

APRIL 2022



Biological Effectiveness Monitoring for the  
**Natomas Basin Habitat  
Conservation Plan Area**



*t h e*  
**NATOMAS**  
**BASIN**  
*c o n s e r v a n c y*

FINAL



**FINAL**

**BIOLOGICAL EFFECTIVENESS MONITORING  
FOR THE NATOMAS BASIN  
HABITAT CONSERVATION PLAN AREA  
2021 ANNUAL SURVEY RESULTS**

**PREPARED FOR:**

The Natomas Basin Conservancy  
2150 River Plaza Drive, Suite 460  
Sacramento, CA 95833  
Contact: John Roberts, Executive Director  
916.649.3331

**PREPARED BY:**

ICF  
980 9th Street, Suite 1200  
Sacramento, CA 95814  
Contact: Douglas Leslie  
916.737.3000

**April 2022**



ICF. 2022. *Biological Effectiveness Monitoring for the Natomas Basin Habitat Conservation Plan Area 2021 Annual Survey Results*. March. Final. (ICF 104332.) Sacramento, CA. Prepared for the Natomas Basin Conservancy, Sacramento, CA.



# Contents

---

List of Tables .....	iv
List of Figures.....	vi
List of Acronyms and Abbreviations.....	ix
<b>Chapter 1 Introduction.....</b>	<b>1-1</b>
1.1 Background .....	1-1
1.1.1 Location .....	1-2
1.1.2 Setting .....	1-2
1.2 The Biological Effectiveness Monitoring Program.....	1-3
1.2.1 Goals and Objectives .....	1-3
1.2.2 Covered Species .....	1-3
1.2.3 Types of Monitoring .....	1-3
1.3 Summary of the 2021 Biological Effectiveness Monitoring Program Results .....	1-5
1.4 References .....	1-6
<b>Chapter 2 Land Cover Mapping, Botanical Inventory, and Noxious Weed Monitoring.....</b>	<b>2-1</b>
2.1 Introduction .....	2-1
2.1.1 Background.....	2-1
2.1.2 Goals and Objectives .....	2-1
2.2 Methods.....	2-2
2.2.1 Land Cover Mapping .....	2-2
2.2.2 Botanical Surveys .....	2-3
2.2.3 Noxious Weed Mapping.....	2-3
2.3 Results.....	2-4
2.3.1 Land Cover Types Basin-Wide .....	2-4
2.3.2 Land Cover Types on Reserves .....	2-5
2.3.3 Noxious Weed Surveys.....	2-6
2.3.4 Botanical Surveys .....	2-6
2.4 Discussion .....	2-7
2.4.1 Land Cover Types Basin-Wide .....	2-7
2.4.2 Land Cover Types on Reserves .....	2-7
2.4.3 Botanical Surveys .....	2-7
2.4.4 Noxious Weeds.....	2-8
2.5 Effectiveness .....	2-8
2.6 Recommendations .....	2-8

2.7	References .....	2-9
<b>Chapter 3 Giant Gartersnake .....</b>		<b>3-1</b>
3.1	Introduction .....	3-1
3.1.1	Background.....	3-1
3.1.2	Goals and Objectives .....	3-2
3.1.3	Life History.....	3-3
3.1.4	History of the Natomas Basin.....	3-5
3.2	Methods.....	3-5
3.2.1	Trapping Giant Gartersnake .....	3-5
3.2.2	Analytical Methods.....	3-7
3.2.3	Habitat Assessment.....	3-10
3.2.4	Radio-Telemetry Translocation Study .....	3-11
3.2.5	American Bullfrog Capture-Mark-Recapture Study .....	3-11
3.3	Results.....	3-12
3.3.1	Demography .....	3-13
3.3.2	Distribution of Giant Gartersnake on Reserve Lands .....	3-15
3.3.3	Habitat Assessment.....	3-16
3.3.4	Radio-Telemetry Translocation Study .....	3-20
3.3.5	American Bullfrog Capture-Mark-Recapture Study .....	3-21
3.4	Discussion .....	3-21
3.4.1	Demography .....	3-21
3.4.2	Distribution of Giant Gartersnake on Reserve Lands .....	3-24
3.5	Effectiveness .....	3-26
3.6	Recommendations.....	3-28
3.7	References .....	3-29
<b>Chapter 4 Swainson’s Hawk .....</b>		<b>4-1</b>
4.1	Introduction .....	4-1
4.1.1	Background.....	4-1
4.1.2	Goals and Objectives .....	4-2
4.1.3	Life History.....	4-2
4.2	Methods.....	4-4
4.2.1	Population Assessment .....	4-4
4.2.2	Habitat Assessment.....	4-4
4.3	Results.....	4-4
4.3.1	Population Assessment .....	4-4
4.3.2	Habitat Assessment.....	4-6
4.4	Discussion .....	4-7

4.5	Effectiveness .....	4-9
4.6	Recommendations .....	4-10
4.7	References .....	4-11
<b>Chapter 5 Other Covered Wildlife Species .....</b>		<b>5-1</b>
5.1	Introduction .....	5-1
5.1.1	Background .....	5-1
5.1.2	Goals and Objectives .....	5-2
5.2	Methods .....	5-2
5.2.1	Surveys on Reserves .....	5-2
5.2.2	Surveys on SAFCA Reserves .....	5-3
5.2.3	Non-Reserve Land Surveys .....	5-3
5.2.4	Analytical Methods .....	5-3
5.3	Results .....	5-4
5.3.1	Generalized Avian Surveys .....	5-4
5.3.2	Other Covered Species .....	5-8
5.4	Discussion .....	5-13
5.5	Effectiveness .....	5-15
5.6	Recommendations .....	5-15
5.7	References .....	5-17
 <b>Appendix A NBHCP Reserve Land Cover Data</b>		
<b>Appendix B Botanical Survey Results</b>		
<b>Appendix C Avian and Other Covered Species Survey Results</b>		

# Tables

---

## Tables appear at the end of the chapter in which they are referenced

1-1	Reserve Lands Acquired under the NBHCP at the beginning of the 2021 Effectiveness Monitoring Season.....	1-7
1-2	Species Covered under the NBHCP.....	1-8
2-1	Basin-Wide Extent (acres) of Mapped Land Cover Types, 2005–2021.....	2-11
2-2	Basin-Wide Summary of Major Habitat Types, 2005–2021.....	2-12
2-3	On-Reserve Extent (acres) of Mapped Land Cover Types, 2005–2021 .....	2-13
2-4	On-Reserve Summary of Major Habitat Types, 2005–2021 .....	2-14
2-5a	On-Reserve Extent of Major Habitat Types as a Proportion of Each Habitat Type in the Basin, 2005–2014.....	2-15
2-5b	On-Reserve Extent of Major Habitat Types as a Proportion of Each Habitat Type in the Basin, 2015–2021.....	2-15
2-6	Noxious Weed Occurrences on TNBC Reserve Lands, 2005–2021 .....	2-16
3-1	Summary of Giant Gartersnake Captures and Sampling Effort at Natomas Basin Conservancy Reserves, 2021.....	3-33
3-2	Prior Probabilities for Parameters of Single-Season Occupancy Models for Giant Gartersnake on Natomas Basin Conservancy Reserve Properties, 2021 .....	3-34
3-3	Model-Averaged Posterior Distributions for Capture Parameters of Closed Abundance Model of Giant Gartersnake in the Natomas Basin, 2021 .....	3-35
3-4	Summary of Giant Gartersnake Captures and Abundance Estimates, 2021 .....	3-35
3-5	Posterior Summaries for Parameters from the Robust-Design CMR Model, 2018–2021 .....	3-35
3-6	Posterior Model Probabilities for Probability of Occurrence of Giant Gartersnake Based on Habitat on Natomas Basin Conservancy Reserves, 2021 .....	3-36
3-7	Posterior Distributions for Parameters of the Final Single-Season Occupancy Habitat Model for Giant Gartersnake on Natomas Basin Conservancy Reserve Properties, 2021 .....	3-36
3-8	Posterior Model Probabilities for Effects of Habitat on Dynamic Occupancy of Giant Gartersnake on Natomas Basin Conservancy Reserves, 2011–2021.....	3-37
3-9	Date of Capture, Microbrand, Location of Capture, and Status for Radio-Tagged Giant Gartersnakes in 2021 .....	3-37
4-1	Results of 2021 Swainson’s Hawk Surveys, NBHCP Area.....	4-14

4-2	Reproductive Data for Active Swainson’s Hawk Territories in the NBHCP Area, 1999–2021 .....	4-18
4-3	Number of Active Territories on the Sacramento River, 2001–2021 .....	4-19
4-4	Swainson’s Hawk Foraging Habitat in the NBHCP Area (acres), 2004–2021 .....	4-19
4-5	Extent and Proportion of Suitable Swainson’s Hawk Foraging Habitat on and off TNBC Reserve Lands, 2021 .....	4-19
5-1	Summary of Results of Monthly Avian Surveys by Reserve and Tract, 2018–2021 .....	5-18
5-2	Number of Pairs of Other Covered Species on TNBC Mitigation Lands, 2004–2021 .....	5-19
5-3	Average Number of Observations per Survey of Other Covered Species Recorded during Monthly Avian Surveys on Reserves, 2005–2021 .....	5-20
5-4	Average Number of Observations per Survey of Other Covered Species Recorded during Monthly Basin-Wide Surveys, 2005–2021 .....	5-20

## Figures follow the tables in each chapter

- 1-1 Project Location
- 1-2 Natomas Basin
- 1-3 Central and Northern Basin Habitats
- 1-4 Riparian Habitats in the Northern Basin
- 1-5 Southern and Western Basin Habitats
- 1-6 Eastern Basin Habitats
- 2-1 Distribution of Land Cover Types in the Natomas Basin, 2021
- 2-2 Changes in Acreage of the Major Habitat Types in the Natomas Basin, 2004–2021
- 2-3 Sankey Canal Giant Gartersnake Tule Bench along the Northwest Edge of the Lucich North Tract in the North Basin Reserve
- 3-1 Giant Gartersnake
- 3-2 Areas Sampled for Giant Gartersnake in the Natomas Basin in 2021
- 3-3 Model Averaged Effect of an Ephemeral Behavioral Response and Snake Size on Giant Gartersnake Capture Probability in the Natomas Basin in 2021
- 3-4 Posterior Distribution of Estimated Giant Gartersnake Abundance in the Sampled Area at BKS Based on Closed Population Models in 2021
- 3-5 Posterior Distribution of Estimated Giant Gartersnake Abundance in the Sampled Area at Sills Based on Closed Population Models in 2021
- 3-6 Posterior Distribution of Estimated Giant Gartersnake Abundance in the Sampled Area at Lucich North Based on Closed Population Models in 2021
- 3-7 Posterior Distribution of Estimated Giant Gartersnake Abundance in the Sampled Area at Lucich South Based on Closed Population Models in 2021
- 3-8 Posterior Distribution of Estimated Giant Gartersnake Abundance in the Sampled Area at SAFCA Wetlands Based on Closed Population Models in 2021
- 3-9 Distribution of Male and Female Snout-Vent Length (A) and Mass (B) in the Natomas Basin, 2021
- 3-10 Annual Apparent Survival Estimate for Giant Gartersnake in the BKS Tract, 2018-2021



- 3-11 Annual Apparent Survival Estimate for Giant Gartersnake in the Lucich North Tract, 2018-2021
- 3-12 Annual Apparent Survival Estimate for Giant Gartersnake in the Sills Tract, 2018-2021
- 3-13 Number of Occupied Sites Based on Static Occupancy Models for the Natomas Basin, 2021
- 3-14 Effect of Reserve Area and Presence of Rice on the Probability of Occurrence of Giant Gartersnake in the Natomas Basin, 2021, Based on the Static Occupancy Model with Uninformative Priors
- 3-15 Effect of (A) Water Temperature and (B) Date on the Detection Probability of Giant Gartersnake in the Natomas Basin, 2021
- 3-16 Annual Probability of Occurrence of Giant Gartersnake on Reserves Based on the Dynamic Occupancy Model
- 3-17 Estimated Number of Sampled Reserve Sites Occupied by Giant Gartersnake
- 3-18 Annual Intrinsic Rate of Occupancy Growth for Giant Gartersnake in Reserves, 2011-2021
- 3-19 Suitability of Habitat in the Canals of the Natomas Basin for Giant Gartersnake in 2021
- 4-1 Swainson’s Hawk
- 4-2 Swainson’s Hawk Range
- 4-3 Swainson’s Hawk Nesting and Foraging Habitat
- 4-4 General Representation of Swainson’s Hawk Breeding Cycle in the Central Valley
- 4-5 Swainson’s Hawk in the Nest
- 4-6 Number of Occupied Swainson’s Hawk Nesting Territories, Successful Nests, and Total Young Fledged in the Natomas Basin, 2001–2021
- 4-7 Trends in the Number of Occupied Territories in the Natomas Basin Nesting Population, 2001–2021
- 4-8 Various Measures of Swainson’s Hawk Reproductive Success in the Natomas Basin, 1999–2021
- 4-9 Trends in the Number of Young Fledged Per Successful Nest in the Breeding Population of Swainson’s Hawk in the Natomas Basin, 1999–2021
- 4-10 Number of Occupied Swainson's Hawk Nesting Territories along the Sacramento River in the Natomas Basin, 2001–2021
- 4-11 Changes in the Abundance of Three Categories of Swainson’s Hawk Foraging Habitat in the Natomas Basin, 2004–2021

- 4-12 Distribution of Suitable Swainson’s Hawk Foraging Habitat, 2021
- 5-1 Monthly Basin-Wide Survey Routes
- 5-2 Mean Number of Raptors Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2021
- 5-3 Mean Number of Waterfowl Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2021
- 5-4 Mean Number of Neotropical Migrants Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2021
- 5-5 Mean Number of Shorebirds Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2021
- 5-6 Mean Number of Yellow-Billed Magpies and Canada Geese Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2021
- 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, 2005–2021
- 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, 2005–2021
- 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, 2005–2021
- 5-10 Mean Number of Burrowing Owls Detected and the Proportion of Surveys on which Owls were Detected on TNBC Reserves in the Natomas Basin, 2005–2021
- 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, 2005–2021

# 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
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

*This Page Intentionally Left Blank*

### CHAPTER HIGHLIGHTS

- 2021 marked the 18th 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 2021 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).<sup>1</sup> 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

---

<sup>1</sup> 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 2021, TNBC owned and operated 34 separate tracts totaling approximately 4,633 acres (1,875 hectares) in the Basin (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).

In addition, TNBC has managed several additional tracts of land purchased by the Sacramento Area Flood Control Agency (SAFCA) as mitigation. Three of the largest tracts consist of created emergent marsh habitats (i.e., AKT, Sharma, and Natomas Farms West tracts). These three tracts, in addition to the giant gartersnake dispersal canal, were monitored by the BEMT using the same protocols as TNBC mitigation lands, and the results of that monitoring are included in this annual report.

### 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 2021 Biological Effectiveness Monitoring Program Results

This section summarizes the 2021 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 2020 to 2021 were relatively minor, with a slight decrease in rice and upland agriculture, with a concomitant increase in fallow lands, created emergent wetlands, and developed lands.

The sampling effort for giant gartersnake was increased in 2021 compared to 2020, but was still lower than other previous years due to poor air quality from wildfires and issues related to the COVID-19 pandemic. The trapping season was shortened (May–August) in 2021, but the time spent sampling each trapline was increased and the number of sites sampled was increased from 2020. The number of snakes caught per unit effort was the lowest since 2018, but higher than years prior to 2018. The size distribution of captured snakes in 2021 was consistent with a healthy population. Estimates of occupancy declined between 2020 and 2021, although the probability that the proportion of occupied sites was stable (i.e., did not change by more than 10%) from 2011 to 2021 was approximately 98%.

Estimates of demographic parameters became possible this year after revising the sampling protocol in 2018. Apparent survival of giant gartersnakes on the BKS tract was higher in 2018–2019 than in subsequent years.

Updates and preliminary information are provided on the status of two additional studies being implemented on TNBC reserves, one on the interactions between bullfrogs and giant gartersnakes and another translocating giant gartersnakes from the Central Basin Reserve to the Fisherman's Lake Reserve.

The total number of Swainson's hawk pairs in the Basin declined substantially from 2020 to 2021, but was still above the average over the monitoring period and the total number of pairs continues to exhibit a statistically significant increase over time. However, most measures of reproductive success declined substantially after rebounding from a previous decline, and a statistically significant decline in the number of young fledged per successful nest over the entire monitoring period is still evident.

The mean number of loggerhead shrike (*Lanius ludovicianus*) detections per survey on reserve lands decreased again in 2021. 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*) nested on the Willey Wetlands Preserve in 2021 with approximately 400 to 600 pairs. Both the mean number of detections per survey and the proportion of surveys with detections increased in 2021 on both reserve and non-reserve lands. Ibis appear to be thriving in the Basin.

Tricolored blackbirds (*Agelaius tricolor*) did not nest in the Basin in 2021 after nesting successfully for the first time in 9 years in 2020. While the mean number of detections per survey on reserve lands decreased from 2020 to 2021, the proportion of surveys in which the species was detected on reserve lands increased. On non-reserve lands, both the mean number of detections per survey and the proportion of surveys on which tricolored blackbirds were detected decreased. 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 2020 to 2021.

The mean number of Pacific Pond Turtle (*Actinemys marmorata*) detections decreased slightly in 2021. However, this species is now 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. 2021. Current Preserve Map. Available: <https://www.natomasbasin.org/helpful-documents/preserve-maps/>. Accessed: February 9, 2020.

**Table 1-1. Reserve Lands Acquired under the NBHCP at the Beginning of the 2021 Effectiveness Monitoring Season<sup>a, b</sup>**

Reserve/Tract	Date Acquired	Acres
<b>North Basin Reserve</b>		
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 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
<b>Central Basin Reserve</b>		
Betts	4/5/99	139
Bianchi West	11/7/06	110
Elsie	11/7/06	158
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
<b>Fisherman's Lake Reserve</b>		
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
<b>Total</b>		<b>4,633</b>

Source: The Natomas Basin Conservancy 2021.

<sup>a</sup> Includes only properties owned by TNBC in fee title. Does not include 27.08 acres under easement.

