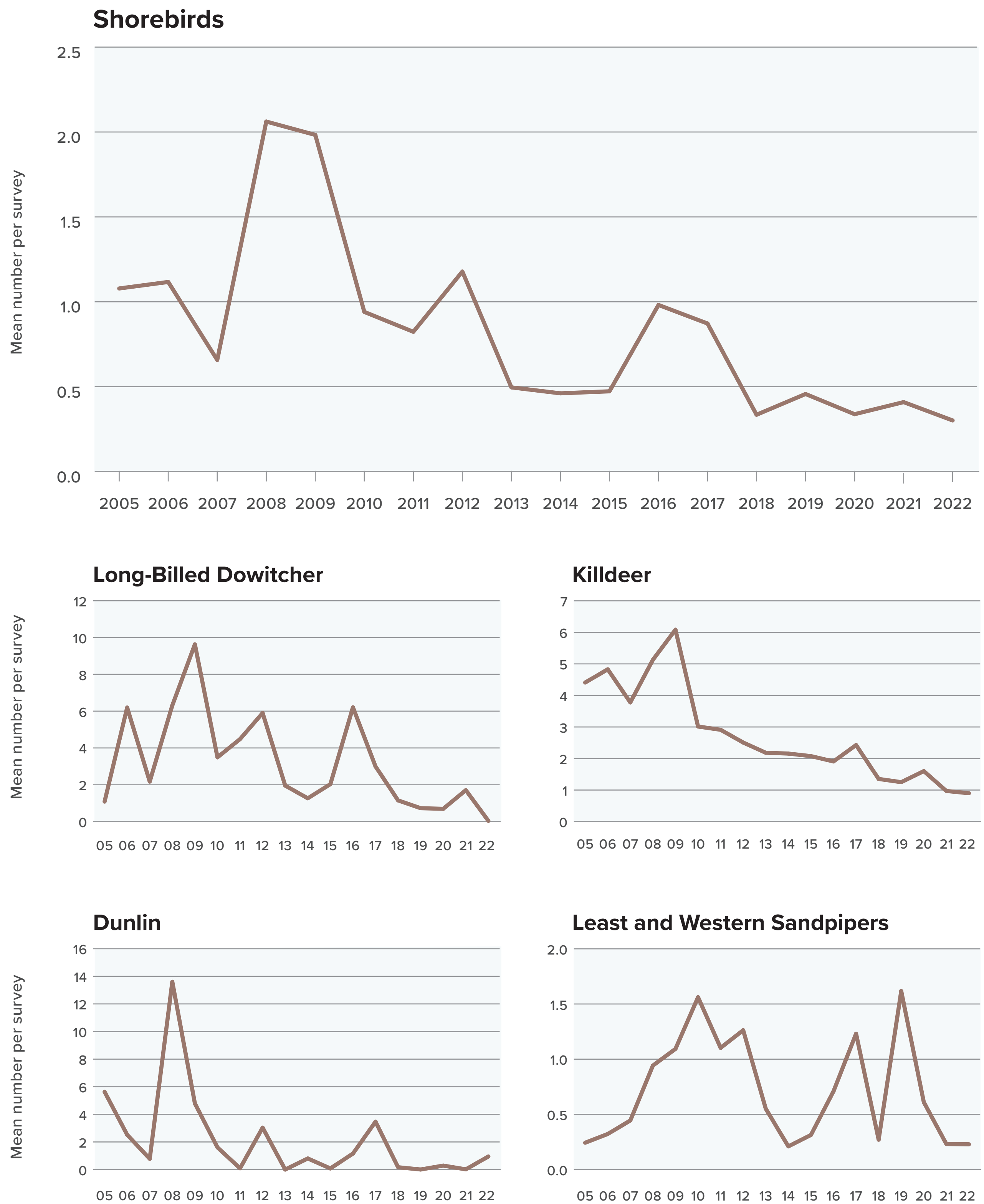


FIGURE 5-5
Mean Number of Shorebirds Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2022

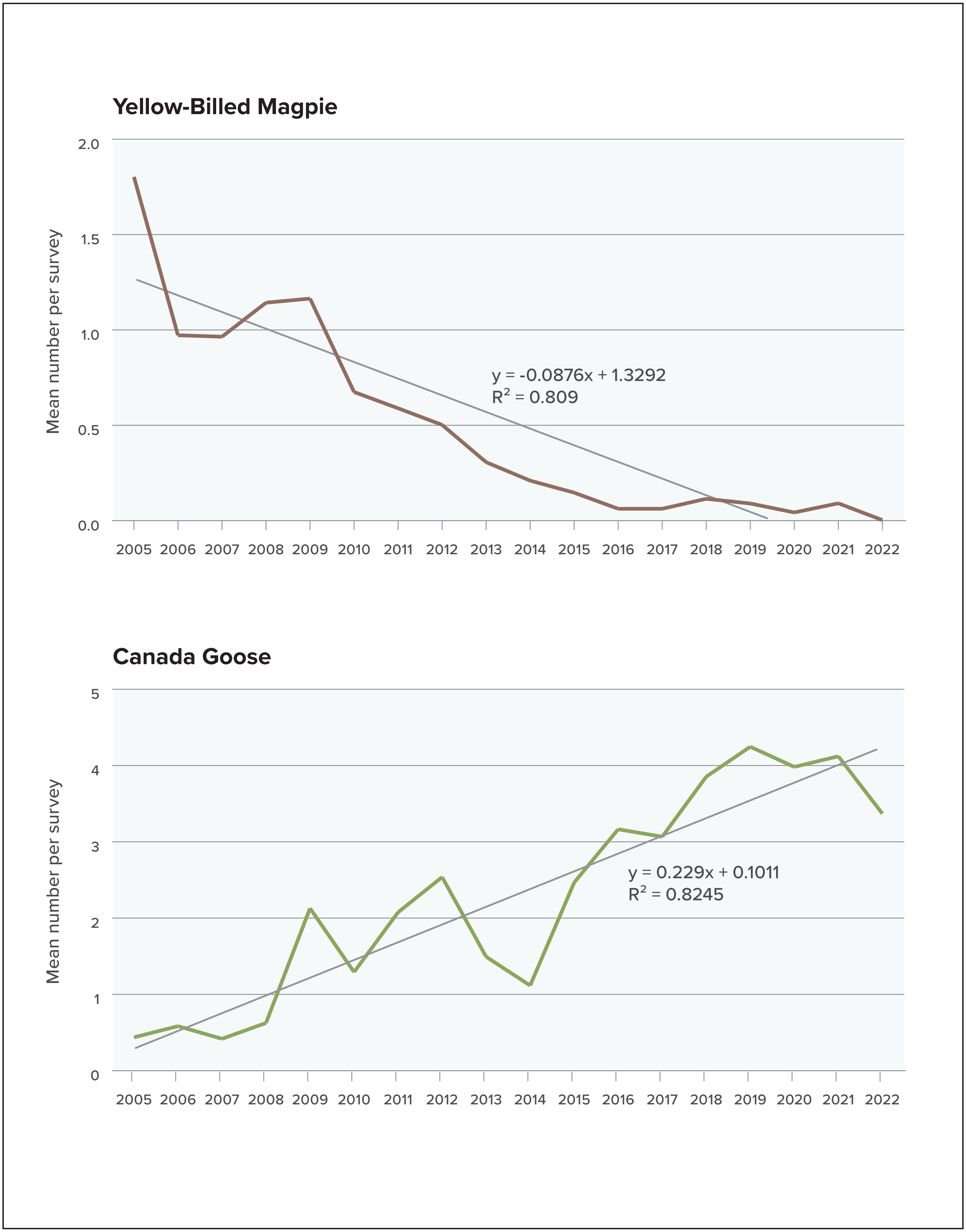
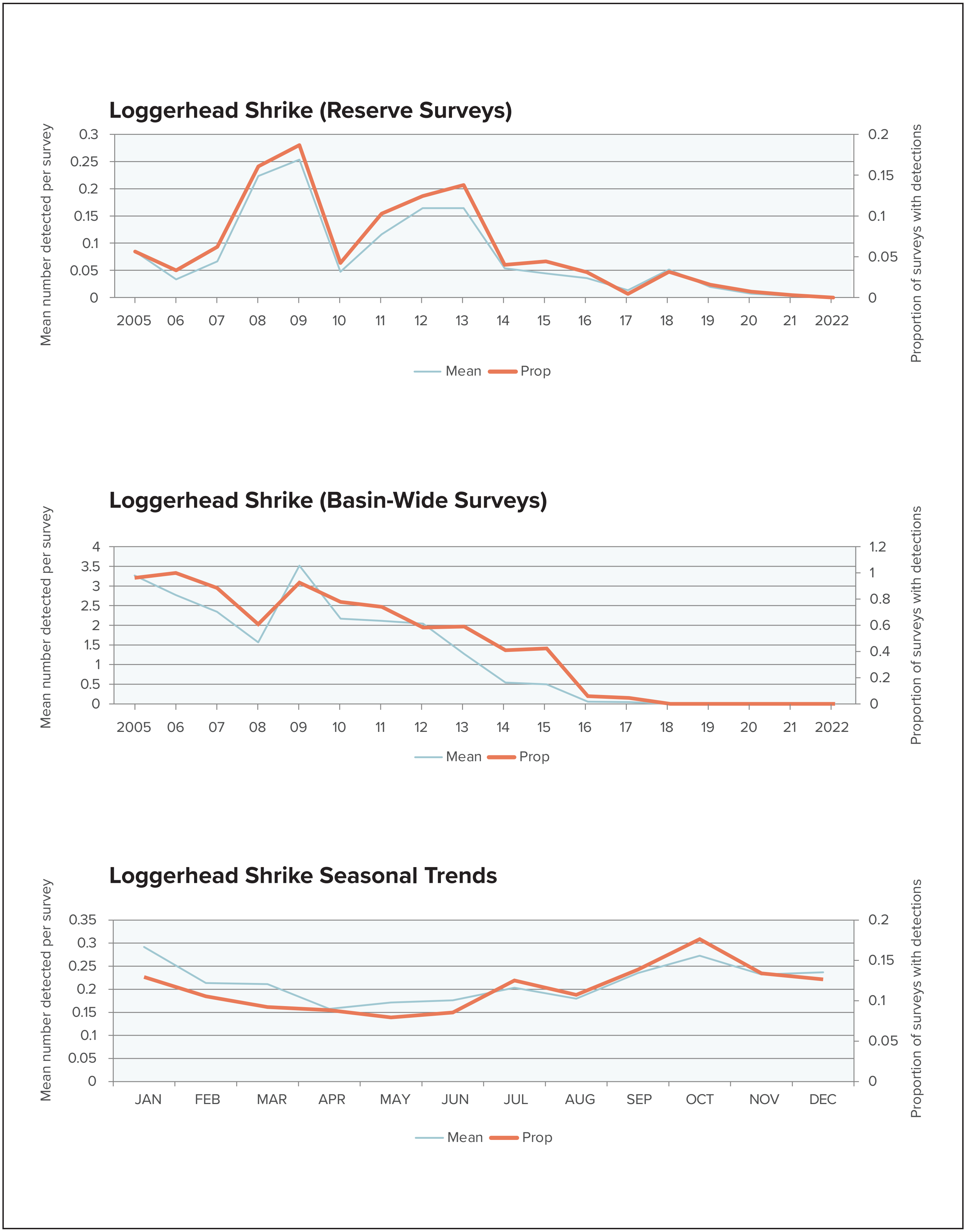


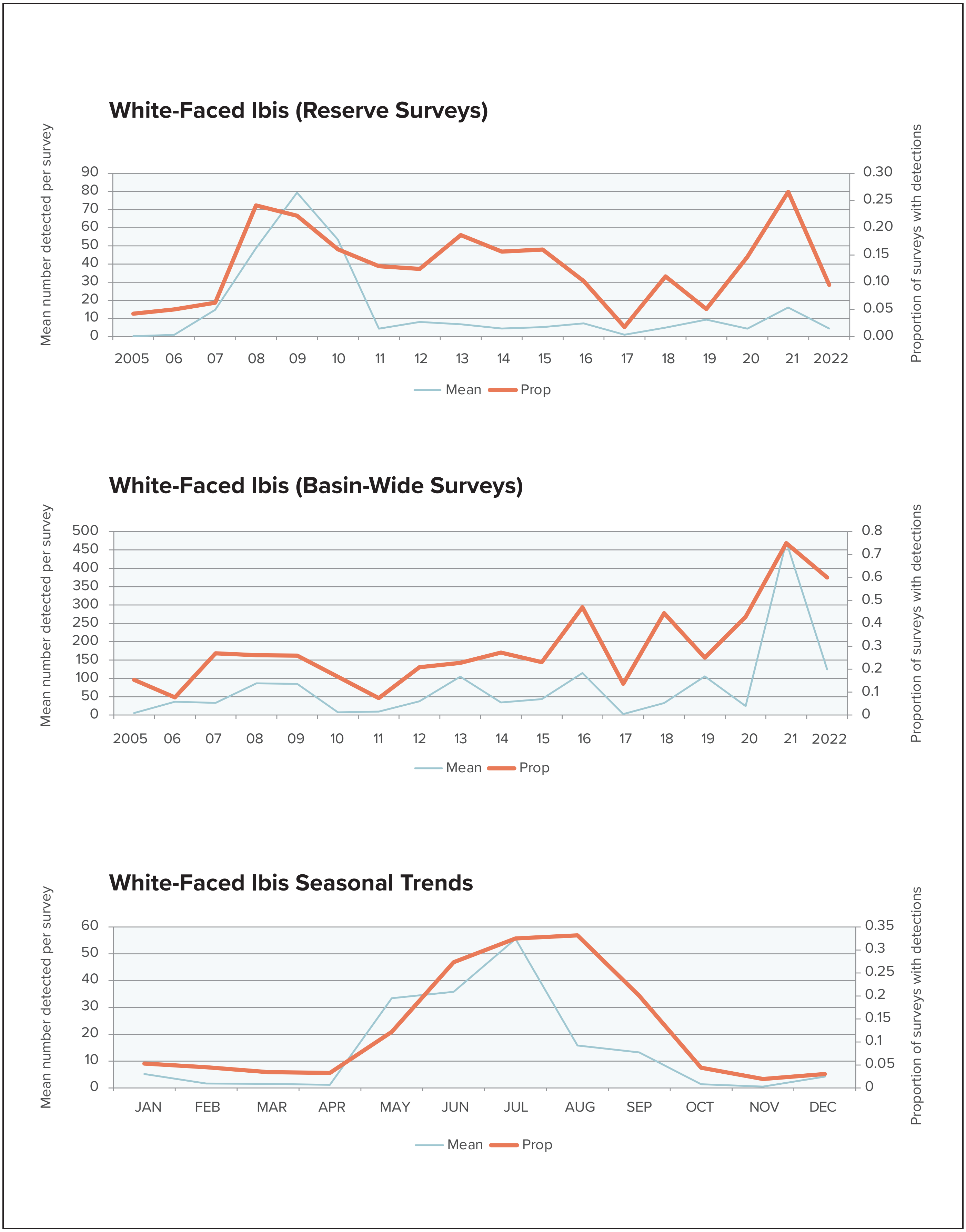
FIGURE 5-6
Mean Number of Yellow-Billed Magpies and Canada Geese Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2022



NBC 104332 (2-27-2023)

FIGURE 5-7

Mean Number of Loggerhead Shrikes Detected and the Proportion of Surveys on which Shrikes were Detected on TNBC Reserves in the Natomas Basin, 2005–2022



NBC 104332 (2-27-2023)

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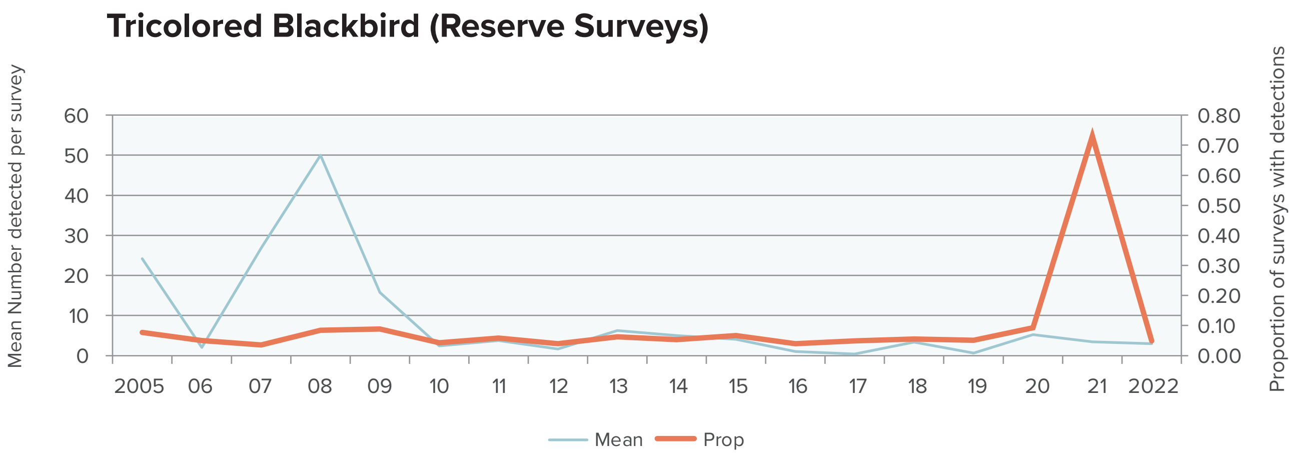
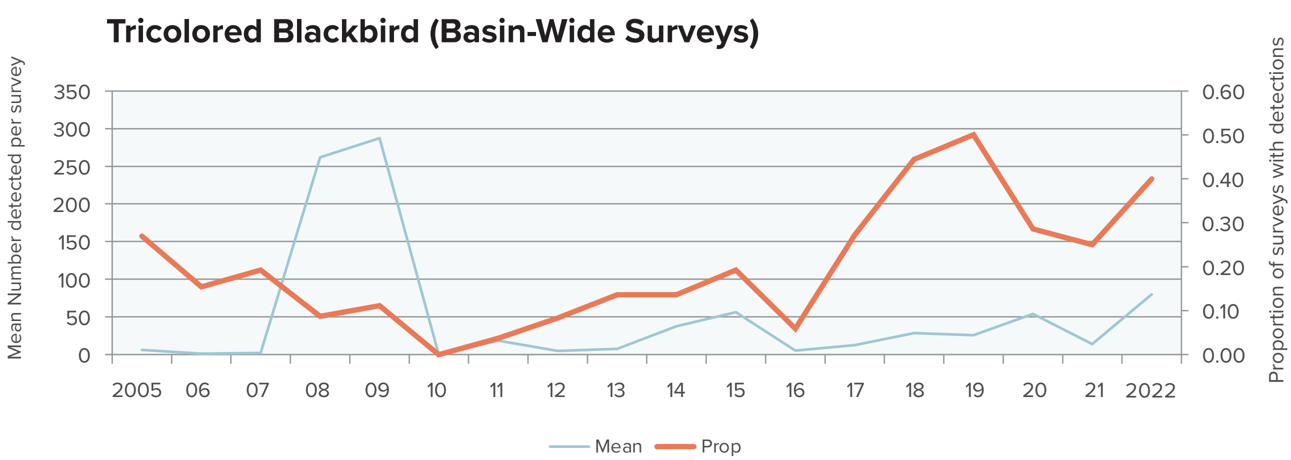
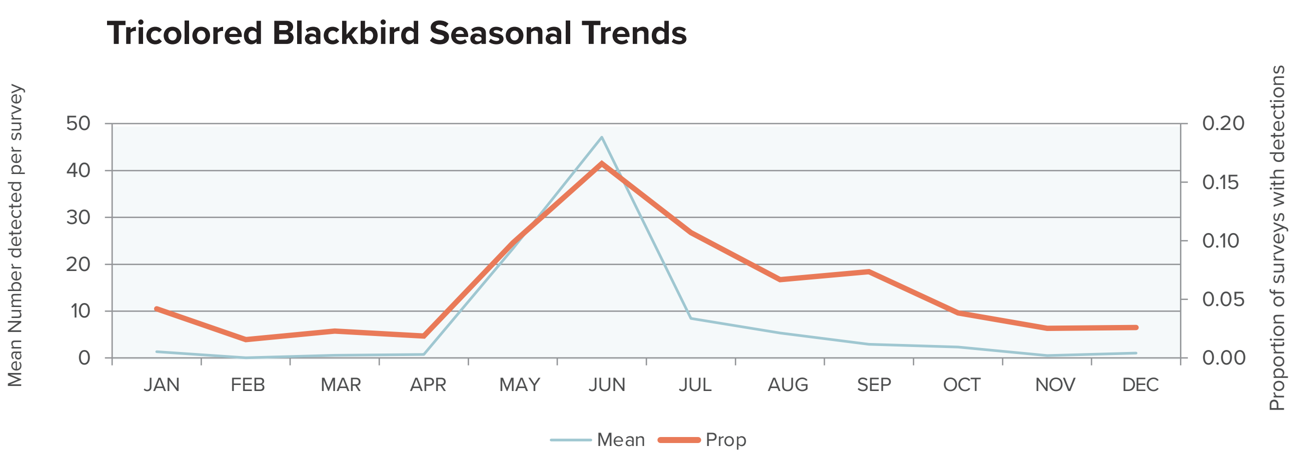
FIGURE 5-8

Mean Number of White-Faced Ibis Detected and the Proportion of Surveys on which Ibis Were Detected on TNBC Reserves in the Natomas Basin, 2005–2022







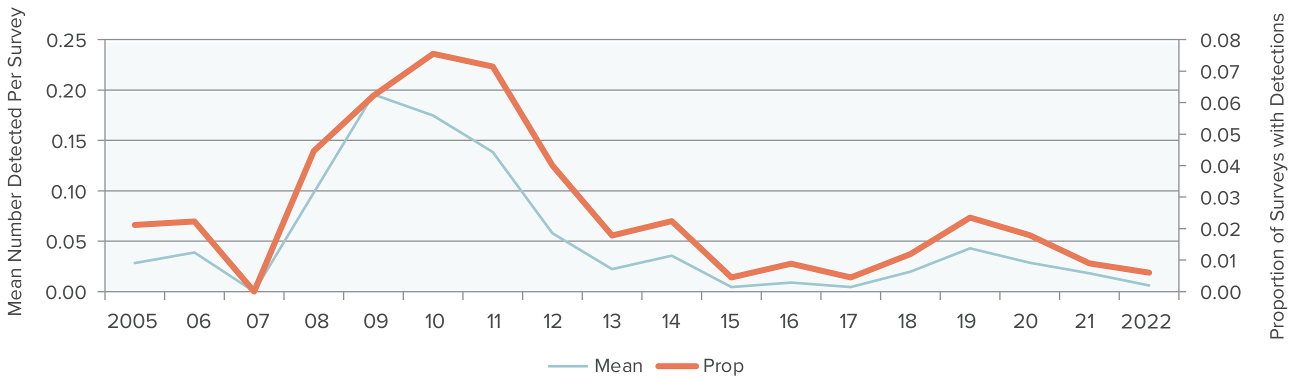
NBC 104332 (3-1-2023)

ICF

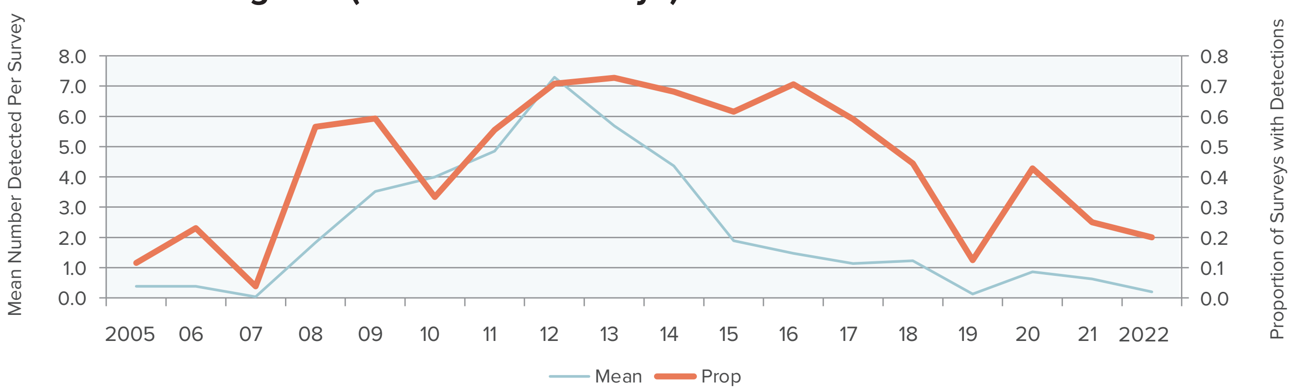
FIGURE 5-9

Mean Number of Tricolored Blackbird Detected and the Proportion of Surveys on which Blackbirds Were Detected on TNBC Reserves in the Natomas Basin, 2005–2022

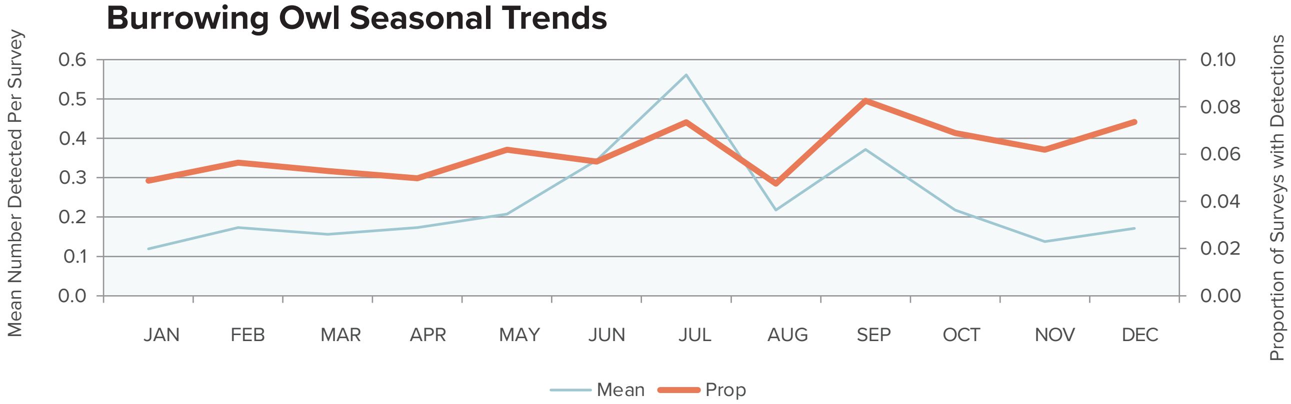
Burrowing Owl (Reserve Surveys)



Burrowing Owl (Basin-Wide Surveys)



Burrowing Owl Seasonal Trends



NBC 104332 (2-27-2023)

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FIGURE 5-10
Mean Number of Burrowing Owl Detected and the Proportion of Surveys on which Owls were Detected on TNBC Reserves in the Natomas Basin, 2005–2022