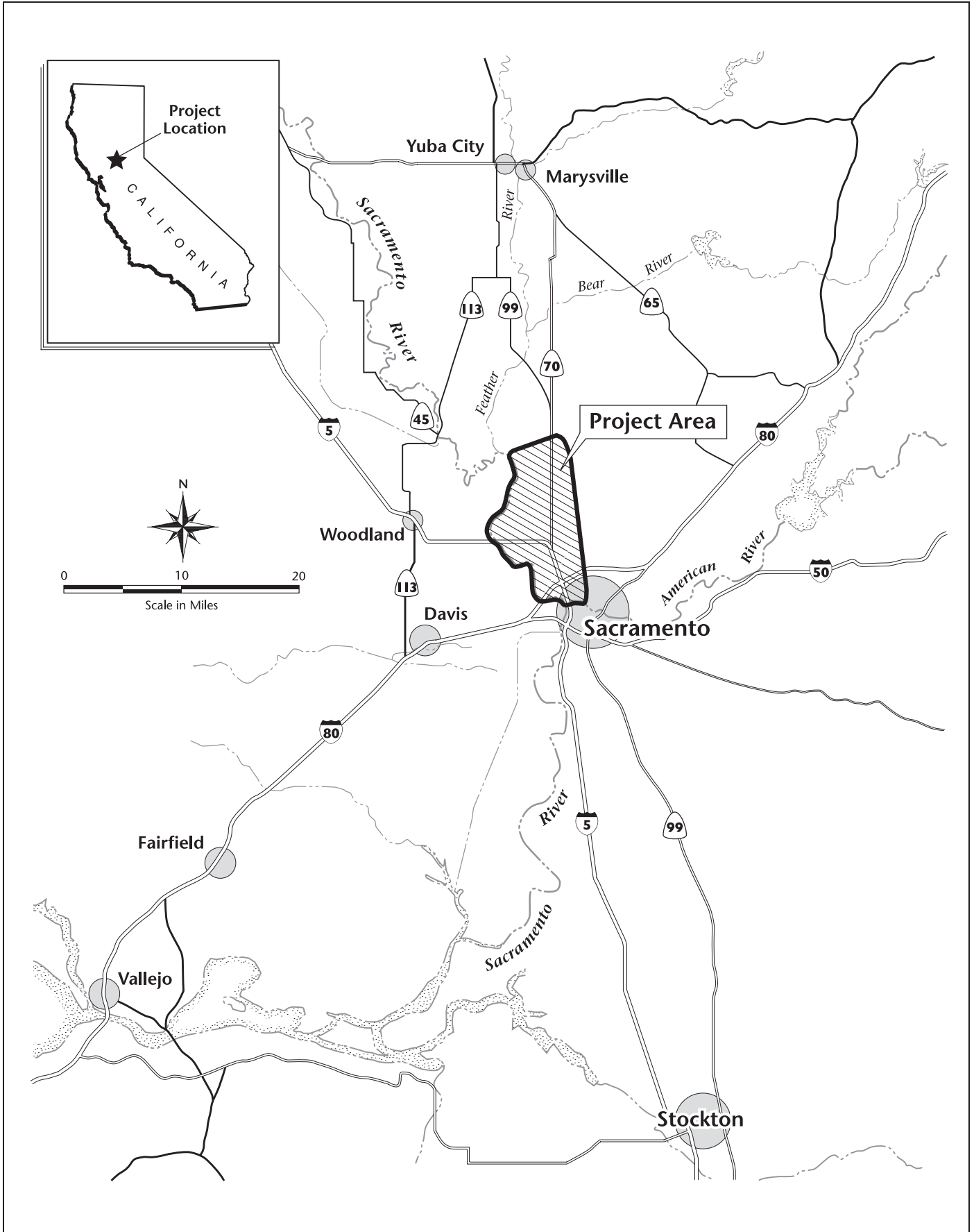
<sup>b</sup> Acreage totals gathered through land cover mapping and GIS analysis may vary slightly.

**Table 1-2. Species Covered under the NBHCP**

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

<sup>a</sup> Formerly Aleutian Canada goose (*Branta canadensis leucopareia*).

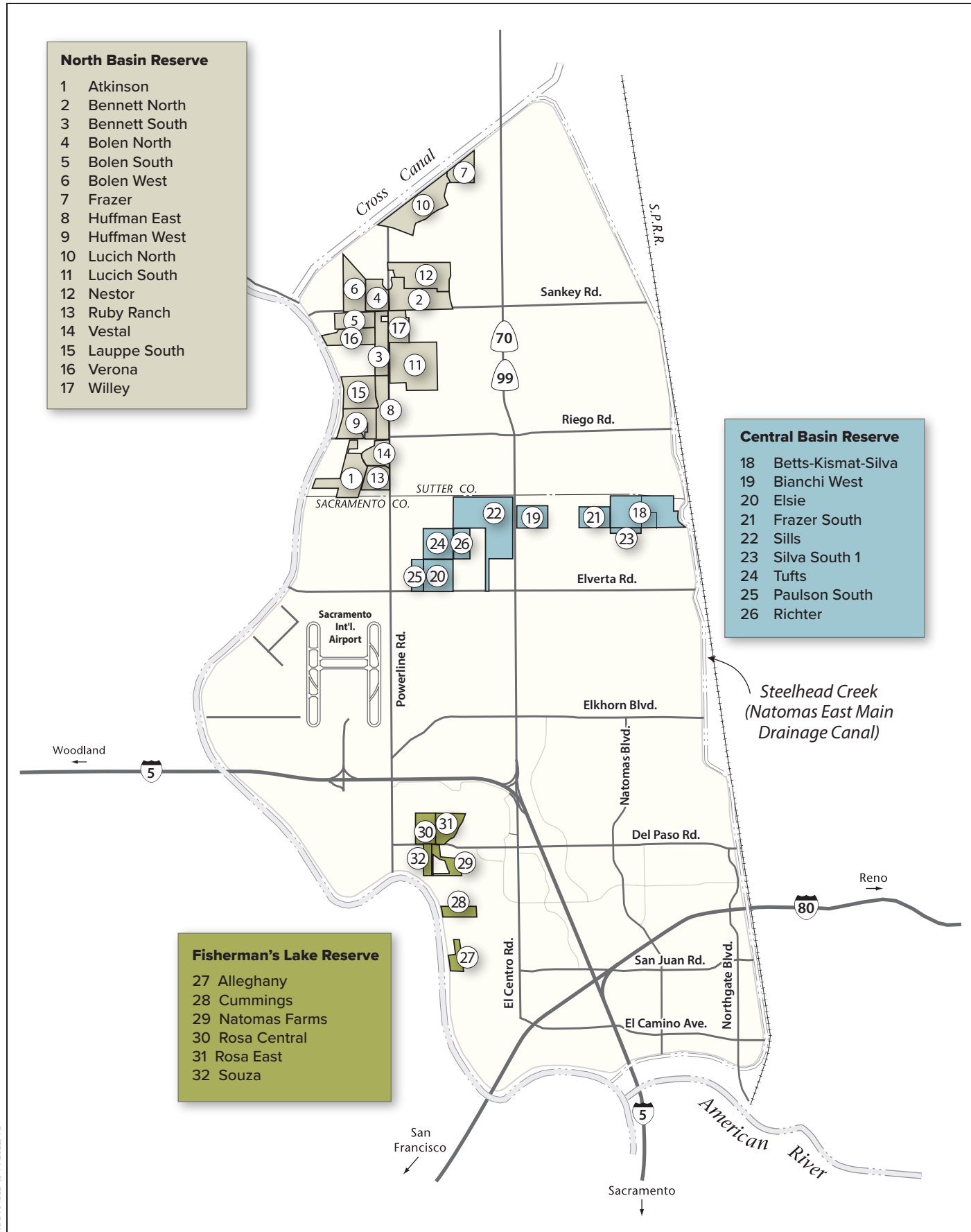




Graphics ... 890.10 NBC 3-11-2021) TAG



**FIGURE 1-1**  
Project Location



NBC104332 (3-14-2022).TG



**FIGURE 1-2**  
Natomas Basin



Typical habitat of the central and northern Natomas Basin



Natomas Cross Canal





Fisherman's Lake



Mature riparian forest along the Sacramento River



Typical habitat of the west and south Natomas Basin



Residential development in the south basin





Typical habitat of the east basin



Steelhead Creek (formerly the Natomas East Main Drain Canal)



# Chapter 2

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

---

### CHAPTER HIGHLIGHTS

- Across the plan area, rice and upland agriculture habitats decreased very slightly from 2020, while fallow lands, managed marsh, and developed lands increased.
- High-density developed areas have increased substantially over the last 3 years.
- Marsh and wetland habitat increased by 199 acres.
- Management of noxious weeds continues to be effective at containing highly invasive species with the potential to decrease habitat values such as perennial pepperweed and evening primrose.
- No covered plant species were detected, and vernal pools did not pond long enough in 2021 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 Game 2009). 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 September 2021 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 2021). 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 2021. 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.

- Active rice fields continue to dominate the landscape. Rice decreased by approximately 498 acres in 2021, covering 37.4% of the Basin in 2020 and 36.4% of the Basin in 2021.
- Managed marsh/wetlands acres increased in 2021 by approximately 198 acres due to development of the wetland created as mitigation for the Brookfield development.
- Upland agricultural lands decreased by approximately 53 acres, covering 16.3% of the Basin in 2020 and 16.2% in 2021.
- Grassland habitats decreased by 2 acres as a result of continued development.
- Fallow lands increased by 180 acres between 2020, covering 6.0% of the Basin in 2020 and 6.3% of the Basin in 2021.

The most significant long-term changes in land and habitat values over the last 9 years continues to be driven by construction of the NLIP, which to date has been coordinated by SAFCA. The project included improvements to the Sacramento River levee system that protects the Basin and the purchase, creation, and management of natural habitats to mitigate the effects of project implementation on Covered Species. The project involved construction of a new setback levee using soil from borrow sites on the Souza and Natomas Farms tracts of the Fisherman's Lake Reserve, as well as other sites within the Basin. Lands affected by the project were classified in 2011 through 2013 as developed (the levee itself) or disturbed/bare (the borrow sites and construction areas). In 2014, construction of the new levee was completed south to the vicinity of Powerline Road, and the borrow sites on and immediately adjacent to reserve lands in the Fisherman's Lake Reserve that were converted to fresh emergent marsh are now considered suitable habitat for giant gartersnake and other Covered Species associated with wetland habitats. Revegetation programs within the

SAFCA NLIP project area have resulted in a Basin-wide increase of grassland (created), open water, valley oak woodland, riparian woodland, and fresh emergent marsh.

Construction of a new segment of the setback levee began in 2020 and will result in significant changes to land cover types in the coming years.

The acreage of developed lands remained relatively stable through 2019 primarily due to the moratorium on development issued in December 2008 out of concern for flood protection in the Basin. The moratorium was lifted in 2017. In 2020, developed—low density increased by 72 acres and developed—high density increased by 279 acres; approximately 158 acres of developed—low density were converted into developed—high density. In 2021, developed—low density decreased by 499 acres and developed—high density increased by 611 acres; approximately 164 acres of developed—low density were converted into developed—high density. 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., 1.8% 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 and now covers approximately 967 acres. 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 2020. 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.

### 2.3.1.1 Sankey Canal Giant Gartersnake Refugia Benches

The Natomas Mutual Water Company has constructed a bench of emergent wetland vegetation composed of tule (*Schoenoplectus acutus*) to provide habitat for giant gartersnake along the Sankey Canal adjacent to the north side of the Lucich North tract in the North Basin Reserve. This patch of habitat was monitored in 2021 during surveys for other Covered Species. Tule habitat was in good shape, and management to eliminate water primrose (*Ludwigia* spp.), an invasive nonnative plant that became established in 2020 and can compromise habitat values, proved mostly successful in the patch in 2021 (Figure 2-3).

### 2.3.2 Land Cover Types on Reserves

The total acreage of each land cover type mapped on reserves from 2005 to 2021 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 Richter, Lauppe South, Verona, Paulsen South, and Willey Reserves, the acreage of reserve lands increased by approximately 529 acres from 2020 to 2021. This resulted in an increase in both rice and upland agricultural habitats on reserve lands. Upland agricultural habitats increased by 175 acres and rice increased by 262 acres. However, the proportion of reserve lands composed of these two land cover categories remained approximately the same.

Table 2-5 summarizes the major habitat types on reserves as a proportion of those habitats in the entire Natomas Basin. In 2021, reserve lands accounted for 41.7% of the managed marsh/wetlands in the Basin, but only 13.2% of the rice lands and 9.2% 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 Brookfield 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 2021 are summarized in Table 2-6.

A total of 74 new weed occurrences were documented in 2021: 1 tree of heaven (*Ailanthus altissima*), 15 bull thistle (*Cirsium vulgare*), 11 yellow star-thistle (*Centaurea solstitialis*), 9 stinkwort (*Dittrichia graveolens*), 1 occurrence of licorice (*Glycyrrhiza glabra*), 3 perennial pepperweed (*Lepidium latifolium*), 8 harding grass (*Phalaris aquatica*), 17 milk thistle (*Silybum marianum*), 3 Himalayan blackberry (*Rubus armeniacus*), 4 Italian thistle (*Carduus pycnocephalus*), and 2 edible fig (*Ficus carica*).

Conversely, a total of 50 weed occurrences documented in 2020 were not found in 2021: 11 bull thistle, 4 harding grass, 2 Himalayan blackberry, 4 milk thistle, 3 pennyroyal (*Mentha pulegium*), 3 stinkwort, 5 tree of heaven, and 18 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 are giant reed (*Arundo donax*) and small smutgrass (*Sporobolus indicus*) on the BKS tract; perennial pepperweed on the Bennett South, BKS, Bolen South, Cummings, and Lucich North tracts; and Himalayan blackberry and evening primrose species (*Ludwigia* sp.) on multiple tracts. 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, and other invasive and undesirable species using mechanical means (e.g., pulling, mowing, changing and managing water levels) and chemical means (e.g., herbicide applications) has been very effective historically. Water primrose, mosquito fern, 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 2021. 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

3 years to allow for vernal pool–dependent plants to germinate. The cumulative list of plant species recorded on each tract through the 2021 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 and (2) the implementation of the NLIP, which resulted in a substantial increase in grasslands and managed marsh/wetland habitats. High-density development has been increasing steadily since the moratorium on development was lifted in 2008.

The resumption of rice agriculture in areas fallowed in 2006 and the increase in managed marsh/wetland habitats in the Basin resulting from the creation of managed marsh 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. Another factor has likely been the anticipation of opportunities to develop, which lead some landowners to fallow their fields. Rainfall that occurs late in the season has also likely resulted in some rice lands being fallowed, particularly in 2017 and 2019.

### 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 2021, active rice fields on reserve lands constituted 13.2% of the Basin-wide total, an increase from 11.6% in 2020. Upland agriculture on reserve lands accounted for approximately 9.2% of the upland agriculture in the Basin in 2021, an increase from 6.8% from 2020.

### 2.4.3 Botanical Surveys

A cumulative total (2005–2021) of 386 plant species from 72 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 78 species (20% of the total), the sunflower family (*Asteraceae*) with 52 species (13%), the bean family (*Fabaceae*) with 22 species, and the mustard family (*Brassicaceae*) with 19 species. Three additional families are represented by more than 10 species each: the sedge family (*Cyperaceae*), the figwort family (*Scrophulariaceae*), and the dock family (*Polygonaceae*).

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 2020, consisting of Harding grass, tree of heaven, licorice, and milk thistle. 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 other land management and weed control contractors hired by TNBC have been effective in ensuring that management actions are implemented in a timely fashion. Education of land management personnel—who are routinely working in habitats sensitive to weed infestations—has probably been the most effective method of identifying and controlling noxious weed infestations. 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, waterfern, perennial pepperweed, 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

- Baldwin, B. G., D. H. Goldman, D. J. Keil, R. Patterson, T. J. Rosatti, and D. H. Wilken (eds). 2012. *The Jepson Manual: Vascular Plants of California*, second edition, revised. Berkeley, CA: University of California Press.
- CalFlora. No date. Information on Wild California Plants. Available: <https://calflora.org/>. Accessed: May–August 2021.
- California Department of Fish and Game. 2009. *Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities*. California Natural Resources Agency. Sacramento, CA.
- Hickman, J. C. (ed.). 1993. *The Jepson Manual*. Berkeley, CA: University of California Press.
- Jepson Flora Project (eds.) 2021. Jepson eFlora. University of Berkeley, Berkeley, California. Available: <http://ucjeps.berkeley.edu/IJM.html>. Accessed May–August 2021.

*This page intentionally left blank*

**Table 2-1. Basin-Wide Extent (acres) of Mapped Land Cover Types, 2005–2021**

Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Rice	22,321	14,792	14,590	14,224	15,014	15,023	15,287 <sup>a</sup>	16,956	19,001	20,104	20,796	20,482	16,329	19,092	17,442	20,256	19,758
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
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
Irrigated grassland	452	374	451	373	378	345	746	750	757	757	352	326	326	311	311	310	314
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 <sup>f</sup>	7,570	7,571	6,220	5,271
Wheat	1,824	2,375	1,104	804	3,919	695	585	413	440	978	650	1,192	383	172	792	705	321
Milo	0	328	211	161	0	0	0	0	155	94	0	0	0	303	104	111	289
Tomatoes	50	145	112	113	8	10	0	0	0	108	63	40	0	51	261	175	389
Sunflower	709	572	0	251	166	804	714	362	821	903	388	519	355	464	181	55	443
Safflower	886	532	244	426	162	214	278	322	0	29	448	426	345	511	196	262	193
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
Orchard	184	184	184	99	99	94	53	50 <sup>b</sup>	50	307 <sup>d</sup>	406 <sup>d</sup>	406	406	480	480	482	463
Fresh emergent marsh (created)	575	575	676	897	897	897	897	897	897	1,042	1,042	1,042	1,042	1,042	1,042	1,042	1,199
Fresh emergent marsh	138	154	154	155	155	155	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
Grassland (created)	49	71	68	74	74	80	74	75	469 <sup>c</sup>	511	511	511	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
Ruderal	329	406	409	399	704	747	864	766	754	856	946	924	824	814	801	661	639
Valley oak woodland	191	195	192	192	194	209	240	242	257	248	261	322 <sup>e</sup>	322	322	322	340 <sup>i</sup>	341
Live oak woodland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38 <sup>h</sup>	34 <sup>h</sup>	28
Mixed oak woodland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11 <sup>i</sup>	11
Riparian woodland	348	346	357	357	354	359	357	398	398	393	389	390	393	393	393	393	407
Riparian scrub	117	117	114	133	133	133	133	133	133	134	134	138	138	138	137 <sup>g</sup>	137	137
Non-riparian woodland	52	50	51	51	51	29	28	43	43	43	28	28	26	26	26	43 <sup>i</sup>	43
Open water	352	340	340	337	337	360	381	387	490	459	459	462	462	462	462	462	462
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
Developed—high density	9,859	10,764	11,533	11,304	11,260	10,910	10,770 <sup>a</sup>	10,604	10,529	10,533	10,505	10,539	10,753	10,868	11,191	11,470	12,081
Disturbed/bare	1,440	1,127	578	573	291	2,321	1,659	1,243	744	58	63	62	62	58	55	81 <sup>j</sup>	177
Vineyard	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19
<b>Total</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>	<b>54,206</b>

<sup>a</sup> 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.  
<sup>b</sup> 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.  
<sup>c</sup> Increase in grassland (created) due to conversion of disturbed/bare by SAFCA.  
<sup>d</sup> Increase in orchard due to conversion of land west of the airport from row crops to orchard in 2014 and 2015.  
<sup>e</sup> Increase in valley oak woodland due to establishment of woodland planted during the SAFCA revegetation of the setback levee.  
<sup>f</sup> 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.  
<sup>g</sup> Small swath of riparian scrub along a canal was developed for housing.  
<sup>h</sup> Maturation of live oak woodland plantings along freeway off-ramps; acreage was refined in 2020  
<sup>i</sup> Maturation of woodlands along off-ramps.  
<sup>j</sup> 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, 2005–2021**

Habitat Type <sup>a</sup>	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
	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	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 <sup>b</sup>	28.2 <sup>b</sup>	16,956	31.3	19,001	35.1	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
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	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
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	11,601	21.4	11,771	21.7	11,890	21.9	11,084 <sup>d</sup>	20.4	11,777	21.7	10,488 <sup>e</sup>	19.3	8,837	16.3	8,784	16.2
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 <sup>c</sup>	4,961	9.2	4,344	8.0	4,157	7.7	4,364 <sup>d</sup>	8.0	4,257	7.8	4,193	7.7	4,043	7.5	4,041	7.4
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	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
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 <sup>b</sup>	26.8 <sup>b</sup>	14,049	25.9	13,581	25.1	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
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	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
<b>Total</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,206</b>	<b>100</b>	<b>54,247</b>	<b>100</b>

<sup>a</sup> 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.

<sup>b</sup> 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.

<sup>c</sup> Increase in grassland (created) due to conversion of disturbed/bare by SAFCA.

<sup>d</sup> 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.

<sup>e</sup> 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, 2005–2021**

Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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
Fallow	820	593	727	373	375	450	668	348	177	206	64	214	643	58	558	144	213
Alfalfa	106	106	150	150	204	127	126	259	204	348	348	348	143	143	88	161	335
Irrigated grassland	0	96	0	0	4	5	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 <sup>f</sup>	356	145	241	136
Wheat	207	497	77	79	132	187	58	58	58	58	47	74	11	23	299	204	71
Milo	0	0	49	0	0	0	0	0	155	94	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
Sunflower	0	0	0	0	0	104	116	84	56	50	0	0	29	104	0	0	204
Safflower	0	0	0	0	104	0	68	11	0	0	0	23	41	0	0	0	0
Other row crops	10	157	279	472	26	32	27	6	27	0	37	59	132	127	28	23	58
Fresh emergent marsh (created) <sup>a</sup>	561	561	627	627	627	627	627	627	627	627	627	627	627	627	627	627	627
Fresh emergent marsh	2	2	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
Grassland (created)	47	76	76	72	72	72	71	72	72	73	73	73	67 <sup>f</sup>	67	67	67	52
Nonnative annual grassland	318	225	254	254	254	254	254	228	226	226	226	203	203	203	203	203	204
Ruderal	38	33	29	29	29	28	25	25	25	36	36	36	47	47	42	44	34
Valley oak woodland	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5 <sup>g</sup>	6
Riparian woodland	13	13	12	12	12	12	12	12	12	12	12	12	12	12	12	12	9
Riparian scrub	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
Open water	0	0	0	0	0	0	0	0	20 <sup>c</sup>	20	20	20	20	20	20	20	22
Developed—low density	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1
Developed—high density	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Disturbed/bare	0	0	0	0	0	0	63 <sup>b</sup>	47	11	0	0	0	0	0	0	0	0
<b>Total<sup>d</sup></b>	<b>3,835</b>	<b>3,931</b>	<b>4,154</b>	<b>4,154</b>	<b>4,154</b>	<b>4,124<sup>b</sup></b>	<b>4,124</b>	<b>4,082<sup>b</sup></b>	<b>4,112<sup>e</sup></b>	<b>4,112</b>	<b>4,112</b>	<b>4,112</b>	<b>4,112</b>	<b>4,112</b>	<b>4,112</b>	<b>4,112</b>	<b>4,593</b>

<sup>a</sup> 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.

<sup>b</sup> Acreage change from previous years is due to the SAFCA NLIP.

<sup>c</sup> 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.

<sup>d</sup> 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.

<sup>e</sup> Acreage increase is due to the acquisition of the Silva South 1 tract.

<sup>f</sup> 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.

<sup>g</sup> Valley oaks were removed as a part of levee improvements and maintenance.

**Table 2-4. On-Reserve Summary of Major Habitat Types, 2005–2021**

Habitat Type	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% of Reserve Lands	Acres	% 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	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	1,819.7	44.3	2,262.2	55.0	2,000.1	48.6	2,343.9	57.0	2,606	56.7
Managed marsh/wetlands	569	14.8	569	14.4	631	15.2	631	15.2	631	15.2	631	15.2	630	15.3	631	15.4	631	15.3	630	15.3	630	15.3	630.1	15.3	630.1	15.3	630.1	15.3	630.1	15.3	630.1	15.3	630	13.7
Upland agriculture	342	8.9	875	22.3	691	16.7	916	22.1	627	15.1	594	14.4	452	11	502	12.3	647	15.7	591	14.4	591	14.4	560	13.6	651 <sup>e</sup>	15.8	794	19.3	560.2	13.6	629.6	15.3	805	17.5
Grassland	403	10.5	334	8.5	359	8.6	355	8.5	355	8.5	331	8.02	350	8.5	325	8.0	323	7.8	334	8.1	334	8.1	312	7.6	317 <sup>e</sup>	7.7	317	7.7	312	7.5	314.0	7.6	290	6.3
Fallow	820	21.4	593	15.1	727	17.5	373	9.0	375	9.0	450	10.9	668	16.2	348	8.5	177	4.3	206	5.0	64	1.5	214	5.2	643	15.6	58	1.4	558.0	13.6	144.0	3.5	213	4.6
Developed	5	0.1	5	0.1	5	0.1	5	0.1	5	0.1	5	0.1	68 <sup>b</sup>	1.6	51	1.2	16	0.4	5	0.1	5	0.1	5	0.1	5	0.1	5	0.1	5	0.1	5	0.1	6	0.1
Other	25	0.7	26	0.7	25	0.6	25	0.6	25	0.6	54	0.8	26	0.6	25	0.6	45	1.1	140	3.4	46	1.1	46	1.1	46	1.1	46 <sup>f</sup>	1.1	46	1.1	44.9	1.1	43	0.9
<b>Total<sup>c</sup></b>	<b>3,835</b>	<b>100</b>	<b>3,931</b>	<b>100</b>	<b>4,154</b>	<b>100</b>	<b>4,154</b>	<b>100</b>	<b>4,154</b>	<b>100</b>	<b>4,124<sup>b</sup></b>	<b>100</b>	<b>4,124</b>	<b>100</b>	<b>4,082<sup>b</sup></b>	<b>100</b>	<b>4,112<sup>d</sup></b>	<b>100</b>	<b>4,112</b>	<b>100</b>	<b>4,112</b>	<b>100</b>	<b>4,112</b>	<b>100</b>	<b>4,112</b>	<b>100</b>	<b>4,112</b>	<b>100</b>	<b>4,112</b>	<b>100</b>	<b>4,112</b>	<b>100</b>	<b>4,593</b>	<b>100</b>

<sup>a</sup> 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.

<sup>b</sup> Acreage change from previous years is due to the SAFCA NLIP.

<sup>c</sup> 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.

<sup>d</sup> Acreage increase is due to the acquisition of the Silva South 1 tract.

<sup>e</sup> "Other" acreage reported incorrectly as 0 acres in 2018; acreage fixed in this report.

<sup>f</sup> 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**

Habitat Type	2005			2006			2007			2008			2009			2010			2011			2012			2013			2014		
	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	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	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	834	68.2	631	936	67.3	631	1,157	54.5	69.6	569	834	68.2	631	936	67.3	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	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	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	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	355	5,461	6.5	319	4,902	6.5	319	4,252	7.5	312	4,193	7.4	314.0	7.8	
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	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	13,531	0	5	13,817	0	5	13,826	0	0	5	13,531	0	5	13,817	0	5	13,826	0	5	12,929	0.0	5	13,062	0.0	5	14,246	0.0	5	0.0	
Other	1,233	2.1	25	1,239	2	25	1,169	2.1	2	26	1,233	2.1	25	1,239	2	25	1,169	2.1	46	1,204	3.8	46	1,399	0	46	1,860	2.5	44.9	3.2	
<b>Total</b>	<b>54,206</b>	<b>7.3</b>	<b>4,154</b>	<b>54,206</b>	<b>7.6</b>	<b>4,154</b>	<b>54,206</b>	<b>7.7</b>	<b>7.1</b>	<b>3,931</b>	<b>54,206</b>	<b>7.3</b>	<b>4,154</b>	<b>54,206</b>	<b>7.6</b>	<b>4,154</b>	<b>54,206</b>	<b>7.7</b>	<b>4,112</b>	<b>54,206</b>	<b>7.6</b>	<b>4,112</b>	<b>54,206</b>	<b>7.6</b>	<b>4,112</b>	<b>54,206</b>	<b>7.6</b>	<b>4,112</b>	<b>54,206</b>	<b>7.6</b>

**Table 2-5b. On-Reserve Extent of Major Habitat Types as a Proportion of Each Habitat Type in the Basin, 2015–2021**

Habitat Type	2015			2016			2017			2018			2019			2020			2021		
	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	11.7%	2,344.4	20,482	11.4	1,820	16,329	11.1	2,262	19,092	11.8	2,000.1	17,442	11.5	2,343.9	20,256	11.6	2,606	19,758	13.2
Managed marsh/wetlands	630	1,311	48.1%	630.1	1,311	48.1	630	1,311	48.1	630	1,311	48.1	630	1,311	48.1	630.1	1,311	48.1	630	1,468	42.9
Upland agriculture	591	11,771	5.0%	560	11,850	4.7	651 <sup>s</sup>	11,089	5.9	794	11,782	6.7	560.2	10,488	5.3	629.6	9,319	6.8	805	8,784	9.2
Grassland	334	4,344	7.7%	312	4,157	7.5	319 <sup>s</sup>	4,902	6.5	319	4,252	7.5	312	4,193	7.4	314.0	4,043	7.8	290	4,041	7.2
Fallow	64	1,366	4.7%	214	1,712	12.5	643	6,442	10.0	58	3,307	1.8	558	4,667	12.0	144.0	3,234	4.5	213	3,414	6.2
Developed	5	12,878	0.0%	5	12,907	0.0	5	12,929	0.0	5	13,062	0.0	5	14,246	0.0	5	14,623	0.0	6	14,831	0.0
Other	46	1,740	2.6%	46	1,787	2.6	46	1,204	3.8	46	1,399	0	46	1,860	2.5	44.9	1,420.2	3.2	43	1,909	2.3
<b>Total</b>	<b>4,112</b>	<b>54,206</b>	<b>7.6%</b>	<b>4,112</b>	<b>54,206</b>	<b>7.6</b>	<b>4,112</b>	<b>54,206</b>	<b>7.6</b>	<b>4,112</b>	<b>54,206</b>	<b>7.6</b>	<b>4,112</b>	<b>54,206</b>	<b>7.6</b>	<b>4,112</b>	<b>54,206</b>	<b>7.6</b>	<b>4,593</b>	<b>54,206</b>	<b>8.5</b>

**Table 2-6. Noxious Weed Occurrences on TNBC Reserve Lands, 2005–2021**

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
<b>North Basin Reserve</b>																		
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
	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	-	-
Bennett North	Harding grass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T
	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	-	
	Bull thistle	-	-	-	-	-	1, L	-	1, L	2, T	3, T	2, T	1, T	1, T	-	-	-	
Bennett South	Harding grass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T
	Bull thistle	-	-	-	-	-	-	-	2, L	-	-	1, L	-	1, T	2, T	-	-	1, T
	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	-
Bolen North	Italian thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, H
	Perennial pepperweed	1, M	1, L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Himalayan blackberry	1, T	1, T	-	-	-	-	-	-	-	-	-	-	-	-	-	1, D	1, L
	Yellow star-thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Bull thistle	-	-	-	-	-	3, L	2, L	2, L	1, T	2, T	1, T	3, T	-	1, L	6, T-M	3, T-L	5, T-M
	Italian thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, M
	Milk thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T
Bolen South	Himalayan blackberry	5, L-H	5, L	-	-	-	2, M	2, M	-	-	-	-	-	3, T-L	1, M	-	-	1, 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	-
	Milk thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2, T	-
	Italian thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2, L-M
Frazer	Bull thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T	1, T	2, T
	Stinkwort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T	3, L-T	4, T
	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	-	-
	Milk thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, M	6, T-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
	Himalayan blackberry	1, M	1, M	-	-	-	-	1, M	-	-	-	-	-	2, T	-	-	-	-
	Bull thistle	-	-	2, T	3, T	3, T	-	-	1, L	-	2, T	-	1, L	-	-	-	-	-
	Milk thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T	-
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	-
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
	Edible fig	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T	1, T	1, L	2, T
	Pennyroyal	-	-	-	-	-	-	-	1, M	1, M	1, M	1, M	1, M	2, T-L	-	-	-	-
	Italian thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T	-	1, L
	Stinkwort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10, T-M	1, T	5, T-L
	Milk thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6, T-D	17, T-M
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
	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	-	-	-	-	-
Nestor	Bull thistle	-	-	-	-	-	-	1, L	-	-	-	-	1, T	-	-	-	-	-
	Yellow star-thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	1, L	-	-	-
	Himalayan blackberry	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, M	-
Ruby Ranch	Yellow star-thistle	1, T	1, T	-	-	1, L	-	1, L	-	1, T	-	1, L	2, T	-	-	-	-	-
	Italian thistle	-	-	1, H	1, H	1, M	-	-	-	-	-	1, T	-	-	-	-	-	-
Verona	Yellow star-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
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	-
	Himalayan blackberry	-	-	1, M	1, M	1, M	-	-	-	-	-	-	-	1, T	-	-	-	-
	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	-	-	-	-
Willey	Bull thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, M
<b>Central Basin Reserve</b>																		
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
	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	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	-	-	-	-	-	-	-	-	-	-
	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
	Licorice	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, M	2, L, H
	Harding grass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, L
Bianchi West <sup>b</sup>	Harding grass <sup>b</sup>	-	-	-	-	-	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	-
Elsie	Yellow star-thistle	-	-	-	-	-	-	2, T	1, M	2, T	-	2, T	1, T	-	-	-	-	-
	Stinkwort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T	-
Frazer South	Stinkwort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2, T-L	1, T	-
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	-
	Bull thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T	-
Tufts	Yellow star-thistle	1, M	1, M	-	-	-	-	-	-	-	-	1, M	-	-	-	-	-	-
<b>Fisherman's Lake Reserve</b>																		
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 <sup>b</sup>	-	-	1, L	1, L	1, L	-	-	-	-	-	-	-	-	-	-	-	-
	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	-
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	-	-	-
	Bull thistle	-	-	-	-	-	-	-	-	1, T	2, M	3, L	1, T	-	-	5, L-T	1, T	-
	Stinkwort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, T	-	-
	Harding grass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3, L-M	1, L
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
	Harding grass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10, L-M	9, T-M
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
	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
Tree of Heaven	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, L	

**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
Souza	English ivy	1, D	1, M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Himalayan blackberry	-	-	1, L	1, L	1, L	-	-	-	-	-	-	-	1, H	2, L-M	-	-	-
	Bull thistle	-	-	1, L	1, L	1, L	1, L	-	1, L	2, L	3, T	-	2, T	-	-	-	-	-
	Harding grass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1, L	-

<sup>a</sup> 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.