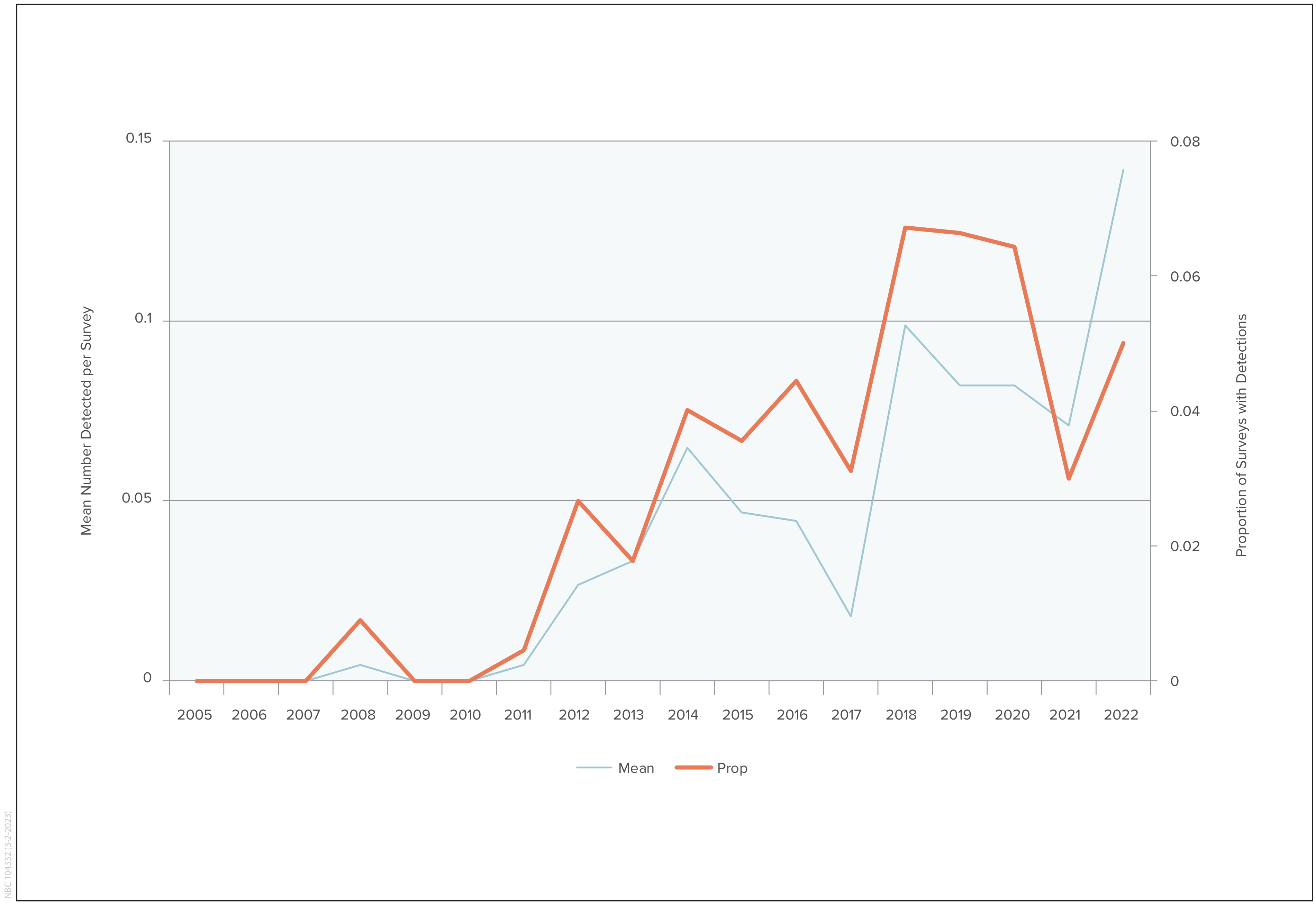

FIGURE 5-11

Mean Number of Pacific Pond Turtles and Unidentified Turtles and the Proportion of Surveys on which Turtles were Detected on TNBC Reserves in the Natomas Basin, 2005–2022

Appendix A

NBHCP Reserve Land Cover Data

Table A-1. Reserve Lands: Extent (acres) of Each Land Cover Type, 2005–2022

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
North Basin Reserve																		
Atkinson[a]																		
Fallow (including fallow rice)	108	70.2	44.3	–	122.7	161.2	161.2	108.7	64.4	93.2	48.8	44.3	44.3	145.7	52.5	104.4	11.2	11.2
Fresh emergent marsh	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Grass hay	–	–	21.3	–	–	–	–	–	–	15.5	15.5	15.5	9.7	9.7	20.1	62.2	54	106.5
Grassland (created)	–	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	15.5	15.5	15.5	15.5	–	–
Milo	–	–	48.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nonnative annual grassland	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Other row crops	9.8	52.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rice	48.9	44.4	52.5	145.7	44.3	–	–	52.5	96.9	52.5	96.97	101.4	101.4	–	93.2	–	48.9	48.9
Riparian scrub	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.4
Riparian woodland	9	9	9	9	9	9	9	9	9	9	9.1	9.1	9.1	9.1	9.1	9.1	6.3	6.3
Ruderal	3.6	3.6	0.7	0.7	0.7	–	–	–	–	–	–	–	11.2	11.2	–	–	–	–
Seasonal wetland	0.1	0.1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2.9
Valley oak woodland	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1	1	1	1	1	1	1	1
Wheat	21.3	–	–	21.3	–	–	–	–	–	–	–	–	–	–	–	–	52.5	–
Bennett North																		
Fallow	–	67	147.8	10.8	10.8	–	–	–	–	–	–	–	–	–	–	–	147.8	–
Fresh emergent marsh (created)	7	7	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
Grassland (created)	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Rice	213.8	146.9	–	137	137	147.8	147.8	147.8	147.8	147.8	147.7	147.8	147.8	147.8	147.8	147.8	–	147.8
Riparian scrub	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ruderal	3.2	3.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Bennett South																		
Fallow (including fallow rice)	87.2	–	–	–	–	4.4	26.9	–	13.2	–	–	13.7	–	–	72.7		13.7	68.8
Fresh emergent marsh (created)	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1
Irrigated grassland	–	–	–	–	4.4	5.3	–	–	–	–	–	–	–	–	–	–	–	–
Grassland (created)	22.7	28.1	28.7	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3

Table A-1. Continued

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Grass hay	–	–	–	–	–	–	–	–	–	–	–	–	26.9	13.7	–	–	–	–
Open water	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Rice	–	81.8	82	86.4	82	59.7	59.5	86.4	73.2	86.4	86.4	72.7	59.5	72.7	13.7	86.4	72.7	17.7
Riparian scrub	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Ruderal	0.8	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bolen North																		
Fallow (to allow field leveling)	–	–	–	–	–	–	112.5	–	–	–	–	–	112.5	–	–	–	–	–
Rice	112.5	112.5	112.5	112.5	112.5	112.5	–	112.5	112.5	112.5	112.5	112.5	–	112.5	112.5	112.5	112.5	112.5
Bolen South																		
Alfalfa	–	–	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	72.17
Fallow	101.7	–	–	–	–	–	57.8	–	–	–	–	57.8	57.8	–	–	–	–	–
Grass hay	–	–	–	–	–	–	–	57.8	57.8	57.8	57.8	–	–	57.8	57.8	57.8	57.8	29.6
Valley oak woodland	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Wheat	–	101.7	57.8	57.8	57.8	57.8	–	–	–	–	–	–	–	–	–	–	–	–
Bolen West																		
Fallow (including fallow rice)	–	–	155.1	–	–	–	–	155.1	–	–	–	–	155.1	–	–	–	–	155.1
Rice	–	–	–	155.1	155.1	155.1	155.1	–	–	155.1	155.1	155.1	–	155.1	155.1	155.1	155.1	–
Milo	–	–	–	–	–	–	–	–	155.1	–	–	–	–	–	–	–	–	–
Frazer[b]																		
Fresh emergent marsh (created)	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7
Grassland (created)	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Nonnative annual grassland	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Open water	–	–	–	–	–	–	–	–	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Huffman East																		
Alfalfa	–	–	–	–	–	–	15.6	–	–	–	–	–	–	–	–	–	–	–
Fallow	15.6	–	–	–	–	–	–	–	15.6	27.3	14.9	–	–	–	118.8	–	–	–
Grass hay	–	–	15.6	15.6	–	–	–	15.6	–	–	–	15.6	15.6	15.6	15.6	15.6	15.6	15.6
Rice	118.8	118.8	118.8	118.8	118.8	118.8	118.8	118.8	18.8	107.1	119.5	118.8	118.8	118.8	–	118.8	118.8	118.8
Wheat	–	15.6	–	–	15.6	15.6	–	–	–	–	–	–	–	–	–	–	–	–
Huffman West[c]																		
Alfalfa	67.9	67.9	67.9	67.9	122.6	44.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	44.5	99.5	157.9	139.4

Table A-1. Continued

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fallow	–	–	–	–	–	–	–	–	–	–	–	–	–	–	58.4	–	–	–
Grass hay	–	–	–	–	–	–	58.4	58.4	58.4	–	58.4	58.4	58.4	58.4	–	58.4	–	19.0
Milo	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Other row and grain crops	–	–	58.4	58.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tomatoes	–	–	54.7	54.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Wheat	113.1	113.1	–	–	58.4	113.3	–	–	–	58.4	–	–	–	–	54.9	–	–	–
Lucich North[d]																		
Fresh emergent marsh (created)	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9
Disturbed/bare	–	–	–	–	–	–	–	27.4	11.1	–	–	–	–	–	–	–	–	–
Grassland (created)	–	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Nonnative annual grassland	23.9	24	27.5	27.5	27.5	27.5	27.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ruderal	15.8	15	15	15	15	15	15	14.9	14.9	26	26	26	26	26	26	26	26	26
Seasonal wetland	3.5	3.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Open water	–	–	–	–	–	–	–	–	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Lucich South																		
Rice	328.1	328.1	328.1	328.1	328.1	328.1	331.2	331.2	331.2	331.2	331.2	331.2	331.2	331.2	331.2	331.2	331.2	196.2
Fallow rice	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	135.0
Fresh emergent marsh (created)	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3
Ruderal	3.1	3.1	3.1	3.1	3.1	3.1	–	–	–	–	–	–	–	–	–	–	–	–
Nestor																		
Fallow	–	–	–	233.1	–	233.1	233.1	–	–	–	–	–	–	–	233.1	–	–	233.1
Rice	–	–	233.1	–	233.1	–	–	233.1	233.1	233.1	233.1	233.1	233.1	233.1	–	233.1	233.1	–
Ruby Ranch																		
Developed—low density	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Fallow	87.3	–	–	–	87.3	–	–	–	–	–	–	87.3	–	–	–	–	–	87.3
Other row and grain crops	–	87.3	87.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rice	–	–	–	87.3	–	87.3	87.3	87.3	87.3	87.3	87.3	–	87.3	87.3	87.3	87.3	87.3	–
Ruderal	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Vestal																		
Milo	–	–	–	–	–	–	–	–	–	93.9	–	–	–	–	–	–	–	

Table A-1. Continued

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Rice	–	93.8	93.8	93.8	93.8	93.8	93.8	93.9	93.9	–	93.9	93.9	93.9	93.9	93.9	93.9	93.9	–
Fallow rice	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	93.9
Valley oak woodland	–	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Central Basin Reserve																		
Betts-Kismat-Silva																		
Developed—low density	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Fresh emergent marsh (created)	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3
Irrigated grassland	0	95.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nonnative annual grassland	188.2	92.7	188.2	188.2	188.2	188.2	188.2	188.3	188.3	188.3	188.3	188.3	188.3	188.3	188.3	188.3	188.3	188.3
Nonriparian woodland	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Riparian scrub	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Riparian woodland	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Seasonal wetland	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Bianchi West																		
Rice	–	–	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2
Elsie																		
Developed - High Density	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fallow rice	–	–	158	–	–	158	158	–	–	–	–	–	–	–	–	–	–	158
Rice	–	–	–	158	158	–	–	158	158	158	158	158	158	158	158	158	158	–
Frazer South																		
Fallow rice	–	–	110.3	110.3	–	–	–	–	–	–	–	–	–	–	–	–	–	110.3
Rice	–	–	–	–	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	–
Sills																		
Fallow	11.9	294.5	–	–	–	–	25.6	25.6	25.6	134.6	–	–	–	–	–	–	–	169.4
Grass hay	–	–	–	–	–	–	–	–	–	25.6	25.6	25.6	25.6	93.7	38.2	25.6	25.6	25.6
Other row and grain crops	–	–	12.3	280.8	–	–	–	–	–	–	–	–	–	–	–	–	–	
Rice	420.2	137.6	436.4	167.9	448.7	448.7	410.6	410.6	423.1	288.6	423.1	423.1	423.1	355	410.6	423.1	423.1	253.7
Sunflower	–	–	–	–	–	–	12.6	12.6	–	–	–	–	–	–	–	–	–	

Table A-1. Continued

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Silva South 1																		
Nonnative annual grassland									0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Rice	–	–	–	–	–	–	–	–	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
Tufts																		
Fallow	–	–	–	–	146.7	–	–	–	–	–	–	–	–	–	–	–	–	–
Rice	147.7	147.7	147.7	147.7	1	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7
Fisherman's Lake Reserve																		
Alleghany[e]																		
Alfalfa	27.5	27.5	27.5	27.5	27.5	27.5	–	–	–	–	–	–	–	–	–	–	–	–
Fallow	–	–	–	18.9	6	18.9	6	0.7	–	–	–	–	–	18.9	–	39.5	10	18.9
Grass hay	18.9	18.9	–	–	12.9	–	12.9	12.9	18.9	18.9	0.7	–	–	0.7	12.9	–	–	–
Other row and grain crops	–	–	–	–	–	–	26.8	6	26.8	–	26.8	0.7	27.5	26.8	27.5	–	–	–
Ruderal	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	7.9	8.8	0.5	0.5
Sunflower	–	–	–	–	–	–	0.7	26.8	0.7	27.5	–	–	18.9	–	–	–	–	–
Valley oak woodland	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1.1	1.1
Wheat	–	–	18.9	–	–	–	–	–	–	–	18.9	45.7	–	–	–	–	18.9	–
Disturbed/bare	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
Cummings[e]																		
Fallow	17.7	–	–	–	–	–	–	–	–	–	–	–	–	22.5	22.5	–	–	–
Fresh emergent marsh (created)	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
Grassland (created)	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Nonnative annual grassland	4.8	4.8	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	–	–	–	–	–	–	–
Ruderal	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1.4	–	–
Safflower	–	–	–	–	–	–	–	–	–	–	–	22.5	22.5	–	–	–	–	–
Valley oak woodland	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1	–	–
Wheat (hay crop)	–	17.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Clover	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	21.8	14.3	14.3
Natomas Farms[e]																		
Disturbed/bare	–	–	–	–	–	–	44.8	0.7	–	–	–	–	–	–	–	–	–	–

Table A-1. Continued

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fresh emergent marsh (created)	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.1	35.1	35.1	35.1
Grass hay	–	–	44.1	44.1	44.1	44.1	–	–	–	–	–	–	–	–	–	–	–	–
Grassland (created)	9.2	10.8	10.8	10.8	10.8	10.8	10.1	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
Nonnative annual grassland	4.1	4.1	4.1	4.1	4.1	4.1	4.1	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Ruderal	3.1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Valley oak woodland	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Wheat	44.1	44.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rosa Central																		
Alfalfa	–	–	–	–	–	–	–	–	–	100.1	100.1	100.1	–	–	–	–	–	–
Fallow	100.1	–	100.1	–	–	–	44.6	–	–	–	–	–	–	–	–	–	–	–
Grass hay	–	–	–	100.1	100.1	100.1	–	55.4	44.6	–	–	–	100.1	–	–	–	–	–
Sunflower	–	–	–	–	–	–	55.4	44.6	55.4	–	–	–	–	100.1	–	–	100.1	100.1
Wheat	–	100.1	–	–	–	–	–	–	–	–	–	–	–	–	100.1	100.1	–	–
Other Row and Grain Crops	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–
Rosa East																		
Alfalfa	–	–	–	–	–	–	–	104.3	104.3	104.3	104.3	104.3	–	–	–	–	–	–
Fallow	104.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	36.7
Other row and grain crops	–	–	104.3	104.3	–	–	–	–	–	–	–	–	104.3	–	–	–	–	–
Riparian woodland	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Safflower	–	–	–	–	104.3	–	67.2	–	–	–	–	–	–	–	–	–	–	–
Sunflower	–	–	–	–	–	104.3	36.7	–	–	–	–	–	–	104.3	–	–	104.3	67.6
Valley oak woodland	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Wheat	–	104.3	–	–	–	–	–	–	–	–	–	–	–	–	104.3	104.3	–	–
Souza																		
Alfalfa	10.8	10.8	10.8	10.8	10.8	10.9	10.9	11	–	–	–	–	–	–	–	18	27.7	39.7
Disturbed/bare	–	–	–	–	–	–	17.7[c]	17.7	–	–	–	–	–	–	–	–	–	–
Fallow	–	12	12	–	–	–	–	–	–	–	–	11	–	16.7	–	–	–	–
Grass hay	–	–	–	–	–	–	–	–	39.7	16.7	–	–	–	–	–	21.6	12	–
Non-riparian woodland	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table A-1. Continued

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Other row and grain crops	–	16.7	16.7	28.7	28.7	28.7	–	–	–	–	11	–	–	–	–	–	–	–
Ruderal	0.1	0. 1	0.1	0.1	0.1	–	–	–	–	–	–	–	–	–	–	–	–	–
Safflower	–	–	–	–	–	–	–	11	–	–	–	–	–	–	–	–	–	–
Sunflower	–	–	–	–	–	–	11	–	–	22.9	–	–	28.7	–	–	–	–	–
Wheat	28.7	–	–	–	–	–	–	–	–	–	28.7	28.7	11	22.9	39.6	–	–	–

[a] Acreage of reserve decreased in 2010 and 2021 due to the Sacramento Area Flood Control Agency (SAFCA) acquiring property for the Natomas Levee Improvement Project (NLIP).

[b] Open water was mapped in 2013 due to the enlargement of an existing linear water conveyance feature.

[c] Acreage of reserve decreased in 2010 due to SAFCA acquiring property for the NLIP.

[d] Open water mapped in 2013 due to the construction of new linear water conveyance feature.

[e] Acreage of reserve decreased in 2011 due to SAFCA acquiring property for the NLIP.

Figure A-1
North Basin Reserve—Frazer and Lucich North Tracts, 2022

Figure A-2
North Basin Reserve—Nestor, Bennett North, Bennett South, Willey, and Lucich South Tracts, 2022

Figure A-3
North Basin Reserve—
Bolen West, Bolen North, Bolen South, and Verona Tracts, 2022

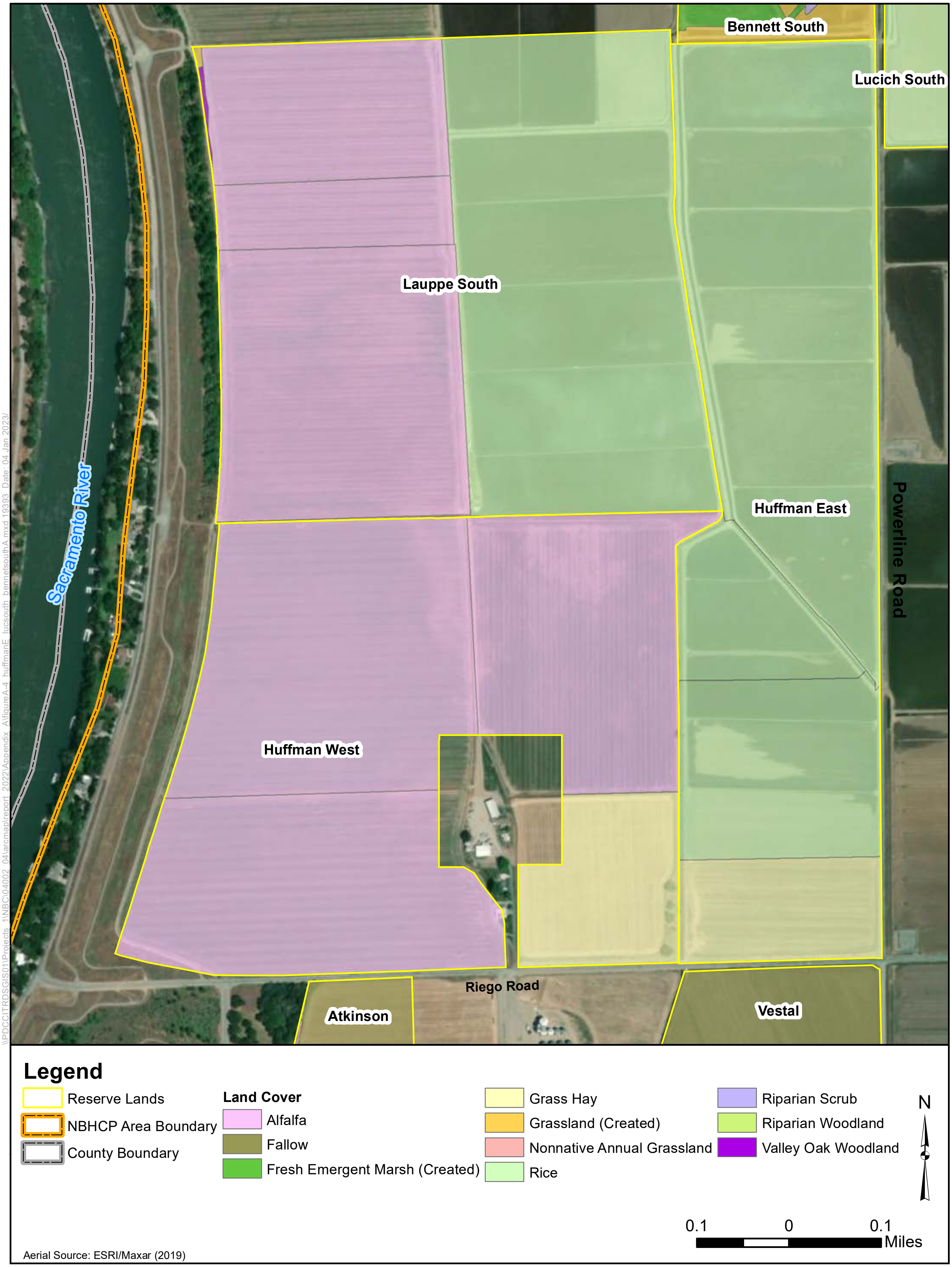

Figure A-4
North Basin Reserve—Lauppe South, Huffman West, and Huffman East Tracts, 2022

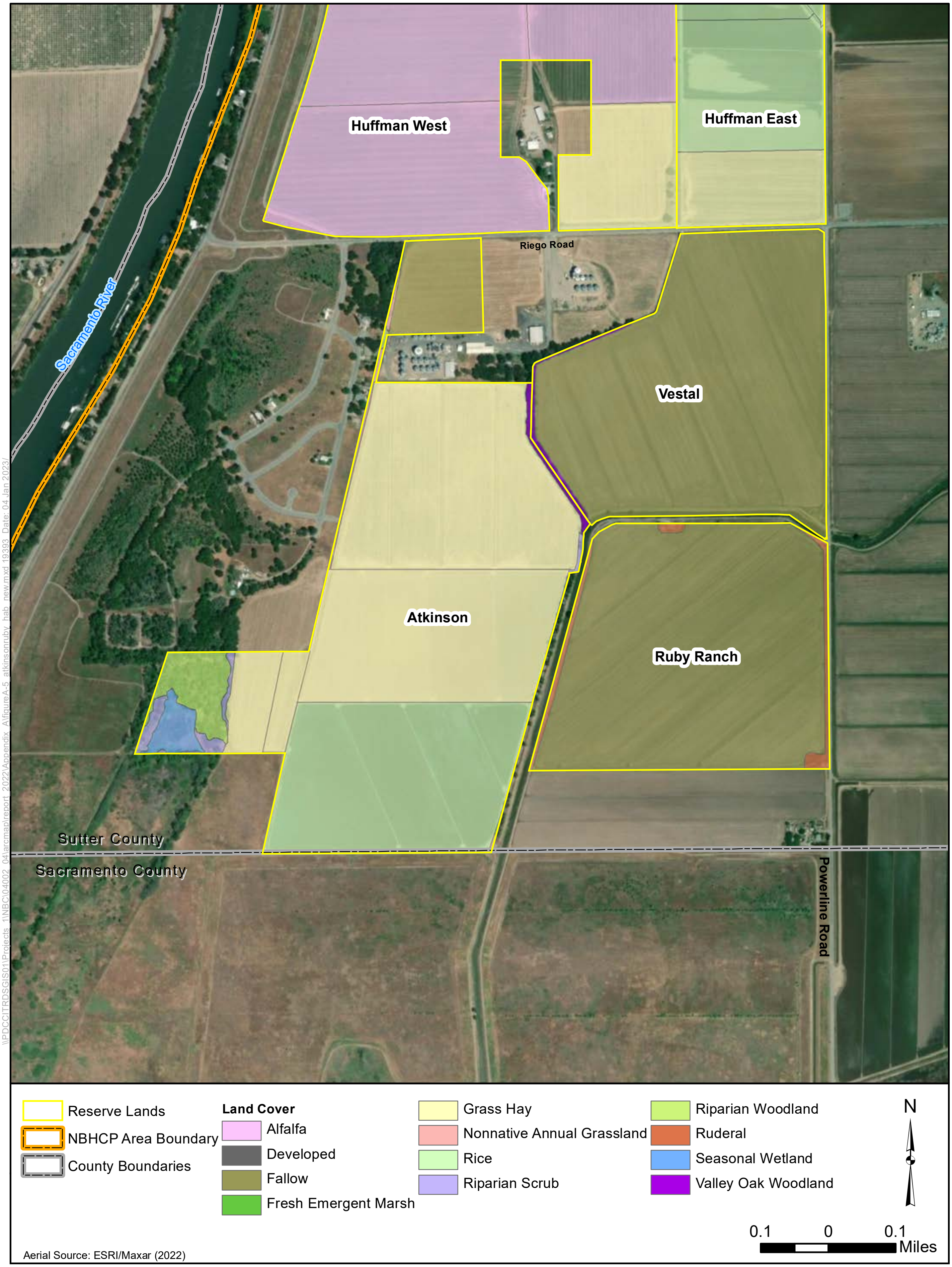

Figure A-5
North Basin Reserve—Atkinson, Vestal, and Ruby Ranch Tracts, 2022

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Figure A-6
Central Basin Reserve—Elsie, Sills, Bianchi West, Paulsen South, Richter, and Tufts Tracts, 2022

Figure A-7
Central Basin Reserve—Frazer South, Betts, Kismat, Silva, and Silva South 1 Tracts, 2022

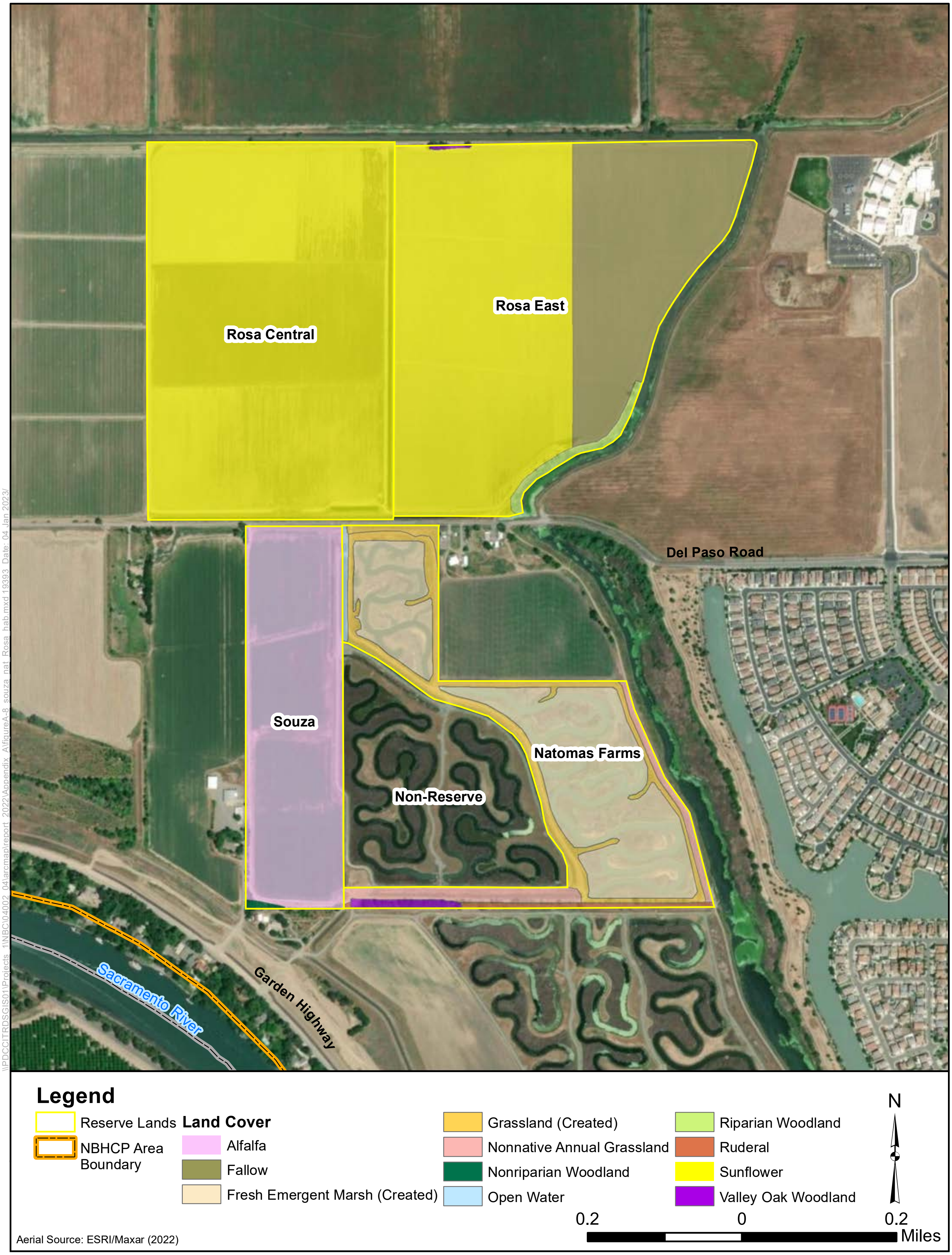

Figure A-8
Fisherman's Lake Reserve—Rosa Central, Rosa East, Souza, and Natomas Farms Tracts, 2022