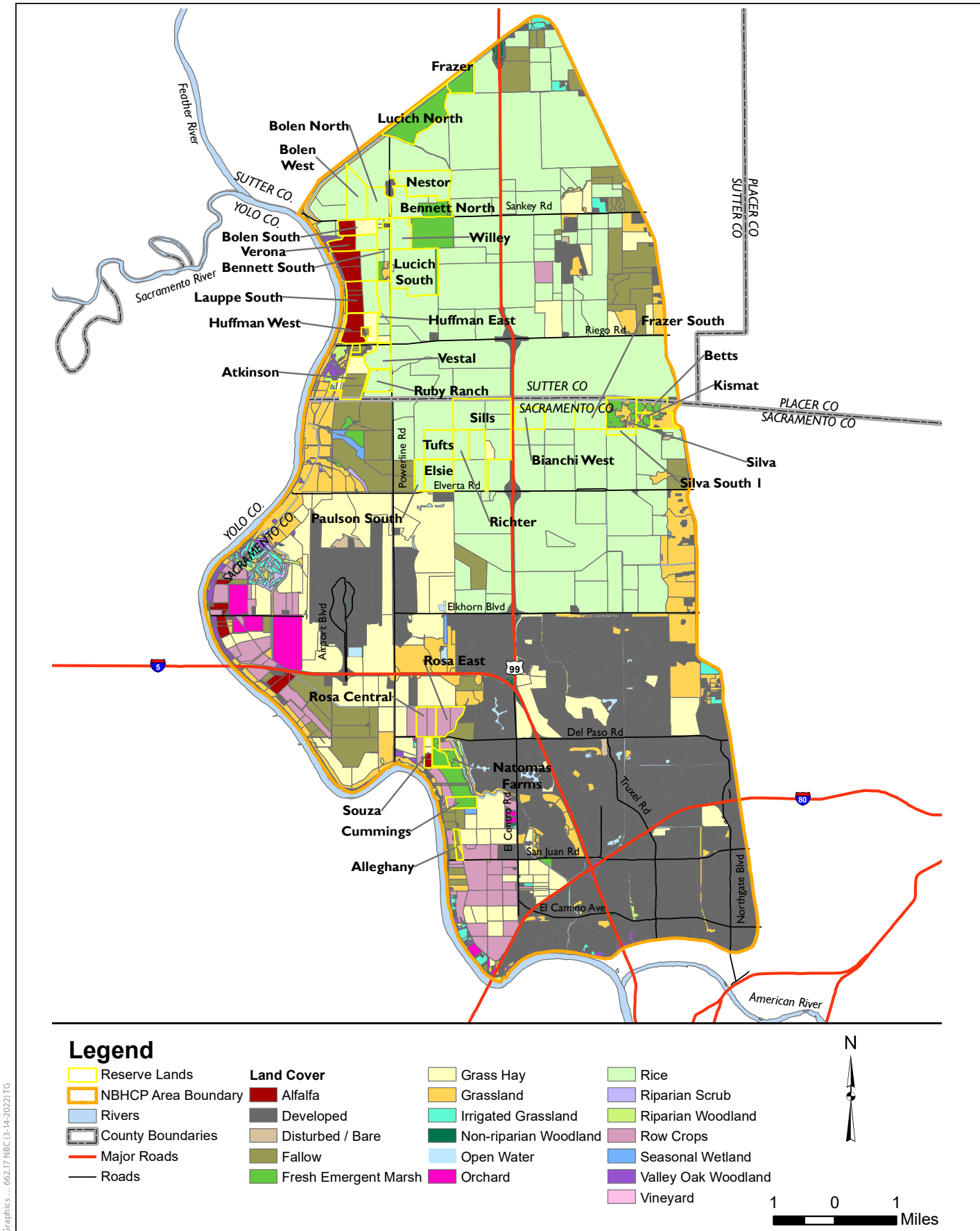
L = Low (occasional plants): 1–5% cover.

M = Moderate (scattered plants): 5–25% cover.

H = High (fairly dense): 25–75% cover.

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

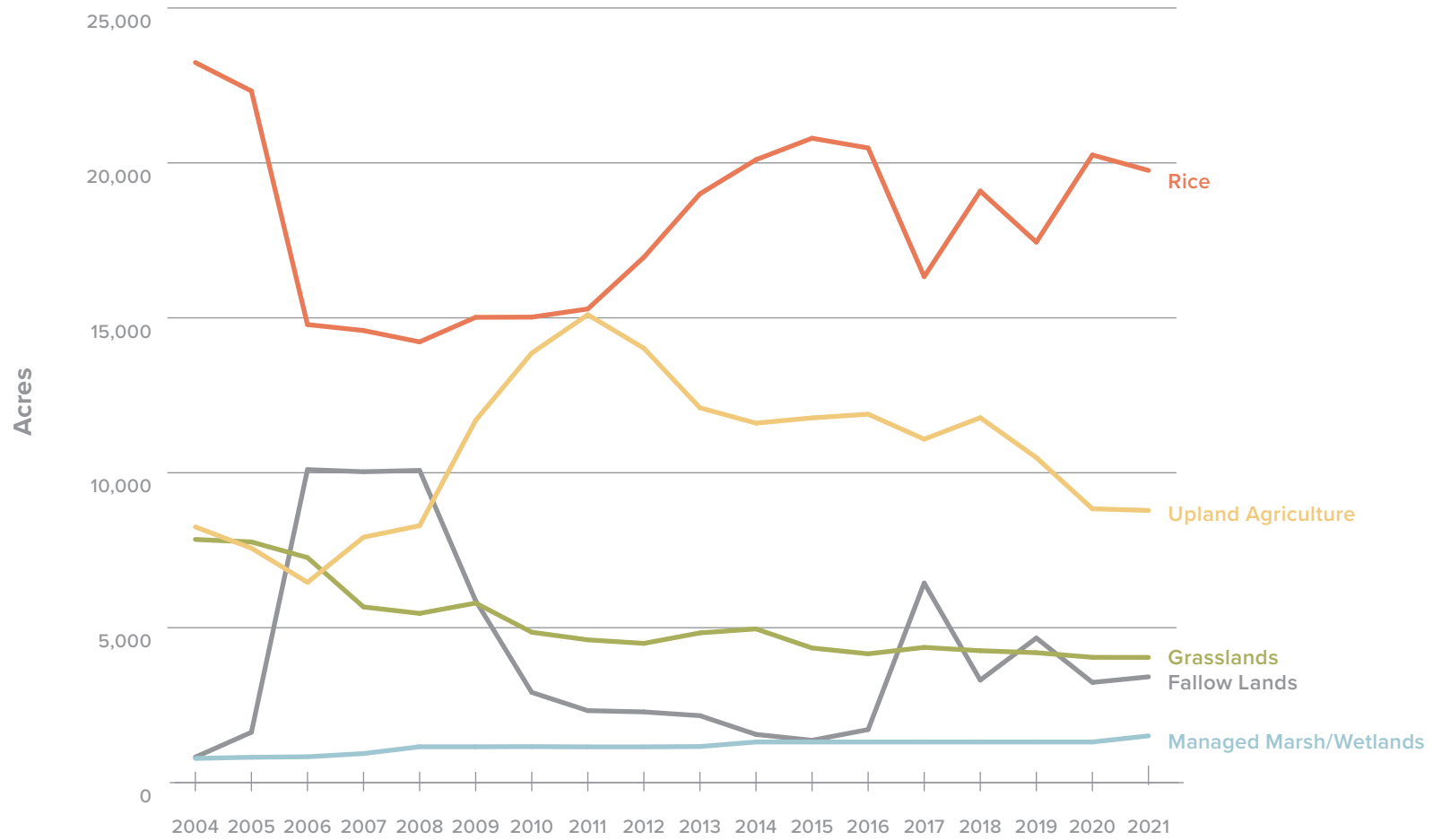
<sup>b</sup> Harding grass was not tracked in 2018 and 2019 because the species did not demonstrate an invasive distribution in the reserves. After several more occurrences were detected in 2020, vegetation monitoring efforts resumed tracking Harding grass.



Graphics... 662,17 NBC (3-14-2022) TG



**FIGURE 2-1**  
Distribution of Land Cover Types in the Natomas Basin, 2021



**FIGURE 2-2**  
Changes in Acreage of the Major Habitat Types in the Natomas Basin, 2004–2021





Graphics ... 662,17 NBC (3-9-2021) TG



**FIGURE 2-3**  
Sankey Canal Giant Gartersnake Tule Bench along the Northwest Edge of the Lucich North Tract in the North Basin Reserve

*This Page Intentionally Left Blank*

### CHAPTER HIGHLIGHTS

- Sampling effort was increased in 2021 compared to 2020, but was reduced overall compared to 2011–2019, due to poor air quality from wildfires and issues related to the COVID-19 pandemic.
- The trapping season was shortened (May–August) in 2021, but we sampled longer at each trapline compared to 2020; the number of sites sampled also increased from 40 in 2020 to 45 in 2021.
- Catch per unit of effort was lower than in 2020. The size distribution of captured snakes in 2021 was consistent with a healthy population. Estimates of occupancy declined between 2020 and 2021, although the probability that the proportion of occupied sites was stable (i.e., did not change by more than 10%) from 2011 to 2021 was approximately 98%.
- Apparent survival of giant gartersnakes at BKS was higher from 2018–2019 than in subsequent years.
- Recommendations to enhance management of giant gartersnake populations throughout the Basin and on reserve lands include (1) creating more managed marsh; (2) enhancing 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 and promoting rice agriculture; and (5) continued monitoring of translocated and repatriated populations of giant gartersnakes.

## 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. However, several years of data are required to estimate demographic parameters under the new sampling regime. This is the first year where the requisite time-series data (i.e.,  $\geq 4$  intervals) have been acquired to allow comparing estimates of demographic parameters using open population models.

### 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 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 immigrate 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 Sierrae*). 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 2015).

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<sup>1</sup> = 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 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

---

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

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. Given what is known today about the historic range of giant gartersnake, 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, and 45 sites in 2021. In 2020 and 2021, we dealt with substantial challenges caused by the COVID-19 pandemic. In 2021, we faced additional obstacles such as adverse air quality due to wildfires, heat waves, and drought causing low water levels. The start date of our field season was delayed to implement and 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. In 2021 we were able to resume 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. Furthermore, we allocated additional sampling effort in the southern basin (i.e., Fisherman's Lake reserve) in 2021 to monitor giant gartersnakes translocated in previous years. Despite these caveats, our total number of sampled sites was higher than in 2021, although still lower than the number sampled in previous years. 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 (including SAFCA Wetlands and Dispersal Canal sites) as a whole. 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 (16 sites in the North Basin Reserve, 13 sites in the Central Basin Reserve, and 16 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 2021, 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 13, 2021) until August 31, 2021. Unlike

occupancy sampling in previous years (2011–2017), trapping continued at a site for the full time-period regardless of whether snakes were captured or not. Due to unhealthy air conditions caused by the Dixie, Caldor, and Cache fires, all active traplines were deactivated from August 6 to August 9, and sampling did not take place on Memorial Day and Independence Day.

For sites that were sampled as “occupancy traplines” in previous years, transects were generally placed in the same location in 2021; 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 2021 differed from the areas sampled from 2011 to 2017. From 2011 to 2017, three transects were placed at each demography sampling location. 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 in 2020 and 2021 only two “old” demography traplines (BKS 2 and 3) were sampled, along with three of the five additional traplines from 2018 and 2019. At Lucich North, no “old” demography traplines were sampled in all 4 years, but seven additional traplines were sampled at wetlands within this tract in 2018 and 2019, with four of these additional traplines sampled in 2021. Within Lucich South, one of the three “old” demography traplines (Lucich South 3) was sampled from 2018–2021, along with two additional traplines in canals in 2018 and 2019, with one of these additional canal traplines sampled in 2020. On the Natomas Farms tract, one “old” demography trapline (Natomas Farms 1) was sampled from 2018–2020, and two “old” demography traplines (Natomas Farms 2 and 3) were sampled in 2021, along with one additional wetland trapline in 2018 and 2019 but no additional traplines in 2021. On the Sills tract, two “old” demography traplines (Sills 2 and 3) were sampled in 2018 and 2019 while no “old” demography traplines were sampled in 2021; however, traplines were placed in three additional canals in all 3 years. These changes meant that a broader area was sampled at most of the old demography sites (except for in 2020 where the entire study was truncated), although some areas that were sampled from 2011 to 2017 were not covered by trap arrays from 2018 to 2020. As noted above, these changes have ramifications for modeling giant gartersnake demography and interpreting changes in abundance estimates, 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 vegetation, floating 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. 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 g), 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 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, except for an adult female and two juveniles, all captured in the SAFCA wetlands. The adult was a telemetry snake that was temporarily removed from the field for radio transmitter removal. Following a 1-week post-surgery recovery period, she was returned to her location of capture. The two juveniles were temporarily removed from the field to be assessed for radio transmitter implantation, but were deemed too small and returned to their locations of capture (see Section 3.2.4, *Radio-Telemetry Translocation Study*, below).

## 3.2.2 Analytical Methods

All 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 symmetric 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).<sup>2</sup> A site is defined as the area between two water control structures. However, for the purposes of this analysis, a site refers to the area sampled by the traplines at each reserve tract. Closed population models are those that assume no emigration out of or immigration into 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.<sup>3</sup> 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 in close proximity to one another, two 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. Given that 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 2021, abundance estimates for these tracts from 2018 to 2021 are not directly comparable to previous years.

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 2021, 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 2021.

---

<sup>2</sup> 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).

<sup>3</sup> 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 5 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).

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 2021.

We calculated estimates of apparent survival using capture-mark-recapture data each year from 2018 to 2021 at three tracts (BKS, Lucich North, and Sills) that had greater than 15 individual giant gartersnakes captured over this time period. All other tracts had fewer than 15 individuals captured over the period from 2018 to 2021. We estimated apparent survival ( $\phi$ ) using a robust-design capture-mark-recapture model designed to give unbiased estimates of survival by accounting for availability of individuals for capture (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.<sup>4</sup>

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.<sup>5</sup> 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.<sup>6</sup> Sexual size dimorphism in SVL and mass was examined throughout the Basin using separate means and variances for males and females. These tests are equivalent to t-tests with unequal variances (Kéry 2010).<sup>7</sup> 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 2021 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

---

<sup>4</sup> The robust-design model used uninformative Beta(1,1) prior distributions for the probabilities of apparent survival ( $\phi$ ), recapture ( $p$ ), and availability on site during sampling ( $\gamma$ ). 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  $\phi$ ,  $p$ , and  $\gamma$ . 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 4 independent chains of 50,000 iterations each after a burn-in of 5,000 iterations. Each chain was thinned by a factor of 10, resulting in a final posterior sample of 20,000 iterations.

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

<sup>6</sup> 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.

<sup>7</sup> Each model was run on 5 independent chains of 20,000 iterations after a burn-in of 2,000; each chain was thinned by a factor of 5. 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.

vegetation, floating 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). Two versions of the occurrence model were fit that differed only in the detection component of the model.

- One version with uninformative priors that assumed no prior information exists on the effects of covariates on the probability of detecting giant gartersnake.
- One version that used information from previous U.S. Geological Survey studies (2003–2009; Halstead et al. 2011b) that included information on the effects of water temperature, date, and unexplained site heterogeneity on the detection probability component of the model (Table 3-2).<sup>8</sup>

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 2021. 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.<sup>9</sup> 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.

## 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.

---

<sup>8</sup> 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 5 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.

<sup>9</sup> All probabilities were given U(0,1) priors. The dynamic occupancy model was run on 5 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).



### 3.2.3.2 Habitat Connectivity

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

### 3.2.4 Radio-Telemetry Translocation Study

In 2021, we continued studying the effects of translocation on the movement, survival, and habitat selection of wild-caught and captive-reared giant gartersnakes. Although no new adult snakes were collected for radio transmitters, we did attempt to collect large enough juveniles (> 55 g body mass) from the Fisherman's Lake area, and we also attempted to recollect any snakes already implanted with radio transmitters from previous seasons.

We tracked the snakes remaining from previous seasons three to five times per week during the active season (April–August) until they were recollected for radio transmitter removal. When located, a GPS point was taken at the location and weather, temperatures, and vegetation characteristics of the location and of a random location (within 50 meters of the snake location) were noted. Also recorded were additional behavioral observations if snakes could be visually observed at the time of location. We aimed to recollect snakes 1 year after their transmitter implantation surgeries, which is the average battery life of the transmitters. Snakes were transported to the Sacramento Zoo where veterinary staff assessed the snakes' health, performed X-radiography to determine reproductive status, and surgically removed radio transmitters using standard methods for snakes (Reinert and Cundall 1982). We captured two juvenile snakes in the Fisherman's Lake area but, after examination by the Sacramento Zoo veterinary staff, both were deemed too small for implantation of radio transmitters and were subsequently released at their sites of capture.

After radio transmitters were removed, the recollected giant gartersnakes were held in captivity for at least 1 week for post-surgical recovery, monitoring, and administration of medication. Recollected giant gartersnakes were then released at their sites of capture. We did not translocate any new snakes in 2021.

In 2021, we increased our trapping efforts in the Natomas Farms and SAFCA wetlands areas. Each of the four Natomas Farms sites (three wetlands, one canal) and each of the eight SAFCA wetlands were trapped for 3 weeks each. We also trapped at three of the Cummings wetlands at the southern end of the wetland complex. Our aim with this intensified trapping was to recapture any captive-born or captive-reared juvenile snakes released at these sites in 2020 and previous seasons.

### 3.2.5 American Bullfrog Capture-Mark-Recapture Study

Resolving conflicting ecological management goals is a challenge that includes the issue of whether to remove invasive species (i.e., the American bullfrog [*Lithobates catesbeianus*]; hereafter *bullfrog*) that imperiled species (i.e., giant gartersnake) heavily depend upon. Such a conundrum exists between conserving the threatened giant gartersnake and planning removal of bullfrog, identified as one of the "world's 100 worst invasive species" (Lowe et al. 2004) in California. On the one hand, large adult bullfrogs are predators of juvenile giant gartersnakes and of the snakes' preferred prey, the native Sierran treefrog. On the other hand, giant gartersnake heavily relies on larval and small

post-metamorphic bullfrogs as prey, especially where Sierran treefrogs are scarce or locally extirpated (Ersan 2015). Bullfrogs are often targeted for removal in California, but it is unknown how bullfrog removals should be planned to facilitate giant gartersnake recovery while minimizing unanticipated consequences. For example, eradication of bullfrogs may deplete prey for the snakes; selectively removing large adult bullfrogs can temporarily reduce predation on juvenile snakes, but it also reduces cannibalism among bullfrogs and can result in an overcompensatory increase (Zipkin et al. 2009) in overall bullfrog abundance (Govindarajulu et al. 2005), with concomitant effects on giant gartersnake in the long term. Understanding what determines the net effect (positive or negative) of bullfrogs on giant gartersnake across all life stages of each species will help resolve the conflicting management goals of removing bullfrogs and facilitating the recovery of giant gartersnake. Therefore, in 2019 a study was initiated to assess (1) whether bullfrog removal will improve demographic rates of giant gartersnake and, if so, (2) identify the stages and sizes of bullfrogs that should be removed in order to maximize the recovery rate of giant gartersnake populations.

To address these questions, between 2019 and 2021 CMR studies were performed on bullfrogs in three BKS wetland units (BKS South Central 1, BKS Southwest Central, and BKS Northeast) in the Central Basin, where CMR on giant gartersnake has also been conducted. We sampled bullfrogs under a robust design that accounts for temporary emigration (Riecke et al. 2018), as we did for giant gartersnakes, but with shorter primary and secondary periods for sampling. CMR on bullfrogs was conducted for 20 days (three primary periods of 6 or 7 days of secondary periods), between July and September each year. We surveyed for bullfrogs between 8 p.m. and 1 a.m. each night, using hand-held spotlights, dip nets, and modified minnow traps. We processed the captured bullfrogs by injecting PIT tags, measuring their snout-urostyle-length (SUL) and mass, and determining their sex. For large bullfrogs that might have consumed giant gartersnakes (e.g., >100 mm SUL), we also collected stomach contents by gently performing gastric lavages with a syringe filled with distilled water, connected to a soft silicone tube which was gently placed inside each frog's jaw. All bullfrogs were released back to their capture locations each night. From the three seasons of CMR data (nine primary periods), we plan to estimate monthly somatic growth and survival rates of bullfrogs. Ultimately, these vital rates will be combined with a model of giant gartersnake demography to investigate the effects of competition and predation on bullfrog and giant gartersnake population dynamics. This model can then be used to make predictions about the effects of alternative bullfrog control regimes (e.g., no removal, low-intensity removal, high-intensity removal) on giant gartersnake population growth.