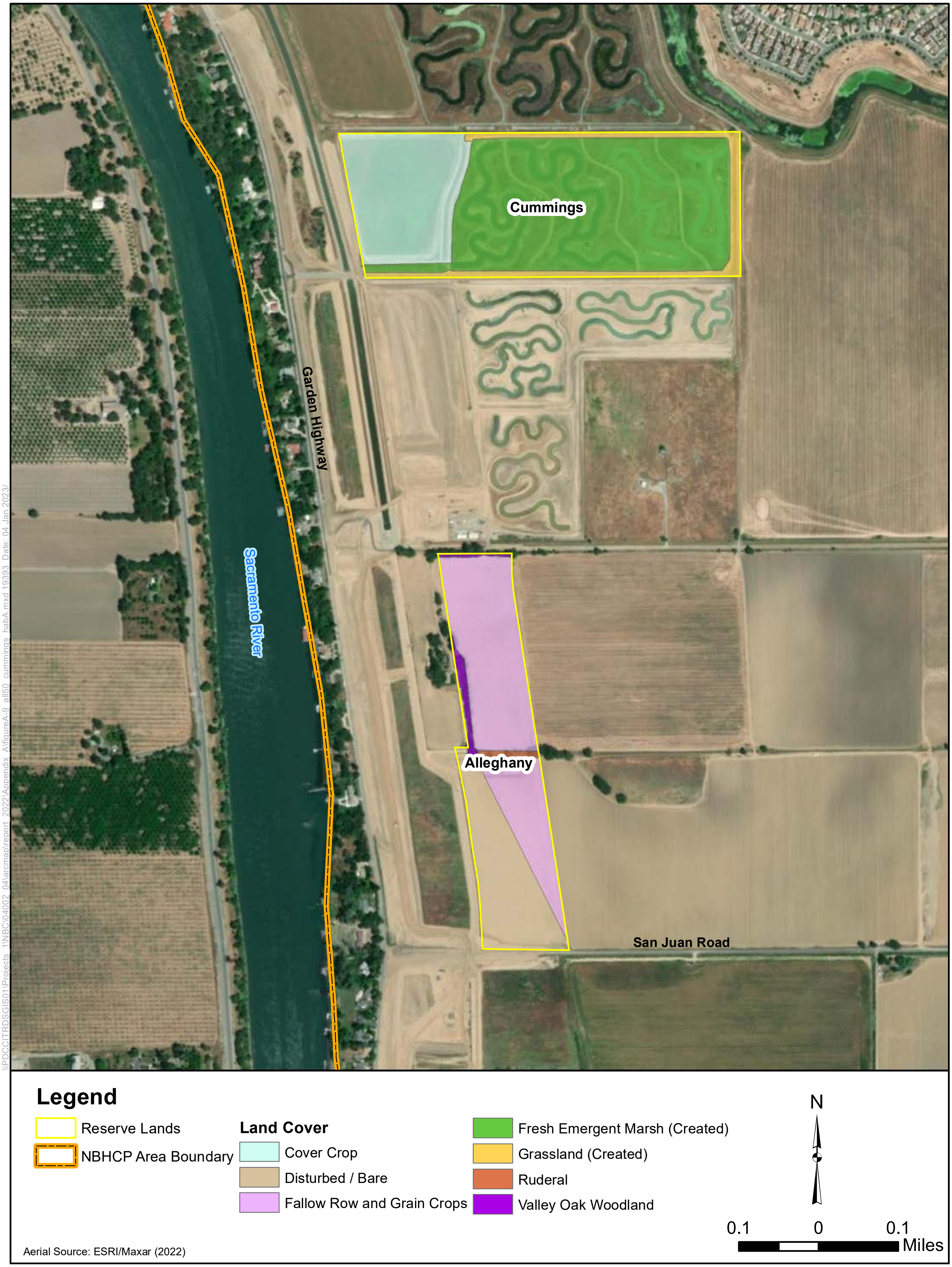

Figure A-9
Fisherman's Lake Reserve—Cummings and Alleghany Tracts, 2022

Appendix B

Botanical Survey Results

Table B-1. Cumulative List of Plant Species Observed on the Natomas Basin Conservancy Reserves, 2005–2022

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
Ferns and Fern Allies																										
Azollaceae	**Mosquito Fern Family**																									
Azolla filiculoides	Mosquito fern		X	X	X			X	X	X	X	X				X				X			X	X		
Equisetaceae	**Horsetail Family**																									
Equisetum telmateia ssp. *braunii*	Giant horsetail	X																				X				
Marsileaceae	**Marsilea Family**																									
Marsilea vestita ssp. *vestita*	Hairy waterclover			X							X													X		
Monocotyledons																										
Alismataceae	**Water-Plantain Family**																									
*Alisma lanceolatum**	Lance-leaved water-plantain	X	X	X	X		X	X	X	X	X	X	X		X		X	X	X	X	X		X	X		
Alisma trivial (Alisma plantago-aquatica)	Common water-plantain																							X		
Echinodorus berteroi	Burhead	X						X	X		X	X		X												
Sagittaria longiloba	Gregg arrowhead								X		X													X		
Sagittaria montevidensis ssp. *calycina*	California arrowhead	X	X	X	X		X	X	X		X	X		X									X	X		
Araceae (Lemnaceae)	**Arum Family (Duckweed Family)**																									
Lemna sp.	Duckweed	X	X	X				X	X	X	X	X				X							X	X		
Cyperaceae	**Sedge Family**																									
Bolboschoenus maritimus (Scirpus maritimus)	Prairie bulrush			X				X			X															
Cyperus esculentus	Nutsedge	X	X	X	X		X	X			X			X											X	

Table B-1. Continued

Scientific Name (previous scientific name)[a]	Common Name	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
		Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*Cyperus difformis**	Variable flatsedge			X				X			X	X		X		X								X	X	
Cyperus eragrostis	Umbrella sedge	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Cyperus odoratus	Fragrant flatsedge							X			X															
Eleocharis acicularis	Needle spikerush	X																								
Eleocharis macrostachya	Creeping spikerush						X	X			X		X			X	X	X	X					X		
Eleocharis engelmannii (Eleocharis obtusa var. *engelmannii)*	Blunt spikerush/ Engelmann's spikerush			X				X			X													X		
Schoenoplectus acutus (Scirpus acutus var. *occidentalis)*	Common tule	X	X	X				X			X	X		X		X	X		X	X		X	X	X	X	
*Schoenoplectus mucronatus (Scirpus mucronatus)**	Ricefield bulrush			X	X			X	X		X	X				X								X		
Hydrocharitaceae	**Waterweed Family**																									
Elodea canadensis	Canadian pondweed								X																	
Juncaceae	**Rush Family**																									
Juncus balticus	Baltic rush			X												X						X				
Juncus bufonius	Toad rush	X		X		X		X			X	X		X	X	X	X		X	X				X	X	X
Juncus effusus	Soft rush	X		X	X		X									X										
Poaceae	**Grass Family**																									
*Agrostis avenacea**	Pacific bentgrass	X	X	X				X			X	X												X		
Alopecurus carolinianus	Tufted foxtail							X			X												X			
Alopecurus saccatus	Foxtail	X	X	X								X		X						X						
*Arundo donax**	Giant reed															X										
*Avena barbata**	Slender wild oats	X		X			X	X	X	X	X	X	X	X		X		X			X				X	X
*Avena fatua**	Common wild oats		X					X			X						X		X	X		X	X	X		X

Table B-1. Continued

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*Briza minor**	Little quaking grass	X														X										
*Bromus catharticus**	Rescue brome	X	X		X						X												X			
*Bromus diandrus**	Ripgut brome	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
*Bromus hordeaceus**	Soft chess	X	X	X		X	X	X			X	X	X			X	X	X	X	X		X	X	X		
Bromus madritensis ssp. *rubens**	Foxtail chess					X		X																		
Cortaderia jubata	Pampas grass																						X			
*Crypsis schoenoides**	Swamp grass							X			X					X										
*Cynodon dactylon**	Bermuda grass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
Deschampsia danthonioides	Annual hairgrass	X	X					X			X	X				X								X		
*Digitaria sanguinalis**	Hairy crabgrass	X		X		X	X			X	X	X	X			X	X	X	X							
Distichlis spicata	Saltgrass					X		X			X				X	X		X			X	X	X			
*Echinochloa crus-galli**	Barnyardgrass	X	X	X	X	X		X	X		X	X		X		X							X	X	X	
*Eleusine tristachya**	Threespike goosegrass															X										
Elymus glaucus	Blue wildrye		X	X				X			X	X											X	X		
Elymus triticoides (Leymus triticoides)	Creeping wildrye					X		X			X															
Eragrostis pectinacea var. *pectinacea*	Tufted lovegrass															X										
Eragrostis sp.*	Lovegrass															X										
*Festuca arundinacea**	Reed fescue	X																						X		
*Festuca bromoides (Vulpia bromoides)**	Foxtail fescue			X					X							X							X			
Festuca microstachys (Vulpia microstachys)	Small fescue		X					X			X	X											X	X		
*Festuca myuros (Vulpia myuros)**	Rattail fescue		X					X								X										

Table B-1. Continued

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*Festuca perennis (Lolium multiflorum)**	Italian ryegrass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Glyceria occidentalis	Sweet flotegrass			X				X			X	X		X		X	X		X	X					X	
*Holcus lanatus**	Velvetgrass										X													X		
Hordeum brachyantherum	Meadow barley		X					X			X	X				X							X	X		
Hordeum marinum ssp. *gussoneanum**	Mediterranean barley							X			X						X		X	X				X		
*Hordeum murinum**	Foxtail barley	X	X	X			X	X		X	X	X	X	X		X	X	X	X	X		X	X	X	X	X
Leersia oryzoides	Rice cutgrass							X			X															
Leptochloa fusca subsp. *Fascicularis (Leptochloa fascicularis)*	Bearded sprangletop	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							X	X	X	
Muhlenbergia rigens	Deergrass															X										
*Oryza sativa**	Rice	X	X	X	X		X		X			X	X	X			X	X	X	X	X				X	
*Paspalum dilatatum**	Dallisgrass	X	X	X	X		X	X	X		X	X	X	X		X	X	X	X		X	X			X	
Paspalum distichum	Knotgrass	X	X	X	X						X	X		X		X								X	X	
*Phalaris aquatica**	Harding grass							X									X					X				
*Phalaris minor**	Littleseed canarygrass	X	X					X	X	X	X									X			X	X	X	X
*Phalaris paradoxa**	Paradox canarygrass			X							X	X				X						X		X		
*Poa annua**	Annual bluegrass		X		X		X	X		X	X	X		X		X				X		X	X	X		
*Polypogon interruptus**	Ditch beard grass	X	X			X		X			X												X	X		
*Polypogon monspeliensis**	Rabbit's-foot grass	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X		X	X	X	X	
*Setaria pumila**	Yellow bristle grass		X							X		X				X								X		
*Sorghum bicolor**	Milo	X								X																
*Sorghum halepense**	Johnsongrass	X	X	X	X	X	X	X	X		X		X	X	X		X	X	X	X		X	X	X	X	

Table B-1. Continued

Scientific Name (previous scientific name)[a]	Common Name	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
		Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
Sporobolus indicus	Small smutgrass															X										
Stipa pulchra (Nassella pulchra)	Purple needlegrass		X													X										
*Triticum aestivum**	Wheat					X																		X		X
Pontederiaceae	**Mud Plantain Family**																									
*Heteranthera limosa**	Ducksalad				X			X			X			X												
Typhaceae	**Cattail Family**																									
Typha angustifolia	Narrow-leaved cattail			X					X											X						
Typha domingensis	Southern cattail	X	X	X	X	X	X	X				X	X		X		X	X	X		X		X	X	X	X
Typha latifolia	Broadleaf cattail		X	X				X	X		X	X	X	X		X		X	X	X	X		X	X		
Dicotyledons																										
Aceraceae	**Maple Family**																									
Acer negundo	Box-elder					X																	X	X		
Adoxaceae	**Muskroot Family**																									
Sambucus nigra subsp. *canadensis (Sambucus mexicana)*	Blue elderberry	X																					X			
Amaranthaceae	**Amaranth Family**																									
Asclepias fascicularis	Narrow-leaf milkweed										X															
Amaranthaceae	**Amaranth Family**																									
*Amaranthus albus**	Pigweed amaranth															X										
Amaranthus sp.	Amaranth				X	X				X													X			
Anacardiaceae	**Sumac Family**																									
Toxicodendron diversilobum	Poison-oak	X				X																				
Apiaceae	**Carrot Family**																									