### 3.3 Results

Overall, 153 individual giant gartersnake were captured 226 times by hand or trap at 45 sites on TNBC and SAFCA reserve tracts over the course of 46,567 trap days in 2021 (Table 3-1; Figure 3-2). The 2021 monitoring year had a larger number of trap days than 2020 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 0.0049 in 2021. For comparison, catch-per-unit effort was 0.0068 in 2020 when 147 individuals were captured 185 times; 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 0.0039 (0.0012–0.0095). The standard deviation of capture probability among sites (0.0021 [0.0005–0.0094]) was slightly lower than the standard deviation of capture probability among days (0.0025 [0.0008–0.0064]). There was less variation in capture probability among individuals (0.0018 [0.0002–0.0042]). There was evidence for a positive ephemeral behavioral response to capture, and some evidence for a positive effect of snake size on capture probability (Figure 3-3; Table 3-3).

Six instances of giant gartersnakes moving between traplines were detected in 2021. Five snakes were captured in multiple traplines within the Sills tract, and one snake was detected moving between a wetland in the BKS tract and a canal in the Frazer South 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 SAFCA wetland complex; one trapline in the Frazer South tract was grouped with traplines in the BKS tract), resulting in six demographic “clusters.” Estimates of abundance and non-spatially explicit density at each of the six demographic clusters where giant gartersnakes were captured are summarized in Table 3-4.

At the five traplines within the BKS cluster (including one trapline from Frazer South), 88 individuals were captured 124 times over 5,380 trap days in 2021 (Table 3-4). Of the 85 individuals captured 103 times at BKS in 2020 over 3,991 trap days, seven were recaptured in 2021. Five snakes captured at BKS in 2018 were recaptured in 2021, and three individuals first captured in 2019 were recaptured in 2021. The estimated abundance in sampled areas at BKS in 2021 was 200 (147–352) individuals, which also corresponds to the highest density of snakes detected at any of the six trapping locations where abundance could be estimated (Figure 3-4, Table 3-4). The estimated abundance at BKS was 566 (256–1,303) individuals in 2020 and 559 (374–944) individuals in 2019.

At four traplines within the Sills cluster (including one trapline in the Elsie tract), 36 individuals were captured 73 times over 4,178 trap days in 2021 (Table 3-4). For comparison, 39 individuals were captured 46 times at the Sills traplines in 2020, when traplines were trapped for 2,099 trap days. Of the 39 individuals captured at Sills in 2020, 10 were recaptured in 2021, including one snake first caught in the Elsie tract in 2020. The estimated abundance at Sills in 2021 was 74 (51–137), which corresponds to the third highest density of snakes out of the six sites where abundance could be estimated (Figure 3-5, Table 3-4). The estimated abundance at Sills in 2020 was higher, with an estimate of 258 (117–590) individuals. Notably, one individual originally captured and marked at Sills in 2018 was recaptured in 2021, and two individuals originally captured and marked at Sills in 2019 were recaptured in 2021.

At five traplines within the Lucich North cluster, 10 individuals were captured 14 times in 2021 over 5,241 trap days (Table 3-4). The estimated abundance at Lucich North in 2021 was 31 (19–55) individuals, which resulted in the lowest density estimate, given the extensive length of shoreline

sampled in this area (Figure 3-6, Table 3-4). In 2020, 15 individuals were captured 22 times at Lucich North. The estimated abundance of giant gartersnake at Lucich North in 2020 was 101 (43–234) individuals at five traplines. One individual captured at Lucich North in 2020 was recaptured in 2021, and two individuals first captured in 2019 were recaptured in 2021.

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 2021 was 23 (12–43) individuals, which corresponds with the third lowest density of snakes out of the six sites where abundance could be estimated (Figure 3-7, Table 3-4). The estimated abundance at Lucich South in 2021 was comparable to the 2020 estimate (24 [8–56]).

No giant gartersnakes were captured at four traplines in the Natomas Farms tract over 4,192 trap days in 2021. Likewise, in 2020 no giant gartersnakes were captured at one trapline in the Natomas Farm tract. In 2019, one giant gartersnake was captured at two traplines, while in 2018, no giant gartersnakes were captured at either trapline in the Natomas Farms tract. Under the previous study design, three traplines were sampled in the Natomas Farms area as part of the demography study. In 2017, two individuals were captured three times, in 2016 one individual was captured three times, and in 2015 one individual was captured once at Natomas Farms.

A total of eight traplines were sampled in the SAFCA wetlands in 2021, and three snakes were captured five times over 8,392 trap days in 2021. One snake was an adult female that had previously been part of the radio-telemetry translocation study (see Section 3.3.4, *Radio-Telemetry Translocation Study*). The other two snakes were males that were first captured and marked in 2021. The estimated abundance of giant gartersnake at the SAFCA wetlands in 2021 was 45 (27–86) individuals (Figure 3-8, Table 3-4).

The only other trapline at which a snake was captured was in the Huffman West tract, where two individuals were captured a total of three times. The median estimated abundance at Huffman West was 24 (13–44) individuals, and this trapline was estimated to have the second highest density of snakes (Table 3-4).

### 3.3.1.2 Size Distribution and Sex Ratio

The overall sex ratio of captured snakes in the Natomas Basin was close to 1, with a marginal female-bias. The sex ratio was 0.97 (0.68–1.33) males per female for all sites in the Basin combined. Basin-wide mean SVL was 562 mm (540–585 mm), and Basin-wide mean mass was 97.35 g (84.58–111.93 g). Mean female SVL (611 mm [577–645 mm]) was 100 mm (59–142 mm) greater than mean male SVL (511 mm [485–536 mm]), and mean female mass (131.76 g [107.88–160.45 g]) was 61.3 g (33.4–91.6 g) greater than mean male mass (70.81 g [59.44–84.27 g]); Figure 3-9).

### 3.3.1.3 Survival Estimates from 2018–2021

The daily recapture probability was slightly higher for female compared to male giant gartersnake, with 79% of posterior probability that  $p$  was greater for females than males (Table 3-5). Annual recapture probabilities, given 21 days of sampling at a site, were 0.11 (0.043–0.29) for female giant gartersnake and 0.084 (0.031–0.23) for male giant gartersnake. On average, survival was higher for male giant gartersnake than female giant gartersnake. There was support for a higher apparent survival rate for male giant gartersnake than female giant gartersnake, with 91% of the posterior distribution indicating males had higher survival. Apparent survival varied among years and sites.

At BKS, apparent survival was highest from 2018 to 2019 and lower from 2019 to 2020 and 2020 to 2021 (Figure 3-10). At Lucich North, apparent survival was similar over each of the year-long intervals (Figure 3-11). At the Sills tract, apparent survival estimates were consistently high each year from 2018 to 2021 (Figure 3-12). The probability a snake was available on site for capture ( $\gamma$ ) was nearly equal among the two sexes (Table 3-5).

### 3.3.2 Distribution of Giant Gartersnake on Reserve Lands

Giant gartersnakes were detected at 16 of 45 sites sampled in 2021 (Figure 3-2). Of the 35 sites surveyed in both 2020 and 2021, giant gartersnakes were detected at six sites in 2020 where no giant gartersnakes were detected in 2021. There were three sites where giant gartersnakes were detected in 2021 but had not been detected in 2020. Of the sites monitored, 20 (16–27) were estimated to be occupied based on uninformative priors; 20 (16–24) were estimated to be occupied based on informative priors (Figure 3-13).

Regardless of the prior probabilities used for the detection component of the occupancy model, there was a positive effect of rice on the probability of occurrence (Table 3-6). The probability that rice had an influence on the probability of occurrence was 0.90 with both uninformative and informative priors. Based on uninformative priors, the odds of a positive relationship between rice and the probability of occurrence was 125 times higher than the odds of a negative effect (Table 3-7; Figure 3-14). The effects of other variables on the probability of occurrence were not supported in 2021.

Regardless of the analysis, daily detection probabilities were positively related to water temperature and negatively related to date of sampling (Figure 3-15). The effects of both variables on detection probability were estimated with greater precision when prior information on the detection process was included in the analysis (Figure 3-15). Daily detection probabilities for giant gartersnake in 2021 at an occupied site on a day with average conditions (e.g., average water temperature) were 0.21 (0.04–0.39) for the model with uninformative priors and 0.14 (0.11–0.17) for the model with informative priors. 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 2021, of 0.99 (0.57–>0.99) from the uninformative model and 0.96 (0.92–0.98) from the informative model.

The probability of occurrence of giant gartersnake varied by reserve (i.e., North Basin, Central Basin, and Fisherman's Lake). Based on uninformative priors, the probability of occurrence in wetlands in the North Basin Reserve was 0.34 (0.08–0.66), the probability of occurrence in wetlands in the Central Basin Reserve was 0.66 (0.34–>0.99), and the probability of occurrence in wetlands in the Fisherman's Lake Reserve was 0.18 (0.02–0.341; Figure 3-14). Informative priors had little effect on estimates, which were 0.34 (0.10–0.63) in wetlands in the North Basin Reserve, 0.66 (0.33–>0.99) in wetlands in the Central Basin Reserve, and 0.18 (0.03–0.39) in wetlands in the Fisherman's Lake Reserve. Most sites in the Fisherman's Lake Reserve were wetland sites (15 of 16), whereas most sites in the Central Basin Reserve were rice sites (10 of 13), and sites were nearly evenly divided between the two types in the North Basin Reserve (10 of 16 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, and a decrease from 2019 to 2021. Large uncertainty in occupancy in 2011 encompassed the modal estimates from all later years (Figure 3-16). The number of occupied sampled sites followed a similar pattern, with a decrease

from 2019 to 2021 (Figure 3-17). 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 in 2020 and 2021 compared to the two previous years, due to decreasing the number of sites to 40 (2020) and 45 (2021) 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 but was higher in 2020 and 2021 (Figure 3-16). The annual probability that unoccupied sites were colonized exhibited no trend from 2011 to 2018, and it increased from 2018 to 2020 and decreased from 2020 to 2021 (Figure 3-16). The increase in colonization in 2020 may be partially explained by translocation studies described in Section 3.2.4, *Radio-Telemetry Translocation Study*. The mean intrinsic growth rate of occupancy from 2011 through 2021 was -0.064 (-0.100 to -0.022; Figure 3-18). Overall, although mean estimates of occupancy growth were slightly negative, credible intervals were close to zero, indicating occupancy was relatively stable from 2011 to 2021. Notably, there was clear evidence of positive occupancy growth from 2018 to 2019, with a mean intrinsic growth rate of occupancy of 0.095 (0.000–0.178). However, occupancy growth was most negative between 2019 and 2020, potentially because of the reduction in the number of sampled sites, and it rebounded slightly between the 2020–2021 period (Figure 3-18). The probability that the number of occupied sites was stable from 2011 through 2021 (less than 10% change; >0.98) was higher than the probability that the number of occupied sites decreased by more than 10% from 2011 through 2021 (<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, and 2020 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 in 2021 likely contributed to the lowest estimate of occupied sites.

There was neither support for effects of habitat on site-survival probabilities nor was there 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 and other emergent wetlands, the highest quality giant gartersnake habitat, constituted 13.7%<sup>10</sup> (630 acres) of the area of reserve properties but just 1.7% (838 acres) of non-reserve lands. TNBC reserves provided 43% 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 56.7% (2,606.4 acres) of the area of reserve properties compared to 34.6% (17,151.9 acres) of the non-reserve lands. Overall,

---

<sup>10</sup> 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.

3,236.2 acres (70.5%) of the total acres of TNBC reserve lands was potential giant gartersnake habitat, while only 36.3% (17,990.2 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. Because rice fields and their associated linear water conveyance features provide almost no giant gartersnake habitat for much of the year (September–June), the total amount of created marsh is a better measure of giant gartersnake habitat for comparison than the sum of created marsh and rice.

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 2021. No rice existed in the Fisherman’s Lake Reserve tracts in 2020. 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 2020, while the other five contained habitat suitable for giant gartersnake.

Tracts in the Central Basin Reserve cover approximately 1,474 acres. A total of 140 of these acres (9.5%) were created marsh in 2021, and 1,108 acres (75.2%) were rice in 2021. This represents an increase of 130 acres compared to the 978 acres (72.8%) of rice that existed in the Central Basin Reserve in 2020. Overall, 1,249.4 acres (84.8%) of the total acreage of the Central Basin Reserve was potential giant gartersnake habitat in 2021, although—as noted above—only created marsh and some canals associated with rice agriculture provide suitable habitat in all seasons. Of the nine tracts in the Central Basin Reserve, three (Richter, Paulsen South, and Silva South) contained only marginal habitat or no canal for giant gartersnake in 2021, while the other seven contained habitat suitable for giant gartersnake. Elsie and Tufts, which contained only marginal habitat in 2020, contained a mix of suitable and marginal habitat in 2021.

In 2021, tracts in the North Basin Reserve covered approximately 2,731 acres. A total of 414 of these acres (17.5%) were created marsh and 1,497.9 acres (54.8%) were in rice cultivation, an increase of 116.7 acres in rice compared to 2020. A total of 147.8 acres of the North Basin were fallowed rice fields in 2021. This represents an increase of 54.6 acres from the 93.2 acres that were classified as fallowed rice in 2020. Overall, 1,911.9 acres (70.0%) of the total acreage of the North Basin Reserve was potential giant gartersnake habitat in 2021. Of the 17 tracts in the North Basin Reserve, 16 contained suitable habitat for giant gartersnakes and one (Frazer North) contained only marginal habitat, based on the canals, for giant gartersnakes in 2021. Frazer North, however, was one of the five tracts (Bennett North, Bennett South, Frazer North, Lucich North, and Lucich South) that contained created marsh.

### 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 immigration and emigration play a role in population dynamics, potentially rescuing local populations from extirpation through

immigration 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 3-19). 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 gartersnake has small home ranges and typically moves 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). The marginal nature of long stretches of the canals that connect tracts, in the three reserves, surrounding land uses inhospitable to giant gartersnake, and potential fragmentation caused by I-5 exacerbate the great distance between tracts of the Central Basin Reserve and those of the Fisherman's Lake Reserve. Given the distance and intervening habitat conditions, it is unlikely that the tracts of Fisherman's Lake Reserve are currently demographically connected to 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 and 2021. Additionally, the canal connects to the Fisherman's Lake Reserve through the West Drainage Canal, which was categorized as suitable habitat in 2020 and 2021 (Figure 3-19). 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. Collection of movement data from radio-tagged snakes translocated to the SAFCA wetlands between 2019 and 2021 (see Section 3.3.4, *Radio-Telemetry Translocation Study*) will provide valuable information on the effective connectivity of these habitats in the coming years.

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 2020 or 2021, but the greater area of the Sills tract sampled in the revised study design should increase the chances that movements of giant gartersnakes between the Bianchi West and Sills tracts are detected in the future. 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; 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 immigration 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 apparently 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 continued tracking of these individuals in 2022 and beyond will provide information about the suitability of these recently created marshes for giant gartersnake.

It should also be noted that during the 2017, 2018, 2019, 2020, and 2021 canal habitat assessments, a few short sections of canal throughout the range of the Natomas Basin (shown in purple in Figure 3-19) were no longer canals and therefore no longer habitat for giant gartersnakes. Although some

sections of canal in each reserve were downgraded from suitable to marginal from 2020 to 2021, many canals in each reserve were upgraded from marginal to suitable habitat in 2021; overall, the continuity of suitable habitat for giant gartersnakes improved in 2021. The most prominent downgrade in habitat suitability occurred in one of the North Basin tracts (Frazer), where two sections of canals were downgraded from marginal to not suitable and one section of canal from suitable to marginal; however, there was great improvement in habitat (marginal to suitable) in the rest of the tracts in the North Basin (e.g., northwest of Bolen North 4, east and west of Bennett South East Canal).

In the Fisherman's Lake and the Central Basin tracts, no canal sections were downgraded to unsuitable habitat, except for the aforementioned sections that were no longer canals. Habitat in the canal sections of the Central Basin tract most prominently improved in the BKS area and area between Rosa Central and Elsie. In the Fisherman's Lake tract, four sections of the canals were upgraded from marginal to suitable, and no canal sections were downgraded to unsuitable habitat. It is possible that canals could change from suitable to marginal habitat and back, as well as from unsuitable to marginal and back based on annual fluctuations in water availability and growth of emergent vegetation. The observed habitat dynamics from 2019 to 2020 indicate that the habitat suitability of canals for giant gartersnake can both improve or degrade from year to year. 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.

### 3.3.4 Radio-Telemetry Translocation Study

Of the 19 telemetry snakes remaining from the 2020 season, eight were recollected for transmitter removal, six had their transmitters die before recollection, three were mortalities, and two had unknown status at the end of the 2021 season (Table 3-9). We wrapped up the fieldwork portion of the telemetry and translocation project in the 2021 season, so no new snakes were collected for telemetry or translocated this year. The eight snakes that were collected for transmitter removals were all released at their capture locations and retired from the program after recovering from surgery. Of these eight snakes, three were from the SAFCA Wetland Complex, four were from the BKS wetlands, and one was from the Sills rice agriculture site. We finished collecting movement data for the project in 2021, completing 792 telemetry surveys during the 2021 season (January–August).

As mentioned above, we increased our trapping efforts in the Natomas Farms, SAFCA, and Cummings Wetlands in an attempt to recapture captive-reared snakes released in 2020 or captive-born snakes released in 2019 and 2020. We captured two juvenile snakes, one at SAFCA 2 and the other at SAFCA 6. We do not believe these snakes were from the captive-reared cohort because each of the captive-reared snakes was given a unique 5-digit microbrand before release and neither of these snakes had unique brands. One of the juvenile snakes did have a single brand on the top half of its body, which is consistent with the location we branded on the captive-born snakes. We could not confirm via microbrands if the other juvenile was also a captive-born snake that we released. However, based on the size of the snake, the timing of the capture, and the lack of previous captures of juvenile snakes in the years prior to the translocation project, we are fairly confident that this snake was either a captive-born snake whose single microbrand faded or was born from one of the adult females that we translocated, because some were gravid at the time of translocation.