Table B-1. Continued

Scientific Name (previous scientific name)[a]	Common Name	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
		Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*Ammi visnaga**	Bisnaga		X			X		X			X															
*Conium maculatum**	Poison hemlock																								X	
*Daucus carota**	Wild carrot								X																	
*Foeniculum vulgare**	Sweet fennel									X												X	X	X	X	
*Torilis arvensis**	Hedge parsley	X																				X				
Araliaceae	**Ginseng Family**																									
*Hedera helix**	English ivy																									X
Asclepiadaceae	**Milkweed Family**																									
Asclepias fascicularis	Narrow-leaf milkweed															X								X		
Asteraceae	**Sunflower Family**																									
Achyrachaena mollis	Blow-wives			X								X				X				X				X		
Ambrosia sp.	Ragweed					X		X			X															
*Anthemis cotula**	Mayweed							X			X															
Baccharis pilularis	Coyote brush	X	X									X				X							X	X		
Baccharis salicifolia	Mulefat															X										
*Carduus pycnocephalus**	Italian thistle										X	X		X		X						X	X			
Centaurium pulchellum	Branched centaury										X	X														
*Centaurea solstitialis**	yellow star-thistle	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X		X	X	X				
Centromadia fitchii	Fitch's spikeweed			X		X										X										
*Cichorium intybus**	Chicory			X					X	X		X				X						X		X		
*Cirsium vulgare**	Bull thistle	X	X	X	X	X	X	X	X		X	X	X		X	X						X	X	X	X	X
*Dittrichia graveolens**	Stinkwort	X						X			X					X			X				X			
Eclipta prostrata	False daisy				X			X			X	X													X	

Table B-1. Continued

Scientific Name (previous scientific name)[a]	Common Name	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
		Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*Erigeron canadensis (Conyza)**	Horseweed	X		X	X	X	X	X	X		X	X	X			X	X	X	X			X	X		X	
*Gnaphalium luteoalbum**	Cudweed everlasting	X	X	X	X	X		X	X	X	X	X	X	X		X					X			X		
Helianthus annuus	Annual sunflower	X																								
*Helminthotheca echioides (Picris echioides)**	Bristly ox-tongue	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Heterotheca grandiflora	Telegraphweed			X												X										
Holocarpha virgata ssp. *virgata*	Common tarweed	X														X										
*Hypochaeris glabra**	Soft cat's-ear															X										
*Lactuca saligna**	Willow lettuce										X													X		
*Lactuca serriola**	Prickly lettuce	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lasthenia glaberrima	Smooth goldfields															X										
*Leontodon saxstilis (taraxacoides)**	Hairy hawkbit											X														
*Logfia gallica (Filago gallica)**	Narrow-leaved filago															X										
*Matricaria discoidea (Chamomila suaveolens)**	Pineapple weed		X									X				X										
Microseris elegans	Elegant microseris															X										
Psilocarphus brevissimus var. brevissimus	Woollyheads															X										
Psilocarphus tenellus	Slender woollyheads															X										
*Senecio vulgaris**	Common groundsel		X	X				X		X	X	X		X		X				X		X				X
*Silybum marianum**	Milk thistle	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X
*Soliva sessilis**	Lawn burweed															X										
Sonchus asper ssp. *asper**	Prickly sow thistle	X	X	X				X			X		X	X	X	X				X		X	X			
*Sonchus oleraceus**	Common sow-thistle	X		X	X	X	X	X	X		X	X	X			X	X	X	X	X		X	X	X	X	X

Table B-1. Continued

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
Symphyotrichum subulatum (Aster subulatus var. *ligulatus)*	Annual water-aster	X	X	X	X	X		X			X	X		X		X							X	X	X	
Taraxacum officinale	Dandelion															X								X		
*Tragopogon porrifolius**	Salsify	X																								
Xanthium spinosum	Spiny coccklebur															X										
Bignoniaceae	**Bignonia Family**																									
*Catalpa bignonioides**	Catalpa															X										
Boraginaceae	**Borage Family**																									
Amsinckia menziesii var. *intermedia*	Common fiddleneck	X		X				X	X	X	X	X		X		X						X				
Heliotropium curassavicum	Heliotrope	X								X	X													X	X	
Plagiobothrys stipitatus var. micranthus	Stipitate popcornflower															X										
Brassicaceae	**Mustard Family**																									
*Brassica nigra**	Black mustard	X	X					X		X	X	X	X									X	X	X		
*Brassica rapa**	Field mustard			X	X		X		X		X		X			X	X	X	X				X		X	
*Capsella bursa-pastoris**	Shepherd's-purse				X		X	X	X	X		X		X	X	X	X		X	X		X	X	X		X
Cardamine oligosperma	Idaho bittercress															X										
*Hirschfeldia incana**	Shortpod mustard		X							X	X	X														
Lepidium dictyotum	Alkali pepperweed																									
*Lepidium didymus (Cornopus didymus)**	Lesser swinecress	X	X					X		X	X	X				X							X	X		X
*Lepidium latifolium**	Perennial pepperweed	X		X	X	X					X					X							X		X	
Planodes virginicum (Sibara virginica)	Common rockcress															X							X			
*Raphanus sativus**	Wild radish	X	X	X		X			X		X	X	X			X						X	X	X	X	X

Table B-1. Continued

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
Rorippa curvisiliqua	Westwen yellowcress	X	X					X			X	X								X						
*Sinapis arvensis**	Charlock mustard		X			X					X									X				X		
*Sisymbrium officinale**	Hedge mustard				X	X																				
Callitrichaceae	**Water-Starwort Family**																									
Callitriche marginata	Water-starwort			X																						
Caryophyllaceae	**Pink Family**																									
*Cerastium glomeratum**	Mouse-ear chickweed			X																						
*Spergularia rubra**	Red sandspurry			X								X				X										
*Stellaria media**	Common chickweed							X						X		X				X			X	X		
Ceratophyllaceae	**Hornwort Family**																									
Ceratophyllum demersum	Hornwort								X		X	X											X			
Chenopodiaceae	**Goosefoot Family**																									
*Chenopodium album**	White goosefoot										X															
Chenopodium sp.	Goosefoot				X	X										X				X			X			X
Salsola tragus (previous family – Asteraceae)*	Russian thistle, tumbleweed										X		X			X								X		
Convolvulaceae	**Morning Glory Family**																									
*Convolvulus arvensis**	Field bindweed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Cressa truxillensis	Alkali weed													X		X						X		X		
Crassulaceae	**Stonecrop Family**																									
Crassula aquatica/solieri	Water pygmy-weed										X	X														
*Crassula tillaea**	Moss pygmy-stonecrop									X																
Elatinaceae	**Waterwort Family**																									

Table B-1. Continued

Scientific Name (previous scientific name)[a]	Common Name	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
		Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*Elatine ambigua**	Asian waterweed							X			X					X							X			
Elatine brachysperma/rubella	Waterweed							X			X															
Euphorbiaceae	**Spurge Family**																									
*Chamaesyce maculata**	Spotted spurge															X									X	
Chamaesyce serpyllifolia ssp. *serpyllifolia*	Thyme-leaved spurge							X			X															
Eremocarpus setiger (setigerus)	Doveweed															X						X		X		
Fabaceae	**Legume Family**																									
Acmispon americanus (Lotus purshianus)	Spanish lotus			X																						
Glycyrrhiza lepidota	Wild licorice																					X		X	X	
*Lotus corniculatus**	Bird's-foot trefoil	X	X	X												X						X		X		
Lupinus bicolor	Miniature lupine			X				X		X	X	X				X										
*Medicago polymorpha**	Bur-clover	X	X				X	X	X	X	X	X	X	X		X	X	X	X	X		X		X	X	X
*Medicago sativa**	Alfalfa					X			X	X				X								X				X
*Melilotus alba**	White sweetclover	X	X	X				X		X	X													X		
*Melilotus indica**	Indian sweetclover		X					X			X													X		
*Robinia pseudoacacia**	Black locust																									
*Trifolium campestre**	Hop clover			X												X							X			
*Trifolium dubium**	Suckling clover			X						X						X								X		
*Trifolium fragiferum**	Strawberry clover															X										
*Trifolium glomeratum**	Clustered clover															X										
Trifolium gracilentum	Pinpoint clover															X										

Table B-1. Continued

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*Trifolium hirtum**	Rose clover									X														X		
*Trifolium pratense**	Red clover															X										
*Trifolium repens**	White clover															X							X			
*Trifolium subterraneum**	Subterranean clover															X										
*Vicia sativa**	Common vetch			X						X				X		X				X						
*Vicia villosa**	Hairy vetch		X					X		X	X	X				X							X	X		
Fagaceae	**Oak Family**																									
Quercus lobata	Valley oak	X		X		X					X	X		X	X	X						X	X	X	X	X
Gentianaceae	**Gentian Family**																									
Zeltnera muehlenbergii (Centaurium muehlenbergii)	Monterey centaury			X				X	X		X												X			
Geraniaceae	**Geranium Family**																									
*Erodium botrys**	Big stork's-bill		X	X	X		X		X			X	X			X	X	X	X							
*Erodium cicutarium**	Red-stemmed filaree		X		X		X	X	X	X	X	X	X		X	X	X	X	X					X		
*Erodium moschatum**	White-stemmed filaree	X	X					X	X	X	X			X		X				X		X				
*Geranium dissectum**	Cut-leaf geranium	X	X	X	X		X	X	X	X	X		X	X		X	X	X	X	X		X	X	X		
*Geranium molle**	Dove's-foot geranium										X					X										
Haloragaceae	**Water-Milfoil Family**																									
Myriophyllum sp.	Water milfoil							X	X																	
Juglandaceae	**Walnut family**																									
Juglans hindsii (Juglans californica var. *hindsii)*	California black walnut															X						X	X	X		X
Lamiaceae	**Mint Family**																									

Table B-1. Continued

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*Lamium amplexicaule**	Henbit deadnettle									X		X								X						
Lycopus americanus	American bugleweed							X																		
*Mentha pulegium**	Pennyroyal										X					X										
Stachys ajugoides/albens	Hedge nettle	X																								
Trichostema lanceolatum	Vinegarweed			X												X										
Lythraceae	**Loosestrife Family**																									
Ammannia coccinea/robusta	Redstem	X		X	X		X	X			X	X				X							X	X	X	
*Lythrum hyssopifolia**	Hyssop loosestrife	X	X	X	X	X	X	X	X	X	X	X				X				X			X	X		
Malvaceae	**Mallow Family**																									
*Abutilon theophrasti**	Velvet-leaf	X			X	X	X	X		X	X	X										X	X	X	X	X
*Malva neglecta**	Common mallow		X		X		X	X					X				X	X	X			X				
*Malva nicaeensis**	Bull mallow	X	X	X		X		X	X		X	X	X	X		X				X			X	X	X	
Malvella leprosa	Alkali mallow	X	X	X	X	X	X	X	X	X	X			X	X	X	X		X	X	X	X		X	X	
*Modiola caroliniana**	Carolina bristle-mallow															X										
Montiaceae (Split from Portulacaceae)	**Miner's Lettuce Family**																									
Calandrinia ciliata	Red maids		X	X				X	X	X	X	X		X						X			X	X		
Claytonia perfoliata	Miner's lettuce			X										X		X								X		
Moraceae	**Mulberry Family**																									
*Ficus carica**	Edible fig	X		X							X				X	X						X		X		
*Morus alba**	White mulberry	X														X									X	
Myrtaceae	**Myrtle Family**																									
*Eucalyptus camulduensis**	River red gum															X							X			

Table B-1. Continued

Scientific Name (previous scientific name)[a]	Common Name	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
		Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*Eucalyptus globulus**	Blue gum															X										
*Eucalyptus polyanthemos**	Silver dollar gum															X										
Oleaceae	**Olive Family**																									
Fraxinus latifolia	Oregon ash																					X	X		X	X
Onagraceae	**Evening-Primrose Family**																									
Epilobium brachycarpum	Panicled willow-herb				X	X	X						X				X	X	X						X	
Epilobium campestre (Epilobium pygmaeum)	Smooth spike-primrose															X										
Epilobium ciliatum	Fringed willowherb	X	X	X	X	X	X	X			X	X	X		X	X	X	X	X	X		X		X		X
Ludwigia peploides	Floating water-primrose				X			X	X		X									X	X					
Ludwigia peploides ssp. *montevidensis**	Floating water-primrose		X	X				X		X	X	X				X				X						
Ludwigia peploides ssp. *peploides*	Floating water-primrose										X					X								X	X	
Oenothera elata	Evening primrose	X						X																		
Orobanchaceae (split from Scrophulariaceae)	**Broomrape Family**																									
Castilleja attenuata	Valley tassels											X														
Triphysaria eriantha	Johnny-tuck															X										
Triphysaria pusilla	Dwarf owl's clover															X										
Oxalidaceae	**Oxalis Family**																									
*Oxalis corniculata**	Yellow sorrel															X										
Oxalis sp.*	Sorrel																					X				
Phrymaceae (split from Scrophulariaceae)	**Lopseed Family**																									

Table B-1. Continued

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
Mimulus guttatus	Seep-spring monkeyflower	X														X										
Plantaginaceae	**Plantain Family**																									
Bacopa eisenii (Bacopa eisenmanii)	Eisen water-hyssop	X	X	X				X	X		X	X												X		
*Dopatrium junceum**	Horsefly's eye			X																						
Gratiola ebracteata	Bractless hedge-hyssop										X															
*Kickxia elatine**	Sharp-leaved fluellin							X																		
Lindernia dubia	Yellowseed false pimpernel			X																						
*Plantago coronopus**	Buckhorn plantain															X										
*Plantago lanceolata**	English plantain							X			X					X	X		X	X						
*Plantago major**	Common plantain															X										
*Veronica anagallis-aquatica**	Water speedwell								X		X									X			X			
*Veronica arvensis**	Corn speedwell															X										
Veronica peregrina ssp. *xalapensis*	Purslane speedwell	X	X	X				X	X	X	X	X		X		X				X		X		X		
*Veronica persica**	Persian speedwell															X										
Platanaceae	**Plane Family**																									
Platanus racemosa	Western sycamore		X									X				X							X			
Polygonaceae	**Buckwheat Family**																									
Persicaria amphibian (Polygonum amphibium)	Water smartweed				X	X	X																			
*Persicaria hydropiper (Polygonum hydropiper)**	Common smartweed, marsh pepper		X	X				X	X	X	X		X											X		
Persicaria lapathifolia (Polygonum lapathifolium)	Willow smartweed	X	X		X	X			X	X	X	X	X			X									X	

Table B-1. Continued

Scientific Name (previous scientific name)[a]	Common Name	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
		Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
Polygonum aviculare subsp. *depressum (Polygonum arenastrum)**	Common knotweed	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
*Rumex conglomeratus**	Clustered dock															X										
*Rumex crispus**	Curly dock	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
*Rumex dentatus**	Toothed dock							X			X															
*Rumex pulcher**	Fiddle dock	X						X			X					X								X		
Portulacaceae	**Purslane Family**																									
*Portulaca oleracea**	Common purslane											X				X										
Primulaceae	**Primrose Family**																									
*Anagallis arvensis**	Scarlet pimpernel	X		X	X	X	X	X	X	X	X	X	X			X	X	X	X				X	X		X
Ranunculaceae	**Buttercup Family**																									
Myosurus minimus	Common mousetail		X									X								X						
Ranunculus bonariensis var. *trisepalus*	Carter's buttercup			X								X		X		X										
*Ranunculus muricatus**	Prickle-fruited buttercup	X						X			X					X							X	X		
Ranunculus sp.	Buttercup							X																		
Rhamnaceae	**Buckthorn Family**																									
Frangula californica (Rhamnus californica)	California coffeeberry																							X		
Rosaceae	**Rose Family**																									
*Pyracantha angustifolia**	Firethorn															X										
Rosa californica	California wild rose	X	X	X												X						X				
*Rubus armeniacus**	Himalayan blackberry	X		X	X	X			X	X					X	X						X	X	X	X	X
Rubus ursinus	California blackberry	X	X			X						X				X						X	X	X		X

Table B-1. Continued

Scientific Name (previous scientific name)[a]	Common Name	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
		Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
Rubiaceae	**Madder Family**																									
Cephalanthus occidentalis var. *californicus (formally in Rosaceae family)*	Buttonwillow		X	X				X			X	X										X	X		X	
Galium aparine	Bedstraw	X		X					X													X	X			X
Salicaceae	**Willow Family**																									
Populus fremontii	Fremont cottonwood	X		X		X		X	X	X	X	X		X		X						X	X	X	X	
Salix exigua	Narrow-leaved willow	X	X	X																						
Salix gooddingii	Black willow	X		X				X	X		X	X				X							X	X	X	
Salix lasiolepis	Arroyo willow	X		X				X				X											X		X	
Scrophulariaceae	**Figwort Family**																									
Limosella acaulis	Broad-leaved mudwort							X			X															
Simaroubaceae	**Quassia Family**																									
*Ailanthus altissima**	Tree-of-heaven															X										
Solanaceae	**Nightshade Family**																									
*Datura stramonium**	Jimson weed	X																					X			
*Lycopersicon esculentum**	Tomato								X																	
*Physalis lancifolia**	Narrowleaf tomatillo	X	X										X			X									X	
*Physalis philadelphica**	Tomatillo							X			X					X										
Solanum americanum	Common nightshade			X	X	X					X		X	X		X									X	
Urticaceae	**Nettle Family**																									
*Urtica urens**	Dwarf nettle																						X			
Verbenaceae	**Vervain Family**																									

Table B-1. Continued

Scientific Name (previous scientific name)[a]	Common Name	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
		Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
Phyla nodiflora var. *nodiflora*	Turkey tangle fogfruit										X					X										
*Verbena bonariensis**	Purpletop vervain		X		X	X	X	X			X	X	X				X	X	X							
Viscaceae	**Mistletoe Family**																									
Phoradendron serotinum (Phoradendron villosum)	*Oak mistletoe*	X																								
Vitaceae	**Grape Family**																									
Vitis californica	California wild grape	X																				X	X	X	X	
Zygophyllaceae	**Caltrop Family**																									
*Tribulus terrestris**	Puncture vine								X			X														
Total plant taxa for reserve		98	84	99	55	54	45	114	65	57	131	96	47	53	26	160	42	36	42	53	19	61	85	103	58	32

* Nonnative species.

[a] Nomenclature follows the 2012 second edition of *The Jepson Manual;* previous name from the 1993 first edition of *The Jepson Manual* is provided in parentheses.

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Appendix C

Avian and Other Covered Species Survey Results

Table C-1. Common and Scientific Names of Wildlife Species Observed on NBHCP Reserves, 2004–2022

Common Name	Scientific Name
Mammals	
Coyote	*Canis latrans*
Raccoon	*Procyon lotor*
River otter	*Lontra canadensis*
Striped skunk	*Mephitis mephitis*
Mink	*Neovison vison*
Long-tailed weasel	*Neogale frenata*
California ground squirrel	*Otospermophilus beecheyi*
Botta's pocket gopher	*Thomomys bottae*
Deer mouse	*Peromyscus maniculatus*
California meadow vole	*Microtus californicus*
Muskrat	*Ondatra zibethicus*
House mouse	*Mus musculus*
Brown rat	*Rattus norvegicus*
Black-tailed jackrabbit	*Lepus californicus*
Desert cottontail	*Silvilagus audubonii*
Mule deer	*Odocoileus hemionus*
Hoary bat	*Lasiurus cinereus*
Mexican free-tailed bats	*Tadarida brasiliensis mexicanus*
Birds	
Greater white-fronted goose	*Anser albifrons*
Snow goose	*Chen caerulescens*
Canada goose	*Branta canadensis*
Tundra swan	*Cygnus columbianus*
Wood duck	*Aix sponsa*
Gadwall	*Anas strepera*
American wigeon	*Anas americana*
Eurasian wigeon	*Anas penelope*
Mallard	*Anas platyrhynchos*
Blue-winged teal	*Anas discors*
Cinnamon teal	*Anas cyanoptera*
Northern shoveler	*Anas clypeata*
Northern pintail	*Anas acuta*
Green-winged teal	*Anas crecca*
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Greater scaup	*Aythya marila*
Lesser scaup	*Aythya affinis*
Bufflehead	*Bucephala albeola*
Common goldeneye	*Bucephala clangula*

Table C-1. Continued

Common Name	Scientific Name
Hooded merganser	*Lophodytes cucullatus*
Common merganser	*Mergus merganser*
Ruddy duck	*Oxyura jamaicensis*
Ring-necked pheasant	*Phasianus colchicus*
Wild turkey	*Meleagris gallopavo*
California quail	*Callipepla californica*
Pied-billed grebe	*Podilymbus podiceps*
Eared grebe	*Podiceps nigricollis*
Horned grebe	*Podiceps auritus*
American white pelican	*Pelecanus erythrorhynchos*
Double-crested cormorant	*Phalacrocorax auritus*
American bittern	*Botaurus lentiginosus*
Great blue heron	*Ardea herodias*
Great egret	*Ardea alba*
Snowy egret	*Egretta thula*
Cattle egret	*Bubulcus ibis*
Green heron	*Butorides virescens*
Black-crowned night-heron	*Nycticorax nycticorax*
White-faced ibis	*Plegadis chihi*
Turkey vulture	*Cathartes aura*
Bald eagle	*Haliaeetus leucocephalus*
Osprey	*Pandion haliaetus*
White-tailed kite	*Elanus leucurus*
Northern harrier	*Circus cyaneus*
Sharp-shinned hawk	*Accipiter striatus*
Cooper’s hawk	*Accipiter cooperii*
Red-shouldered hawk	*Buteo lineatus*
Swainson’s hawk	*Buteo swainsoni*
Ferruginous hawk	*Buteo regalis*
Red-tailed hawk	*Buteo jamaicensis*
Rough-legged hawk	*Buteo lagopus*
American kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Prairie falcon	*Falco mexicanus*
Peregrine falcon	*Falco peregrinus*
Virginia rail	*Rallus limicola*
Sora	*Porzana carolina*
Common gallinule	*Gallinula galeata*
American coot	*Fulica americana*
Sandhill crane	*Grus canadensis*
Killdeer	*Charadrius vociferus*
Black-necked stilt	*Himantopus mexicanus*
American avocet	*Recurvirostra americana*

Table C-1. Continued

Common Name	Scientific Name
Greater yellowlegs	*Tringa melanoleuca*
Lesser yellowlegs	*Tringa flavipes*
Long-billed curlew	*Numenius americanus*
Western sandpiper	*Calidris mauri*
Least sandpiper	*Calidris minutilla*
Baird’s sandpiper	*Calidris bairdii*
Dunlin	*Calidris alpina*
Short-billed dowitcher	*Limnodromus griseus*
Long-billed dowitcher	*Limnodromus scolopaceus*
Wilson’s snipe	*Gallinago gallinago*
Wilson’s phalarope	*Phalaropus tricolor*
Red-necked phalarope	*Phalaropus lobatus*
Ring-billed gull	*Larus delawarensis*
California gull	*Larus californicus*
Herring gull	*Larus argentatus*
Caspian tern	*Sterna caspia*
Black tern	*Chlidonias niger*
Forster’s tern	*Sterna forsteri*
Rock pigeon	*Columba livia*
Eurasian-collared dove	*Streptopelia decaocto*
Mourning dove	*Zenaida macroura*
Barn owl	*Tyto alba*
Great horned owl	*Bubo virginianus*
Burrowing owl	*Athene cunicularia*
Short-eared owl	*Asio flammeus*
Lesser nighthawk	*Chordeiles acutipennis*
White-throated swift	*Aeronautes saxatalis*
Black-chinned hummingbird	*Archilochus alexandri*
Anna’s hummingbird	*Calypte anna*
Rufous hummingbird	*Selasphorus rufus*
Belted kingfisher	*Ceryle alcyon*
Acorn woodpecker	*Melanerpes formicivorus*
Nuttall’s woodpecker	*Picoides nuttallii*
Downy woodpecker	*Picoides pubescens*
Northern flicker	*Colaptes auratus*
Western wood-pewee	*Contopus sordidulus*
Willow flycatcher	*Empidonax traillii*
Pacific-slope flycatcher	*Empidonax difficilis*
Black phoebe	*Sayornis nigricans*
Say’s phoebe	*Sayornis saya*
Ash-throated flycatcher	*Myiarchus cinerascens*
Western kingbird	*Tyrannus verticalis*
Loggerhead shrike	*Lanius ludovicianus*

Table C-1. Continued

Common Name	Scientific Name
Warbling vireo	*Vireo gilvus*
California scrub-jay	*Aphelocoma californica*
Yellow-billed magpie	*Pica nuttalli*
Common Raven	*Corvus corax*
American crow	*Corvus brachyrhynchos*
Horned lark	*Eremophila alpestris*
Tree swallow	*Tachycineta bicolor*
Violet-green swallow	*Tachycineta thalassina*
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Cliff swallow	*Petrochelidon pyrrhonota*
Barn swallow	*Hirundo rustica*
Oak titmouse	*Baeolophus inornatus*
Bushtit	*Psaltriparus minimus*
White-breasted nuthatch	*Sitta carolinensis*
Bewick's wren	*Thryomanes bewickii*
House wren	*Troglodytes aedon*
Marsh wren	*Cistothorus palustris*
Ruby-crowned kinglet	*Regulus calendula*
Golden-crowned kinglet	*Regulus satrapa*
Western bluebird	*Sialia mexicana*
Mountain bluebird	*Sialia currucoides*
Swainson's thrush	*Catharus ustulatus*
Hermit thrush	*Catharus guttatus*
American robin	*Turdus migratorius*
Northern mockingbird	*Mimus polyglottos*
European starling	*Sturnus vulgaris*
American pipit	*Anthus rubescens*
Cedar waxwing	*Bombycilla cedrorum*
Phainopepla	*Phainopepla nitens*
Orange-crowned warbler	*Vermivora celata*
Yellow warbler	*Dendroica petechia*
Yellow-rumped warbler	*Dendroica coronata*
Black-throated gray warbler	*Dendroica nigrescens*
Townsend's warbler	*Dendroica townsendi*
MacGillivray's warbler	*Oporornis tolmiei*
Common yellowthroat	*Geothlypis trichas*
Wilson's warbler	*Wilsonia pusilla*
Western tanager	*Piranga ludoviciana*
Spotted towhee	*Pipilo maculatus*
California towhee	*Pipilo crissalis*
Chipping sparrow	*Spizella passerina*
Lark sparrow	*Chondestes grammacus*
Savannah sparrow	*Passerculus sandwichensis*

Table C-1. Continued

Common Name	Scientific Name
Fox sparrow	*Passerella iliaca*
Song sparrow	*Melospiza melodia*
Lincoln's sparrow	*Melospiza lincolnii*
White-crowned sparrow	*Zonotrichia leucophrys*
Golden-crowned sparrow	*Zonotrichia atricapilla*
Dark-eyed junco	*Junco hyemalis*
Black-headed grosbeak	*Pheucticus melanocephalus*
Blue grosbeak	*Guiraca caerulea*
Lazuli bunting	*Passerina amoena*
Red-winged blackbird	*Agelaius phoeniceus*
Tricolored blackbird	*Agelaius tricolor*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Brewer's blackbird	*Euphagus cyanocephalus*
Great-tailed grackle	*Quiscalus mexicanus*
Brown-headed cowbird	*Molothrus ater*
Western meadowlark	*Sturnella neglecta*
Bullock's oriole	*Icterus bullockii*
House finch	*Carpodacus mexicanus*
Lesser goldfinch	*Carduelis psaltria*
American goldfinch	*Carduelis tristis*
House sparrow	*Passer domesticus*
Reptiles	
Pacific pond turtle	*Actinemys marmorata*
Red-eared slider	*Trachemys scripta elegans*
Pacific gopher snake	*Pituophis catenifer catenifer*
Western yellow-bellied racer	*Coluber constrictor mormon*
California king snake	*Lampropeltis getulus californiae*
Giant gartersnake	*Thamnophis gigas*
Valley gartersnake	*Thamnophis sirtalis fitchi*
Western fence lizard	*Sceloporus occidentalis*
California alligator lizard	*Gerrhonotus multicarnatus multicarnatus*
Amphibians	
Sierran tree frog	*Pseudacris Sierra*
Bullfrog	*Rana catesbeiana*