Now that we have completed fieldwork for the project, we are focusing solely on analyzing the data collected. We have almost wrapped up survival analysis on the resident, translocated, and captive-reared juvenile snakes and we are working on analyzing movement metrics, home range size, and

habitat selection between the different treatment groups. We will be concluding our analysis later this year and are hopeful that our results will provide more information on translocation and captive rearing in giant gartersnake and how we can possibly improve or add upon these conservation methods in the future.

### 3.3.5 American Bullfrog Capture-Mark-Recapture Study

A total of 1,439 individual bullfrogs from the three BKS wetlands were captured 1,650 times and processed between 2019 and 2021. In 2021, we captured 109 individuals at BKS Northeast, 97 individuals at BKS South Central 1, and 95 individuals at BKS Southwest Central. For comparison, in 2019 we captured 170 individuals at BKS Northeast, 140 individuals at BKS South Central 1, and 234 individuals at BKS Southwest Central; in 2020, we captured 122 individuals at BKS Northeast, 165 individuals at BKS South Central 1, and 314 individuals at BKS Southwest Central.

Recapture rates varied by wetland and were higher in BKS Northeast (26% in July, 29% in August, and 42% in September) than in BKS South Central 1 (19% in July, 21% in August, and 35% in September) and in BKS Southwest Central (19% in July, 29% in August, and 13% in September). For comparison, recapture rates ranged between 0% and 35% each month in 2019 and 2020. The higher recapture rates in 2021 are likely due to the revision in our study design to limit the size cut-off of sampled frogs to >60 mm SUL.

We detected two snake predations by bullfrogs at BKS South Central 1. In July, a bullfrog 125 mm SUL had consumed a juvenile giant garter snake; in August, a bullfrog 131 mm SUL had consumed a juvenile California kingsnake (*Lampropeltis californiae*). Most of the bullfrog's diet was composed of aquatic invertebrates (e.g., water beetles [Coleoptera] and invasive Louisiana crayfish [*Procambarus clarkii*]) based on observed stomach contents. The most frequently consumed vertebrate prey were smaller bullfrogs and bullfrog tadpoles (i.e., cannibalism).

We plan to analyze these body size-based demographic data and diet data on bullfrogs to construct a two-species demographic model. Using this data-driven model, we plan to project alternative bullfrog management scenarios, including a "no removal" scenario, and explore the potential trade-offs in each management scenario, in combination with various environmental variables.

## 3.4 Discussion

### 3.4.1 Demography

#### 3.4.1.1 Abundance

Abundance varied substantially among sites. For half of the demography clusters, three or fewer snakes were captured, and abundance was estimated to be in the range of 20–50 individuals. A similar abundance estimate was obtained for Lucich North, at which only 10 individuals were captured in 2021. For two sites with more than 30 individuals captured, abundance was estimated to be much greater, with >50 individuals (Sills), or >140 individuals (BKS). The return to trapping for 21 days per trapline in 2021 led to a greater number of within-year recaptures, compared to the compressed schedule of trapping for 14–16 days per site at fewer sites in 2020. The daily capture probability of marked giant gartersnake in 2021 was higher than in 2020 and the abundance

estimates were less uncertain in 2021 than 2020. The average number of captures per individual was higher in 2021 (1.57 captures per individual) than in 2020 (1.26 captures per individual). The number of captures per individual in 2021 was comparable to 2019 (1.44) and 2018 (1.41). Promisingly, the recapture rate of snakes among years appears to be high enough to obtain estimates of survival at sites with abundant giant gartersnake populations. Capture probabilities varied substantially, with slightly more variance attributable to temporal variation (fluctuations from day to day) than 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.

It should be noted that comparing abundance across sites is problematic because of the potential for the area (or length of shoreline) sampled to differ among sites. Thus, two sites could have different abundance estimates but similar densities of giant gartersnake if the area sampled by traps at the two sites differs. For example, the abundance estimate at Sills is approximately five times larger than the median abundance estimate at other rice canal sites (e.g., Bennett South, Elsie), but the length of shoreline sampled was also nearly three times greater at Sills than at Elsie and two and a half times greater at Sills than Bennett South. In addition to differences in the number of traplines within a site, differences in effective area sampled can arise from different spatial configurations of trap transects (e.g., a linear canal vs. a wetland with an irregular shoreline), variability in movement behavior of individuals at different sites, or a combination of these factors.

In keeping with findings from 2018, 2019, and 2020, there was little support for an effect of water temperature on capture probabilities in 2021. This difference is likely attributable to the revised study design implemented in 2018. From 2011 to 2017, demography sites were trapped during the spring and early summer, from mid-April through mid-July. 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 2018 and 2019, trapping was spread from April through September, and more sampling was done during the summer when water temperatures are likely higher and more stable. In 2021, trapping occurred from May through August, further supporting this hypothesis. As in 2018, 2019, and 2020, there was evidence of a positive ephemeral behavioral response to capture (“trap-happiness”) in 2021. 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 2021, there was support for a higher capture probability for male giant gartersnake than female giant gartersnake. Finally, in 2021 there was evidence in support of a positive relationship between the SVL of a giant gartersnake and its capture probability; larger snakes were more likely to be captured than smaller snakes. This finding matches results from 2019 but runs counter to 2020, when there was some evidence in support of a negative relationship between SVL and capture probability, indicating larger snakes were less likely to be captured.

### 3.4.1.2 Size Distribution and Sex Ratio

The sex ratio of giant gartersnake in the Natomas Basin was slightly lower than one male per female, but closer to one and higher than in 2020. Although the credible interval overlapped 1 in 2021, 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 one site, Lucich North (two males and eight females); in contrast, at Sills, a higher proportion of captured individuals were males (21 males and 14 females). Trapping on the four traplines within Lucich North in which moderately more female giant gartersnake were captured in 2021 occurred during late summer, from 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 by the fact that the average SVL and mass of captured females were higher in 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 2021 (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. In particular, small yearling snakes were caught in spring 2021 that were likely born in summer 2020, and neonate snakes likely born in summer 2021 were captured in August 2021. 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

For the first time since the start of the revised study design in 2018, we were able to obtain estimates of apparent survival (the probability of surviving and remaining available on site for

capture) for giant gartersnake in 2021. The only clear trend in the survival estimates was that apparent survival was much higher at BKS from 2018–2019 than in 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) and 2021 (five 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 in 2020 and 2021 or (2) evaded capture during the shorter sampling period in 2020. Trapping effort was more consistent in the Sills tract, and survival estimates were generally high and nearly equal among years. The high apparent survival rate in the Sills tract could reflect the fact that canals are the only habitat available to giant gartersnake in this area. With less available habitat to disperse into, emigration of snakes away from the area sampled by funnel traps is less likely. 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 some support for higher survival among male giant gartersnake than female giant gartersnake. This sex difference in survival could reflect innate differences in risk of mortality between the two sexes, or it could reflect a propensity for greater site fidelity in males than females. There was no support for a difference in availability for capture between the two sexes, however.

### 3.4.2 Distribution of Giant Gartersnake on Reserve Lands

The occupancy analysis for 2021 indicated that giant gartersnake is expected to occur in nearly half 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. Despite this great uncertainty, our results from both uninformative and informative models suggested that the presence of rice likely had positive effects on the occurrence of giant gartersnakes in 2021. This potentially highlights the importance of rice agriculture as an alternative wetland habitat for this conservation-reliant species (Halstead et al. 2019). It also should be noted, however, that the Central Basin has historically had the highest proportion of sites occupied and also the highest proportion of sites that are considered rice agriculture; these patterns remained evident in 2021. 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 an effect of emergent vegetation on occurrence was notable in 2021. In 2020, a negative effect of emergent vegetation on occurrence was seen in 2020, but this habitat covariate was found to have an important positive effect in 2017, 2016, and in years prior to 2014. In 2021, emergent vegetation was not found to be an important variable for explaining occurrence probability. However, this likely does not demote the importance of emergent vegetation; rather, given our 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 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, three giant gartersnakes were captured five times at the SAFCA wetlands in 2021, after three captures in 2020 (albeit males released in the Fisherman’s Lake Reserve), one capture in 2019, and no captures in 2018. In 2022 and beyond, our 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 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 2021 with >98% 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, and 2019. 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 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) was lower in 2021 than in 2020, but higher than in 2019. The probability that unoccupied sites became occupied (site colonization) in 2021 was slightly lower than in 2020 but comparable to 2019 (which itself was higher than in 2018), 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 2021, there does appear to be a decline in the number occupied sites over this time 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 in 2021. 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 2019 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 a long enough time period 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 increased (although  $<0$ ) between the 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. Occupancy dynamics on TNBC reserves were not strongly related to any habitat variables at the surveyed sites. Continued monitoring in 2022 and beyond could help understand how habitat improvement in the TNBC reserves might buffer against environmental stress factors on giant gartersnakes.

Sampling the Giant Gartersnake Drainage Canal between the Central Basin Reserve and the Fisherman's Lake Reserve first occurred in 2017. Although no giant gartersnakes were captured in the three trap arrays that were sampled along the length of this canal between 2017 and 2021, the survey of the vegetation indicated that the majority of this canal represents suitable habitat for giant gartersnake, with the southernmost stretches presenting marginal habitat. Given the recent construction of this canal, and the distance between the canal and occupied habitat to the north, it is possible giant gartersnakes have not yet had time to disperse into this new habitat. Future surveys should seek to determine if giant gartersnakes are colonizing this new habitat and whether snakes appear to be resident or if they use the canal primarily as a dispersal corridor.

## 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. In 2021, the TNBC acquired five new reserves: Richter (81 acres), Paulsen South (51 acres), Willey (111 acres), Lauppe South (171 acres), and Verona (117 acres).

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 164% greater in created marsh habitats in the BKS tract compared to the third highest density (and second highest in abundance) estimate on the Sills tract, which is composed of rice and associated canals. 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 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 Huffman West, Sills, and Lucich South tracts had the second, third, and fourth highest density estimates of giant gartersnake in 2021, illustrating the importance of rice agricultural habitats in the Natomas Basin, particularly in the Central Basin Reserve. TNBC has been highly effective in creating managed marsh habitats and providing for the continuation of rice agriculture in the Natomas Basin. Creation of additional 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 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 fluctuating water levels 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 provide relatively persistent aquatic habitat throughout the year.

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 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 water levels throughout the active season will also enhance the quality of existing habitats for giant gartersnake. Lowering water levels in the late summer and early fall might also help to concentrate prey prior to hibernation; the effectiveness of this practice as a management strategy warrants further attention.

## 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.
- 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 vegetation where possible. Giant gartersnake tends to avoid mosquito fern and other floating vegetation when it occurs at high densities (U.S. Geological Survey unpublished data), despite apparent positive selection at low densities (Halstead et al. 2016) and the positive relationship found between some floating vegetation cover and giant gartersnake occurrence in the Natomas Basin in 2020. Apparent selection of floating 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 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 from aquatic to 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 try to restrict changes in water levels to the minimum number of fluctuations possible.
- Maintain as many muskrat burrows, crayfish burrows, 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 of natural wetlands in the Central Valley. Doing so might 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.

## 3.7 References

- California Department of Fish and Game Commission. 1971. *California Code of Regulations: Animals of California Declared to be Endangered or Threatened*. Sacramento, CA.
- Casazza, M. L., G. D. Wylie, and C. J. Gregory. 2000. A Funnel Trap Modification for Surface Collection of Aquatic Amphibians and Reptiles. *Herpetological Review* 31:91–92.
- Caughley, G. 1974. Interpretation of Age Ratios. *The Journal of Wildlife Management* 38:557–562. doi: 10.2307/3800890.
- City of Sacramento, Sutter County, and Natomas Basin Conservancy. 2003. *Natomas Basin Habitat Conservation Plan; Sacramento and Sutter Counties, California*. Sacramento, CA.
- Coates, P. S., G. D. Wylie, B. J. Halstead, and M. L. Casazza. 2009. Using Time-Dependent Models to Investigate Body Condition and Growth Rate of the Giant Gartersnake. *Journal of Zoology* 279:285–293.
- Denwood, M. J. 2016. runjags: An R package providing interface utilities, model templates, parallel computing methods and additional distributions for MCMC models in JAGS. *Journal of Statistical Software* 71, 1–25.
- Ersan, J. S. M. 2015. *Diet and Prey Preference of Giant Gartersnakes (Thamnophis gigas) in the Sacramento Valley of California*. M.S. Thesis. California State University, East Bay, Hayward, CA.
- Fitch, H. S. 1940. A Biogeographical Study of the Ordinoidea Artenkreis of Garter Snakes (Genus *Thamnophis*). *University of California Publications in Zoology* 44:1–150.
- Framer, W. E., D. D. Peters, and H. R. Pywell. 1989. *Wetlands of the California Central Valley: Status and Trends: 1939-mid-1980's*. U. S. Fish and Wildlife Service, Region 1, Portland, OR.
- Govindarajulu, P., R. Altwegg, and B. R. Anholt. 2005. Matrix model investigation of invasive species control: bullfrogs on Vancouver Island. *Ecological Applications* 15:2161–2170.
- Halstead, B. J., G. D. Wylie, and M. L. Casazza. 2010. Habitat Suitability and Conservation of the Giant Gartersnake (*Thamnophis gigas*) in the Sacramento Valley of California. *Copeia* 2010:591–599.

- Halstead, B. J., G. D. Wylie, M. L. Casazza, and P. S. Coates. 2011a. Temporal and Maternal Effects on Reproductive Ecology of the Giant Gartersnake (*Thamnophis gigas*). *The Southwestern Naturalist* 56:29–34.
- Halstead, B. J., G. D. Wylie, P. S. Coates, and M. L. Casazza. 2011b. Bayesian Adaptive Survey Protocols for Resource Management. *The Journal of Wildlife Management* 75:450–457.
- Halstead, B. J., G. D. Wylie, P. S. Coates, P. Valcarcel, and M. L. Casazza. 2012. Bayesian Shared Frailty Models for Regional Inference about Wildlife Survival. *Animal Conservation* 15:117–124.
- Halstead, B. J., G. D. Wylie, and M. L. Casazza. 2013a. Efficacy of Trap Modifications for Increasing Capture Rates of Aquatic Snakes in Floating Aquatic Funnel Traps. *Herpetological Conservation and Biology* 8:65–74.
- Halstead, B. J., G. D. Wylie, M. L. Casazza, E. C. Hansen, and J. R. Roberts III. 2013b. *Thamnophis gigas* (Giant Gartersnake) Movement. *Herpetological Review* 44:159–160.
- Halstead, B. J., S. M. Skalos, G. D. Wylie, and M. L. Casazza. 2015. Terrestrial Ecology of Semi-Aquatic Giant Gartersnakes (*Thamnophis gigas*). *Herpetological Conservation and Biology* 10:633–644.
- Halstead, B. J., P. Valcarcel, G. D. Wylie, P. S. Coates, M. L. Casazza, and D. K. Rosenberg. 2016. Active Season Microhabitat and Vegetation Selection by Giant Gartersnakes Associated with a Restored Marsh in California. *Journal of Fish and Wildlife Management* 7:397–407.
- Halstead, B. J., J. P. Rose, G. A. Reyes, G. D. Wylie, and M. L. Casazza. 2019. Conservation reliance of a threatened snake on rice agriculture. *Global Ecology and Conservation* 19:e00681.
- Hansen, G. E., and J. M. Brode. 1980. *Status of the Giant Garter Snake Thamnophis couchii gigas (Fitch)*. California Department of Fish and Game, Sacramento, CA.
- Hansen, R. W., and G. E. Hansen. 1990. *Thamnophis gigas* (Giant Garter Snake) Reproduction. *Herpetological Review* 21:93–94.
- Kellner, K. 2016. jagsUI: A Wrapper Around “rjags” to Streamline ‘JAGS’ Analyses. <https://cran.r-project.org/web/packages/jagsUI/index.html>
- Kéry, M. 2010. *Introduction to Winbugs for Ecologists: Bayesian Approach to Regression, ANOVA, Mixed Models and Related Analyses*. Academic Press: Burlington, MA.
- Kéry, M., and J. A. Royle. 2016. *Applied Hierarchical Modeling in Ecology*. Academic Press: San Diego, CA.
- Kéry, M., and M. Schaub. 2011. *Bayesian Population Analysis using WinBUGS: A hierarchical perspective*. Academic Press: Waltham, MA.
- Kuo, L., and B. Mallick. 1998. Variable Selection for Regression Models. *Indian Journal of Statistics* 60:65–81.
- Lowe, S., M. Browne, S. Boudjelas, and M. De Poorter. 2004. 100 of the World’s Worst Invasive Alien Species. [A selection from the global invasive species database.] Invasive Species Specialist Group, Species Survival Commission, World Conservation Union. Auckland, New Zealand.

- MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. *Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence*. Academic Press: Amsterdam, The Netherlands.
- Madsen, T., B. Stille, and R. Shine. 1996. Inbreeding Depression in an Isolated Population of Adders *Vipera berus*. *Biological Conservation* 75:113–118.
- Madsen, T., B. Ujvari, and M. Olsson. 2004. Novel Genes Continue to Enhance Population Growth in Adders (*Vipera berus*). *Biological Conservation* 120:145–147.
- Mills, L. S. 2007. *Conservation of Wildlife Populations: Demography, Genetics, and Management*. Blackwell Publishing: Malden, Massachusetts.
- Plummer, M. 2003. JAGS: A Program for Analysis of Bayesian Graphical Models using Gibbs Sampling. In *Proceedings of the 3rd International Workshop on Distributed Statistical Computing* 124:125.
- R Core Team. 2019. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing. Vienna, Austria. Version 3.6.2. Retrieved from <http://www.R-project.org>.
- Reinert, H. K., and D. Cundall. 1982. An improved surgical implantation method for radio-tracking snakes. *Copeia*, 1982(3):702-705.
- Reyes, G. A., B. J. Halstead, J. P. Rose, J. S. M. Ersan, A. C. Jordan, A. M. Essert, K. J. Fouts, A. M. Fulton, K. B. Gustafson, R. F. Wack, G. D. Wylie, and M. L. Casazza. 2017. *Behavioral Response of Giant Gartersnakes (Thamnophis gigas) to the Relative Availability of Aquatic Habitat on the Landscape*. U.S. Geological Survey Open-File Report 2017-1141. doi:10.3133/ofr20171141.
- Riecke, T. V., A. G. Leach, D. Gibson, and J. S. Sedinger. 2018. Parameterizing the robust design in the BUGS language: Lifetime carry-over effects of environmental conditions during growth on a long-lived bird. *Methods in Ecology and Evolution* 9:2294–2305. doi:10.1111/2041-210X.13065
- Rose, J. P., J. S. M. Ersan, G. D. Wylie, M. L. Casazza, and B. J. Halstead. 2018a. Reproductive Frequency and Size-Dependence of Fecundity in the Giant Gartersnake (*Thamnophis gigas*). *Herpetological Conservation and Biology* 13:80–90.
- Rose, J. P., G. D. Wylie, M. L. Casazza, and B. J. Halstead. 2018b. Integrating Growth and Capture-Mark-Recapture Models Reveals Size-Dependent Survival in an Elusive Species. *Ecosphere* 9:e02384.
- Rose, J. P., J. S. M. Ersan, G. A. Reyes, K. B. Gustafson, A. M. Fulton, K. J. Fouts, R. F. Wack, G. D. Wylie, M. L. Casazza, and B. J. Halstead. 2018c. *Findings from a Preliminary Investigation of the Effects of Aquatic Habitat (Water) Availability on Giant Gartersnake (Thamnophis gigas) Demography and Reproduction in the Sacramento Valley, California, 2014–17*. U.S. Geological Survey Open-File Report 2018-1114. doi:10.3133/ofr20181114
- Rose, J. P., B. J. Halstead, G. D. Wylie, and M. L. Casazza. 2018d. Spatial and Temporal Variability in Growth of Giant Gartersnakes: Plasticity, Precipitation, and Prey. *Journal of Herpetology* 52:40–49.
- Rose, J. P., J. S. M. Ersan, G. D. Wylie, M. L. Casazza, and B. J. Halstead. 2019. Demographic factors affecting population growth in giant gartersnakes. *Journal of Wildlife Management* 83:1540–1551.

- Rossman, D. A., and G. R. Stewart. 1987. *Taxonomic Reevaluation of *Thamnophis couchii* (Serpentes: colubridae)*. Louisiana State University.
- Rossman, D. A., N. B. Ford, and R. A. Seigel. 1996. *The Garter Snakes: Evolution and Ecology*. University of Oklahoma Press: Norman, OK.
- Royle, J. A., and R. M. Dorazio. 2008. *Hierarchical Modeling and Inference in Ecology: The Analysis of Data from Populations, Metapopulations and Communities*. 1st edition. Academic Press: London.
- Royle, J. A., and M. Kéry. 2007. A Bayesian State-Space Formulation of Dynamic Occupancy Models. *Ecology* 88:1813–1823.
- Schwartz, J. M., G. F. McCracken, and G. M. Burghardt. 1989. Multiple Paternity in Wild Populations of the Garter Snake, *Thamnophis sirtalis*. *Behavioral Ecology and Sociobiology* 25:269–273.
- Shine, R., D. O'Connor, M.P. Lemaster, and R.T. Mason. 2001. Pick on Someone Your Own Size: Ontogenetic Shifts in Mate Choice by Male Garter Snakes Result in Size-Assortative Mating. *Animal Behaviour* 61:1133–1141.
- Skalski, J. R., K. E. Ryding, and J. J. Millspaugh. 2005. *Wildlife Demography: Analysis of Sex, Age, and Count Data*. Academic Press: Burlington, MA.
- Su, Y. S., and M. Yajima. 2015. R2jags: A Package for Running jags from R. R package version 0.05-01.
- U.S. Geological Survey. 2019. Unpublished data on the movement of radio-tracked giant gartersnakes (*Thamnophis gigas*) in the Sacramento Valley from 2009–2017. Western Ecological Research Center, Dixon, CA.
- U.S. Fish and Wildlife Service. 1993. Determination of Threatened Status for the Giant Garter Snake. *Federal Register* 58:54053–54066.
- U.S. Fish and Wildlife Service. 1999. *Draft Recovery Plan for the Giant Garter Snake (Thamnophis gigas)*. U.S. Fish and Wildlife Service, Sacramento, CA.
- Valcarcel, P. 2011. *Giant Gartersnake Spatial Ecology in Agricultural and Constructed Wetlands*. M.S. Thesis, Oregon State University, Corvallis, OR.
- Winne, C. T., J. D. Willson, K. M. Andrews, and R. N. Reed. 2006. Efficacy of Marking Snakes with Disposable Medical Cautery Units. *Herpetological Review* 37:52–54.
- Wylie, G. D., M. L. Casazza, and L. L. Martin. 2003. Giant Garter Snake Surveys in the Natomas Basin: 2000–2002. U.S. Geological Survey, Sacramento, CA.
- Wylie, G. D., M. L. Casazza, B. J. Halstead, and C. J. Gregory. 2009. Sex, Season, and Time of Day Interact to Affect Body Temperatures of the Giant Gartersnake. *Journal of Thermal Biology* 34:183–189.
- Wylie, G. D., M. L. Casazza, C. J. Gregory, and B. J. Halstead. 2010. Abundance and Sexual Size Dimorphism of the Giant Gartersnake (*Thamnophis gigas*) in the Sacramento Valley of California. *Journal of Herpetology* 44:94–103.
- Zipkin, E. F., C. E. Kraft, E. G. Cooch, and P. J. Sullivan. 2009. When can efforts to control nuisance and invasive species backfire? *Ecological Applications* 19:1585–1595.

**Table 3-1. Summary of Giant Gartersnake Captures and Sampling Effort at Natomas Basin Conservancy Reserves, 2021**

Reserve Area and Reserve	Number of Giant Gartersnakes		Dates Trapped (2021)	Total Trap Days
	Individuals	Captures		
<b>North Basin</b>				
Bennett North Central West (wetland)	0	0	21 Jul–14 Aug	1050
Bennett North Central (wetland)	0	0	17 Jul–10 Aug	1050
Bennett North Central East (wetland)	0	0	31 Jul–24 Aug	1050
Bennett North (rice)	0	0	16 Jul–6 Aug	1050
Bennett South East (canal)	0	0	24 Jun–17 Jul	1048
Frazer North Wetland North	0	0	7 Jul–28 Jul	1046
Frazer North Wetland Central	0	0	9 Jul–30 Jul	1050
Huffman West	2	3	13 Aug–31 Aug	900
Lucich North South 1	3	3	30 Jul–23 Aug	1049
Lucich North South 2	1	2	3 Aug–27 Aug	1043
Lucich North East	0	0	9 Aug–30 Aug	1050
Lucich North Northeast 2	0	0	14 Jul–4 Aug	1049
Lucich South South (rice)	1	1	25 May–14 Jun	700
Lucich South 3	0	0	14 Aug–31 Aug	850
Nestor East	7	9	10 Aug–31 Aug	1050
TNBC6	1	1	22 Jun–15 Jul	1050
<b>Central Basin</b>				
BKS North Central	10	12	26 Jul–20 Aug	1050
BKS Southwest Central	58	80	11 Jul–2 Aug	1199
BKS2	6	7	13 May–5 Jun	1050
BKS3	8	14	27 May–19 Jun	1050
Elsie	1	2	27 Jun–22 Jul	981
Frazer South North	10	16	1 Aug–26 Aug	1031
NACONN1	0	0	27 Jul–20 Aug	1050
NACONN3	0	0	20 Jun–13 Jul	1049
NACONN5	0	0	15 Jun–8 Jul	1049
Sills4	25	43	14 Jun–10 Jul	1098
Sills5	15	26	22 May–14 Jun	1049
Sills6	2	2	2 Jul–25 Jul	1050
Tufts3	0	0	12 Jul–2 Aug	1049
<b>Fisherman's Lake</b>				
Cummings East	0	0	19 May–11 Jun	1047
Cummings East Central	0	0	11 Aug–31 Aug	1000
Cummings West	0	0	29 May–21 Jun	1050
Natomas Farms North	0	0	10 Jun–1 Jul	1048
Natomas Farms 1	0	0	17 May–9 Jun	1047
Natomas Farms 2	0	0	12 Jun–3 Jul	1049

**Table 3-1. Continued**

Reserve Area and Reserve	Number of Giant Gartersnakes		Dates Trapped (2021)	Total Trap Days
	Individuals	Captures		
Natomas Farms 3	0	0	10 Aug–31 Aug	1048
Rosa Central	0	0	5 Jun–26 Jun	1046
SAFCA 1	0	0	15 May–7 Jun	1048
SAFCA 2	2	3	3 Jul–26 Jul	1048
SAFCA 3	0	0	30 Jun–23 Jul	1050
SAFCA 4	0	0	1 Jul–24 Jul	1049
SAFCA 5	0	0	8 Jun–29 Jun	1050
SAFCA 6	1	2	23 Jul–16 Aug	1047
SAFCA 7	0	0	24 Jul–17 Aug	1050
SAFCA 8	0	0	25 Jul–18 Aug	1050
<b>Total</b>	<b>153</b>	<b>226</b>		<b>46,567</b>

<sup>a</sup> This capture was a translocated telemetry snake; it was not included in the capture-mark-recapture analysis.

**Table 3-2. Prior Probabilities for Parameters of Single-Season Occupancy Models for Giant Gartersnake on Natomas Basin Conservancy Reserve Properties, 2021**

Component	Model	Parameter	Prior Distribution	
			Uninformative	Informative
Detection	All	$\beta_0$	$N(0,1.648)$	$N(-1.860,0.128)$
	All	$\beta_{temp}$	$N(0,1.648)$	$N(0.263,0.051)$
	All	$\beta_{date}$	$N(0,1.648)$	$N(-0.288,0.058)$
	All	$\sigma_{site}$	$U(0,10)$	$Gamma(167.982,129.831)$
Occupancy	$\psi_{habitat}$ and $\psi_{basin}$	$\beta_0$	$N(0,1.648)$	NA
		$\beta_{rice}$	$N(0,1.648)$	NA
		$\beta_{em.vegergent}$	$N(0,1.648)$	NA
		$\beta_{fl.veg}$	$N(0,1.648)$	NA
		$\beta_{open.water}$	$N(0,1.648)$	NA
		$\beta_{terr.veg}$	$N(0,1.648)$	NA
	$\psi_{basin}$	$\beta_{north}$	$N(0,1.648)$	NA
		$\beta_{central}$	$N(0,1.648)$	NA
		$\beta_{south}$	$N(0,1.648)$	NA



**Table 3-3. Model-Averaged Posterior Distributions for Capture Parameters of Closed Abundance Model of Giant Gartersnake in the Natomas Basin, 2021**

Model Component	Parameter	Median (95% CI)
Capture	$p_0$	0.0039 (0.0012–0.0094)
	$\alpha_{temp}$	-0.14 (-0.50–0.52)
	$\alpha_{SVL}$	0.19 (-0.12–0.52)
	$\alpha_{sex}$	0.52 (-0.05–1.12)
	$\alpha_{behav}$	1.93 (1.33–2.48)
	$\sigma_{site}$	0.0021 (0.0005–0.0094)
	$\sigma_{ind}$	0.0018 (0.0002–0.0042)
	$\sigma_{day}$	0.0026 (0.0008–0.0064)

**Table 3-4. Summary of Giant Gartersnake Captures and Abundance Estimates, 2021**

Site	Indiv	Cap	<i>N</i>	Trap Days	Shoreline Sampled (kilometers)	Density (snakes/kilometer)
BKS	88	124	200 (147–352)	5,380	3.04	65.79
Huffman West	2	3	24 (13–44)	900	0.78	30.61
Lucich North	10	14	31 (19–55)	5,241	4.14	7.50
Lucich South	1	1	23 (12–43)	1,550	1.58	14.58
SAFCA	3	5	45 (27–86)	8,392	4.33	10.39
Sills	36	73	74 (51–137)	4,178	2.98	24.82
<b>Total</b>	<b>140</b>	<b>220</b>		<b>25,641</b>		

**Table 3-5. Posterior Summaries for Parameters from the Robust-Design CMR Model, 2018–2021**

Model component	Parameter	Median (95% CI)
Recapture	$p_{female}$	0.0056 (0.0021–0.0165)
	$p_{male}$	0.0042 (0.0015–0.0123)
	$\beta_{wt}$	0.29 (-0.4–1.01)
	$\sigma_{site}$	0.44 (0.02–1.89)
	$\sigma_{year}$	0.27 (0.01–1.03)
Survival	$\phi_{female}$	0.47 (0.28–0.75)
	$\phi_{male}$	0.64 (0.41–0.89)
	$\sigma_{\phi}$	0.83 (0.11–2.28)
Availability	$\gamma_{female}$	0.69 (0.33–0.98)
	$\gamma_{male}$	0.64 (0.21–0.98)
	$\sigma_{\gamma}$	0.43 (0.02–2.35)

**Table 3-6. Posterior Model Probabilities for Probability of Occurrence of Giant Gartersnake Based on Habitat on Natomas Basin Conservancy Reserves, 2021**

Rice	Explanatory Variable				Posterior Probability	
	Emergent Vegetation	Floating Vegetation	Open Water	Terrestrial Vegetation	Uninformative	Informative
1	0	0	0	0	0.167	0.195
1	0	0	1	0	0.106	0.106
1	1	0	0	0	0.075	0.085
1	0	1	0	0	0.074	0.078
1	0	0	0	1	0.064	0.064
1	0	1	1	0	0.059	0.050
1	1	0	1	0	0.050	0.046
0	0	0	0	0	0.014	0.016

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, 2021**

Model Component	Parameter	Form of Priors on Detection Component of Model	
		Uninformative	Informative
Detection	$\mu_p$	0.21 (0.04 to 0.39)	0.14 (0.11 to 0.17)
	$\alpha_0$	-1.32 (-2.69 to -0.28)	-1.80 (-2.04 to -1.56)
	$\alpha_{temp}$	0.13 (-0.16 to 0.42)	0.25 (0.15 to 0.34)
	$\alpha_{date}$	-0.30 (-0.95 to 0.37)	-0.29 (-0.40 to -0.18)
	$\sigma_{site}$	1.78 (1.01 to 2.85)	1.36 (1.18 to 1.55)
Occurrence	$\psi_{North}$	0.35 (0.08 to 0.66)	0.34 (0.10 to 0.63)
	$\psi_{Central}$	0.66 (0.34 to >0.99)	0.66 (0.33 to >0.99)
	$\psi_{Fisherman's\_Lake}$	0.18 (0.02 to 0.41)	0.18 (0.03 to 0.39)
	$\beta_{North}$	-0.69 (-2.15 to 0.81)	-0.68 (-1.99 to 0.69)
	$\beta_{Central}$	0.65 (-1.17 to 2.97)	0.65 (-1.11 to 2.85)
	$\beta_{Fisherman's\_Lake}$	-1.50 (-2.96 to -0.07)	-1.52 (-2.98 to -0.22)
	$\beta_{rice}$	1.25 (-0.68 to 3.26)	1.27 (-0.58 to 3.35)
$N_{occ}$	19 (16 to 25)	19 (16 to 23)	

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, 2011–2021**

Explanatory Variable						Posterior Probability
Emergent Vegetation	Terrestrial Vegetation	Floating Vegetation	Submerged Vegetation	Rice		
0	0	0	0	0	0	0.278
0	0	0	0	1	1	0.177
0	1	0	0	1	1	0.125

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.