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Table C-2. Total Numbers of Bird Detections on NBHCP Mitigation Lands during 2022 Avian Surveys

	North Basin Reserve																		Central Basin Reserve									Fisherman's Lake Reserve					
Common Name	*Atkinson*	*Bennett North*	*Bennett South*	*Bolen North*	*Bolen South*	*Bolen West*	*Frazer*	*Huffman East*	*Huffman West*	*Lauppe North*	*Lauppe South*	*Lucich North*	*Lucich South*	*Nestor*	*Ruby Ranch*	*Verona*	*Vestal*	*Willey*	*Betts Kismat Silva*	*Bianchi West*	*Elsie*	*Elverta Silva South*	*Frazer South*	*Paulson South*	*Richter*	*Sills*	*Tufts*	*Alleghany 50*	*Cummings*	*Natomas Farms*	*Rosa Central*	*Souza*	**Total**
Greater White-fronted Goose	0	335	4	0	0	0	196	0	0	0	0	470	0	0	60	0	270	0	381	0	90	965	33	60	15	300	70	0	0	0	0	72	3,321
Snow Goose	0	0	0	0	0	0	0	0	0	8	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
Canada Goose	4	132	2	0	0	0	81	0	0	0	0	221	0	0	0	0	0	0	558	0	0	0	0	0	0	0	0	0	4	93	0	7	1,102
Wood Duck	0	0	2	0	0	0	4	0	0	0	0	1	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	6	3	0	0	28
American Wigeon	0	45	0	0	0	0	5	0	0	0	0	32	0	0	0	0	0	0	88	0	0	0	0	6	0	0	0	0	4	0	0	0	180
Mallard	9	65	17	12	0	0	88	16	0	4	7	148	51	2	0	0	0	3	262	23	0	14	0	13	0	45	9	0	32	38	6	0	864
Blue-winged Teal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	40
Cinnamon Teal	0	4	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	36	2	0	0	0	0	0	10	0	0	0	0	0	0	62
Northern Shoveler	0	0	0	0	0	0	0	0	0	500	120	2	40	0	0	0	0	0	13	210	0	0	0	64	0	0	0	0	0	0	0	0	949
Northern Pintail	60	1	0	0	0	0	3	0	0	400	0	3	0	0	0	0	0	0	16	120	0	0	0	53	0	0	0	0	0	0	0	0	656
Green-winged Teal	0	0	0	0	0	0	0	0	0	250	0	12	160	0	0	0	0	0	30	8	0	0	84	0	0	0	0	0	0	0	0	0	544
Canvasback	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Redhead	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Greater Scaup	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	4	0	0	0	17
Lesser Scaup	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Bufflehead	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	2	0	0	70
Common Goldeneye	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	3	0	0	22
Hooded Merganser	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	7
Common Merganser	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	4	0	0	9
Ruddy Duck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Wild Turkey	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73
California Quail	15	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
Pied-billed Grebe	0	31	3	0	0	0	23	0	0	0	0	24	1	0	0	0	0	0	45	0	0	0	0	0	0	1	0	0	1	3	0	0	132
American White Pelican	0	3	0	0	0	0	121	0	0	0	1	175	9	0	0	0	0	0	80	0	0	0	0	0	0	0	0	0	0	20	0	0	409
Double-crested Cormorant	0	15	1	0	0	0	11	0	0	0	0	114	4	0	0	0	0	0	57	0	0	0	0	0	0	0	0	0	0	28	0	0	230
American Bittern	0	0	0	1	0	0	1	2	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	12
Great Blue Heron	6	27	4	2	0	3	25	14	0	7	4	34	30	4	3	4	8	0	27	5	1	17	6	4	0	21	8	0	1	15	1	0	281
Great Egret	15	16	8	13	2	3	29	101	8	66	45	58	96	0	3	6	3	3	98	37	5	56	19	35	1	40	17	0	6	44	1	1	835
Snowy Egret	1	0	0	0	0	0	7	1	0	20	0	22	10	0	0	0	0	0	61	7	0	6	33	19	0	3	1	0	4	12	5	0	212
Cattle Egret	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Green Heron	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Black-crowned Night-Heron	2	48	0	0	0	0	14	11	0	0	8	7	35	0	0	0	2	0	121	5	0	3	2	0	0	1	3	0	0	0	1	0	263
White-faced Ibis	53	0	0	210	0	0	20	346	0	185	16	15	223	0	0	0	0	0	37	135	0	120	0	22	0	27	3	0	0	0	0	0	1,412
Turkey Vulture	11	2	0	0	0	1	3	1	0	1	0	7	2	0	0	1	0	1	1	0	0	3	1	0	0	0	0	0	0	0	1	0	36
White-tailed Kite	12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	1	0	0	0	0	0	0	1	0	0	0	22
Northern Harrier	1	3	5	5	0	2	2	1	0	2	1	1	4	3	3	1	0	1	4	0	1	1	1	1	2	2	3	0	1	3	0	0	54
Cooper's Hawk	1	0	1	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Red-shouldered Hawk	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	1	2	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Swainson's Hawk	2	0	1	0	2	2	1	0	0	2	1	0	2	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	4	0	20
Red-tailed Hawk	15	3	4	2	4	3	6	2	4	2	1	9	13	4	7	0	6	3	36	6	6	16	11	0	2	15	5	3	2	3	2	0	195

Table C-2. Continued

	North Basin Reserve																		Central Basin Reserve									Fisherman's Lake Reserve					
Common Name	*Atkinson*	*Bennett North*	*Bennett South*	*Bolen North*	*Bolen South*	*Bolen West*	*Frazer*	*Huffman East*	*Huffman West*	*Lauppe North*	*Lauppe South*	*Lucich North*	*Lucich South*	*Nestor*	*Ruby Ranch*	*Verona*	*Vestal*	*Willey*	*Betts Kismat Silva*	*Bianchi West*	*Elsie*	*Elverta Silva South*	*Frazer South*	*Paulson South*	*Richter*	*Sills*	*Tufts*	*Alleghany 50*	*Cummings*	*Natomas Farms*	*Rosa Central*	*Souza*	**Total**
American Kestrel	11	0	0	0	0	1	0	1	4	1	0	1	3	1	0	0	4	0	4	0	1	2	2	0	0	1	0	0	0	0	2	1	40
Prairie Falcon	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Common Gallinule	0	1	0	0	0	0	9	0	0	0	0	7	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	49
American Coot	0	116	3	0	0	0	7	0	0	0	0	102	0	0	0	0	0	0	638	0	0	0	5	0	0	0	0	0	0	1	0	0	872
Sandhill Crane	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Killdeer	4	20	4	7	0	0	9	14	8	6	5	2	38	4	5	3	4	31	60	10	9	5	11	5	0	9	2	1	3	5	9	1	294
Mountain Plover	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Black-necked Stilt	0	0	0	2	0	0	0	0	0	6	0	3	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	16
American Avocet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Greater Yellowlegs	4	0	0	0	0	0	11	0	0	32	32	32	18	0	4	0	0	0	4	9	0	0	16	7	0	1	0	0	0	0	0	0	170
Long-billed Curlew	0	0	0	0	0	0	0	0	0	0	87	0	0	0	0	0	0	0	0	1	0	0	0	10	0	0	0	0	0	0	0	0	98
Least Sandpiper	0	0	0	0	0	0	0	0	0	0	32	3	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	75
Dunlin	0	0	0	0	0	0	0	0	0	0	0	140	100	0	0	0	0	50	0	0	0	0	20	0	0	0	0	0	0	0	0	0	310
Long-billed Dowitcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	12
Wilson's Snipe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	5
Ring-billed Gull	0	0	0	1	0	0	0	0	0	61	0	0	10	1	0	0	0	0	0	0	0	0	0	7	0	2	0	0	3	2	0	0	87
California Gull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Rock Pigeon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	10
Eurasian Collared-Dove	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Mourning Dove	55	0	5	0	2	0	6	3	2	0	0	6	2	0	7	0	1	0	44	0	1	0	0	0	0	0	2	4	7	15	15	10	187
Great Horned Owl	0	1	2	0	0	0	0	1	1	0	0	2	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Burrowing Owl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
White-throated Swift	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Anna's Hummingbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2
Belted Kingfisher	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	7
Acorn Woodpecker	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Nuttall's Woodpecker	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	19
Northern Flicker	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	7
Western Wood-Pewee	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Black Phoebe	9	5	2	1	9	0	6	1	0	0	2	14	10	1	0	0	5	0	33	1	0	4	4	0	1	3	0	4	5	10	4	3	137
Say's Phoebe	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	3
Ash-throated Flycatcher	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Western Kingbird	36	5	5	0	26	6	1	1	14	7	1	7	0	0	0	5	6	1	18	0	0	0	0	0	0	1	0	4	1	0	11	3	159
California Scrub-Jay	21	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	2	0	2	32
Yellow-billed Magpie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
American Crow	13	0	0	0	1	0	0	7	9	0	28	0	1	0	4	0	5	1	0	0	0	0	0	0	0	0	0	0	0	5	24	7	105
Common Raven	0	2	0	2	2	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	1	2	0	0	2	0	0	0	0	0	0	15
Horned Lark	0	75	0	0	0	0	0	0	0	0	0	0	30	120	0	4	0	30	0	2	6	0	0	0	8	50	4	0	0	0	1	0	330
Tree Swallow	69	35	1	0	10	0	11	0	2	0	2	16	0	0	0	0	4	0	60	0	0	0	0	0	0	3	0	0	0	0	22	0	235
Cliff Swallow	15	7	7	0	7	10	10	2	4	8	9	16	4	0	13	1	5	0	180	0	7	18	12	0	1	21	0	0	20	46	3	0	426

Table C-2. Continued

	North Basin Reserve																		Central Basin Reserve										Fisherman's Lake Reserve					
Common Name	*Atkinson*	*Bennett North*	*Bennett South*	*Bolen North*	*Bolen South*	*Bolen West*	*Frazer*	*Huffman East*	*Huffman West*	*Lauppe North*	*Lauppe South*	*Lucich North*	*Lucich South*	*Nestor*	*Ruby Ranch*	*Verona*	*Vestal*	*Willey*	*Betts Kismat Silva*	*Bianchi West*	*Elsie*	*Elverta Silva South*	*Frazer South*	*Paulson South*	*Richter*	*Sills*	*Tufts*	*Alleghany 50*	*Cummings*	*Natomas Farms*	*Rosa Central*	*Souza*	**Total**
Barn Swallow	0	0	7	1	1	0	0	0	4	0	5	7	8	0	0	0	0	1	24	2	0	2	1	0	1	4	4	1	5	7	4	0	89
Unknown swallow	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6
Oak Titmouse	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	13
Bushtit	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	7	0	0	18
Bewick's Wren	10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
House Wren	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Marsh Wren	0	86	13	0	0	0	108	0	0	0	0	143	37	0	0	0	0	0	266	0	0	0	0	0	0	0	0	0	2	4	0	0	659
Ruby-crowned Kinglet	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Western Bluebird	21	0	0	0	0	0	0	0	2	0	0	5	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	2	2	0	3	0	39
American Robin	0	0	0	0	2	0	0	0	5	4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12
Northern Mockingbird	3	0	0	0	3	0	0	0	1	0	0	0	0	1	0	0	2	0	13	0	4	0	0	0	0	0	0	1	5	13	10	8	64
European Starling	167	0	0	0	112	0	0	30	160	5	167	0	0	0	0	11	0	0	63	0	0	0	0	0	0	0	0	12	0	10	17	18	772
American Pipit	12	20	25	31	0	0	5	22	0	0	1	0	0	45	20	14	1	15	5	0	26	7	0	1	24	85	60	0	1	1	0	0	421
Phainopepla	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Yellow-rumped Warbler	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	2	0	0	15
Common Yellowthroat	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	12	6	0	0	22
Wilson's Warbler	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Spotted Towhee	19	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
California Towhee	7	0	0	0	4	0	0	0	0	0	1	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	42	0	0	0	1	60
Lark Sparrow	24	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26
Savannah Sparrow	140	104	159	137	12	174	24	197	3	52	22	92	102	93	81	142	73	55	56	69	48	95	177	27	17	234	91	0	20	12	21	2	2,531
Song Sparrow	0	3	16	0	0	0	12	0	0	0	0	17	14	0	0	1	0	0	12	0	0	0	0	0	0	2	1	0	6	5	0	0	89
White-crowned Sparrow	54	34	2	19	5	32	9	0	0	0	0	0	3	27	2	0	2	0	71	0	0	22	0	0	0	0	0	0	38	6	0	0	326
Golden-crowned Sparrow	0	0	0	0	3	0	14	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	5	0	0	54
Red-winged Blackbird	299	97	3262	74	78	5	732	733	51	84	578	437	9035	3	20	9	277	400	3303	326	1,502	180	117	47	0	563	241	5	376	121	74	25	23,054
Tricolored Blackbird	0	0	220	80	0	0	151	80	50	20	2	0	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	903
Western Meadowlark	38	155	114	35	1	96	70	21	2	27	16	89	36	121	94	52	135	6	254	58	38	35	48	29	8	117	73	0	2	22	3	0	1795
Yellow-headed Blackbird	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	13
Brewer's Blackbird	15	26	832	100	81	0	0	116	216	77	0	5	1,000	3	45	11	238	408	97	0	61	74	33	39	5	26	66	0	0	0	2	0	3,576
Great-tailed Grackle	0	22	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	6	0	1	0	0	0	0	0	0	0	0	35
Brown-headed Cowbird	9	2	75	0	3	0	11	0	0	0	0	0	10	0	0	0	0	400	59	0	2	2	9	0	0	2	0	0	2	9	2	2	599
Bullock's Oriole	5	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	8
House Finch	167	2	36	4	23	8	15	0	27	0	0	6	2	1	41	8	33	1	94	1	0	36	17	0	0	22	0	7	9	33	27	19	639
Lesser Goldfinch	28	0	0	0	6	2	0	2	0	0	0	0	0	0	0	0	9	0	12	0	0	2	0	0	0	0	0	0	0	3	4	1	69
American Goldfinch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4
House Sparrow	6	1	2	0	0	0	4	0	9	1	0	2	0	1	0	0	2	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	50

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