**Table 3-9. Date of Capture, Microbrand, Location of Capture, and Status for Radio-Tagged Giant Gartersnakes in 2021**

MB	Trapline	Re-Capture Date	Status
13078	SAFCA 2	7/21/2021	Retired 8/2/2021
2891A	BKS SWC	-	Transmitter Died 3/24/2021
2818	SAFCA 6	-	Mortality 7/15/2021
13151	SAFCA 1	8/22/2021	Retired 8/30/2021
2445	SAFCA 4	8/30/2021	Retired 9/10/2021
13234	BKS SWC	-	Transmitter Died, 7/30/21
13235	BKS SWC	6/27/2021	Retired 7/9/2021
13299	BKS NC Wet	8/5/2021	Retired 8/16/2021
13335	BKS NC Wet	7/19/2021	Retired 8/2/2021
2947	BKS NC Wet	-	Mortality 4/10/2021
13339	BKS NC Wet	8/2/2021	Retired 8/16/2021
2907	Sills 5	-	Transmitter Died, 7/3/2021
13271	Sills 4	6/10/2021	Retired 6/25/2021
13289	Sills 4	-	Unknown
13295	Elsie	-	Mortality 7/8/2021
2891B	Sills 4	-	Transmitter Died, 8/3/2021
13334	Sills 6	-	Unknown
13308	SAFCA 1	-	Transmitter Died, 2/5/2021
13314	SAFCA 3	-	Transmitter Died, 3/5/2021

*This page intentionally left blank*

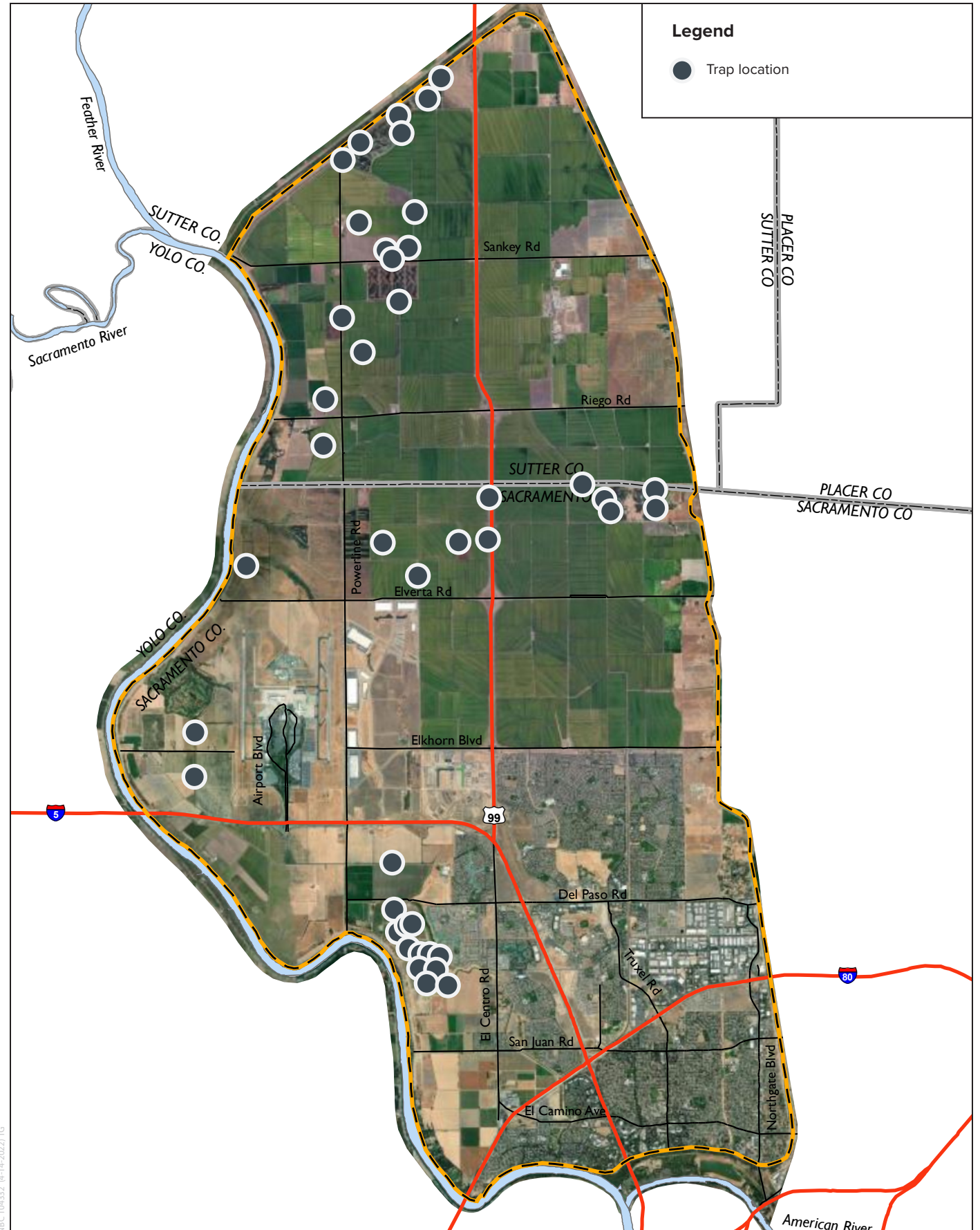


NBC104332 (3-9-2022)TG



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

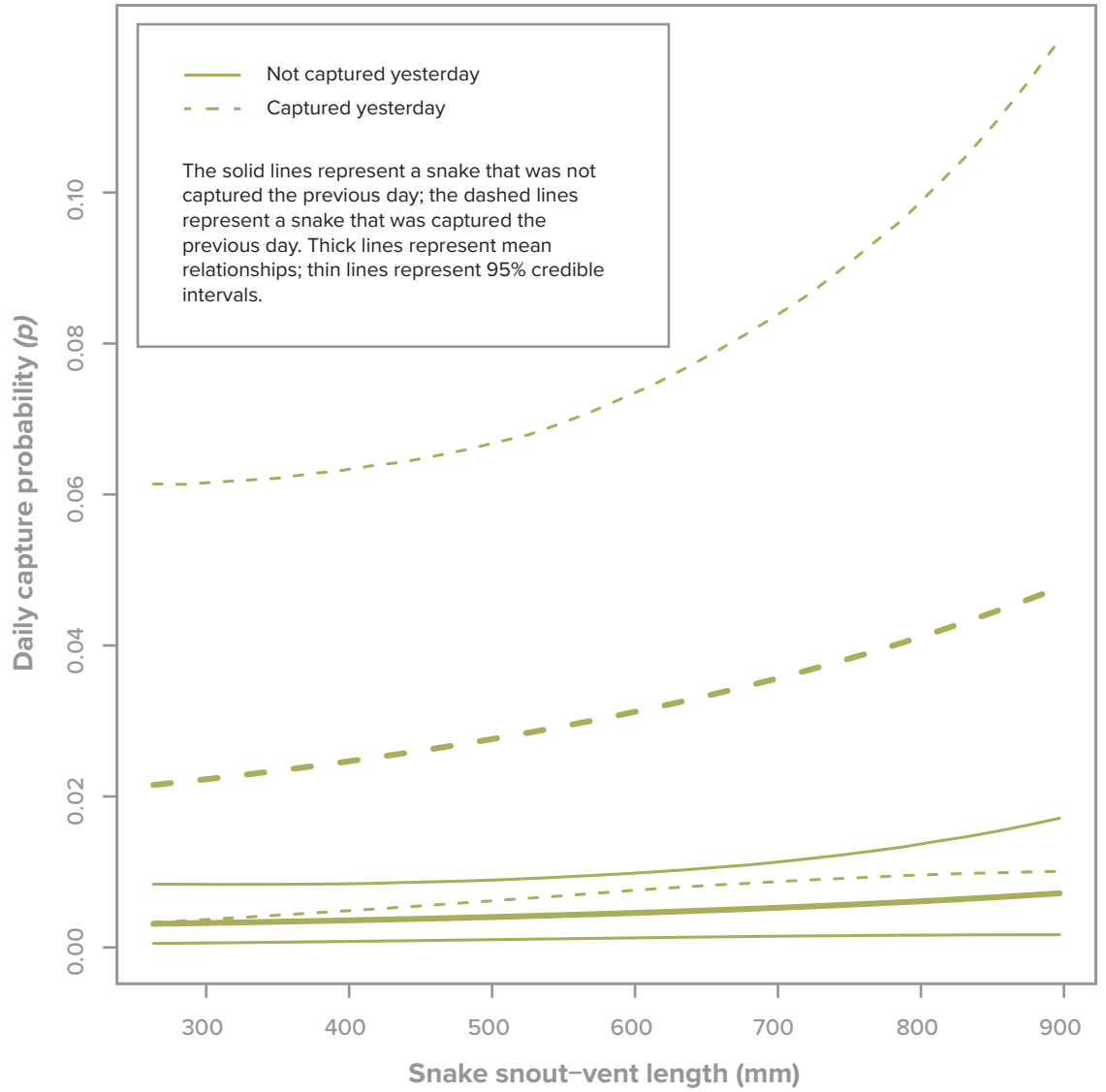




NBC104332 (4-14-2022) TG



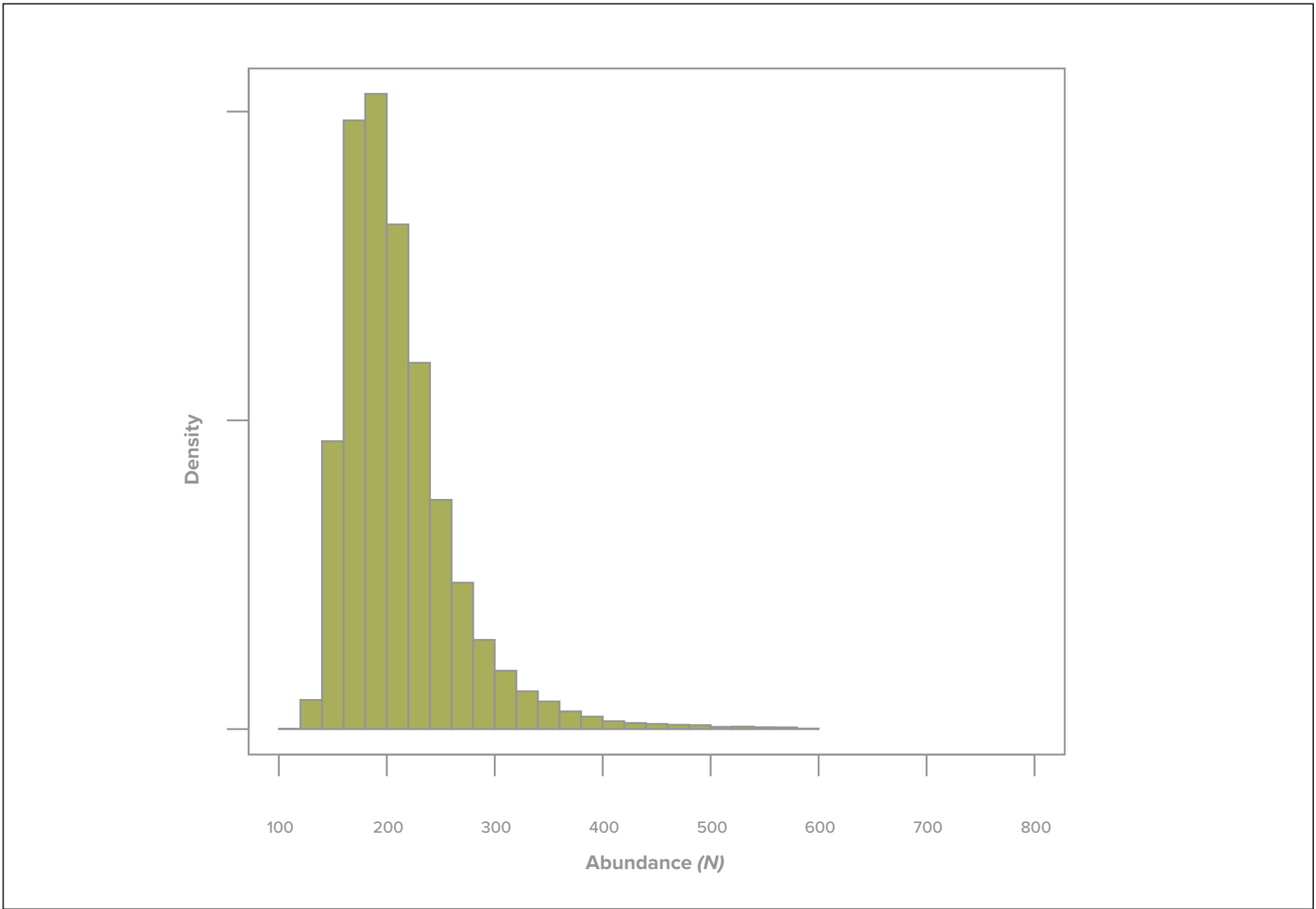
**FIGURE 3-2**  
Areas Sampled for Giant Gartersnake  
in the Natomas Basin in 2021



NBC104332 (3-9-2022)TG

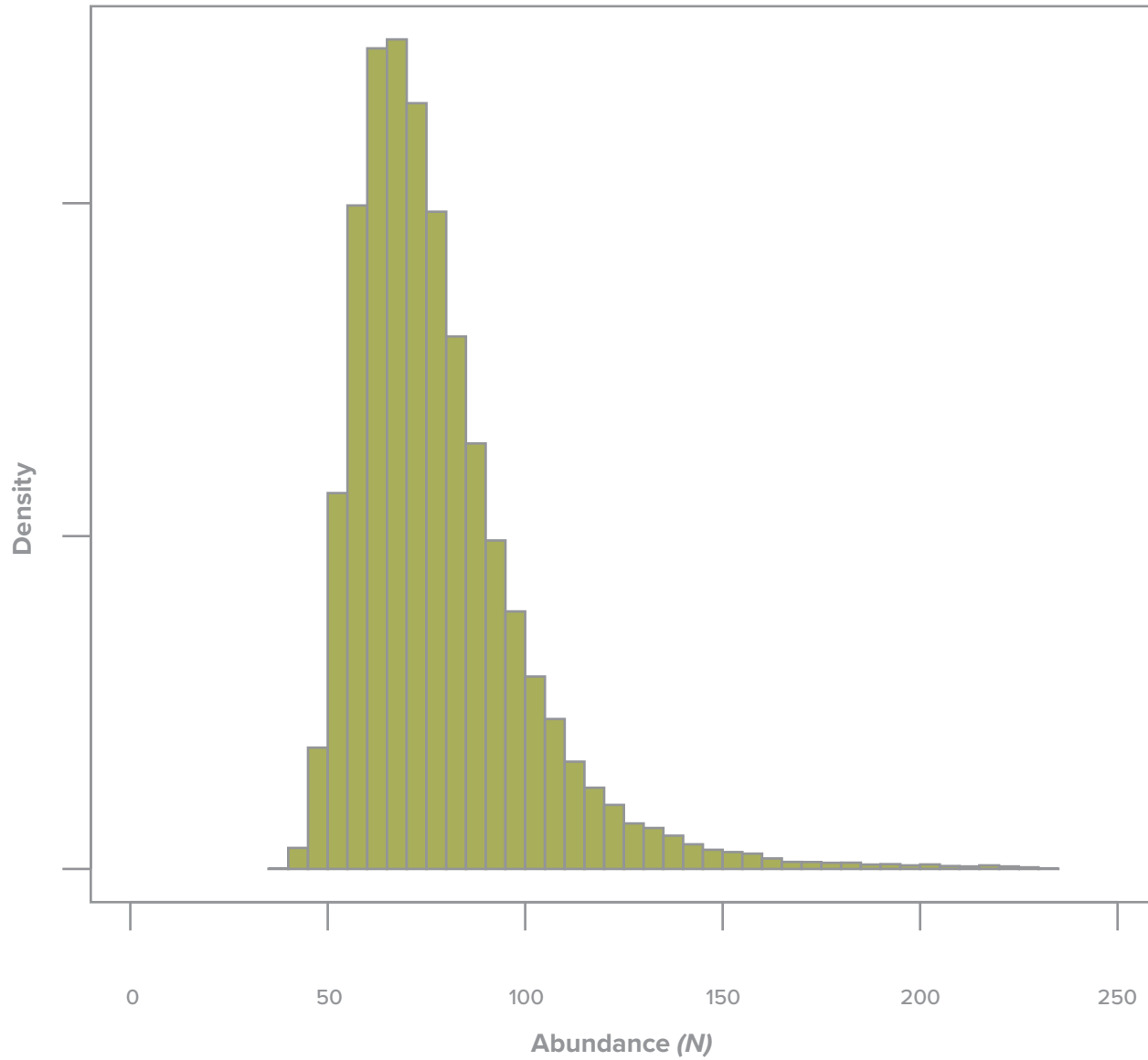


**FIGURE 3-3**  
 Model Averaged Effect of an Ephemeral Behavioral Response and Snake Size on  
 Giant Gartersnake Capture Probability in the Natomas Basin in 2021



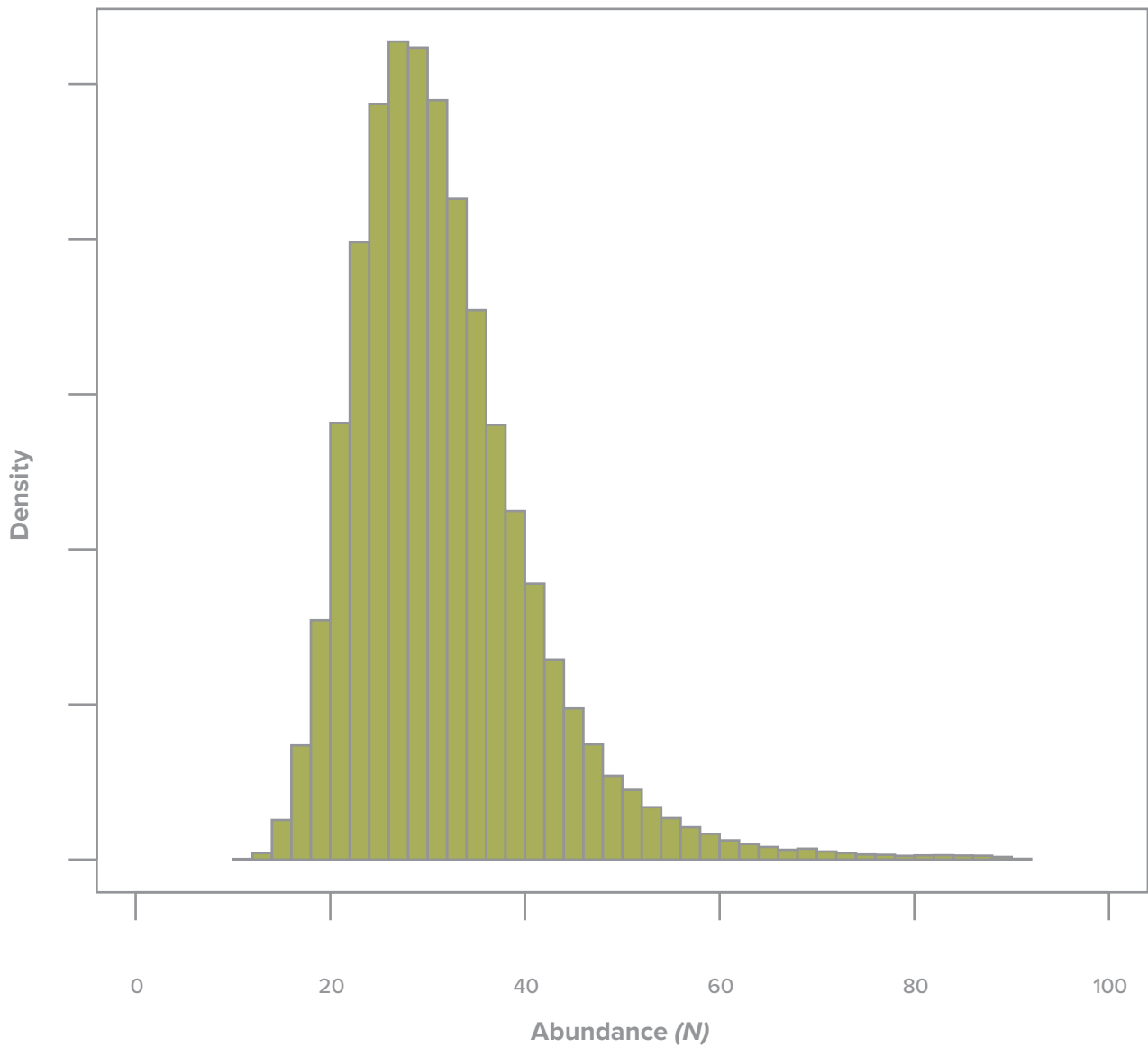
**FIGURE 3-4**  
Posterior Distribution of Estimated Giant Gartersnake Abundance in the  
Sampled Area at BKS Based on Closed Population Models in 2021



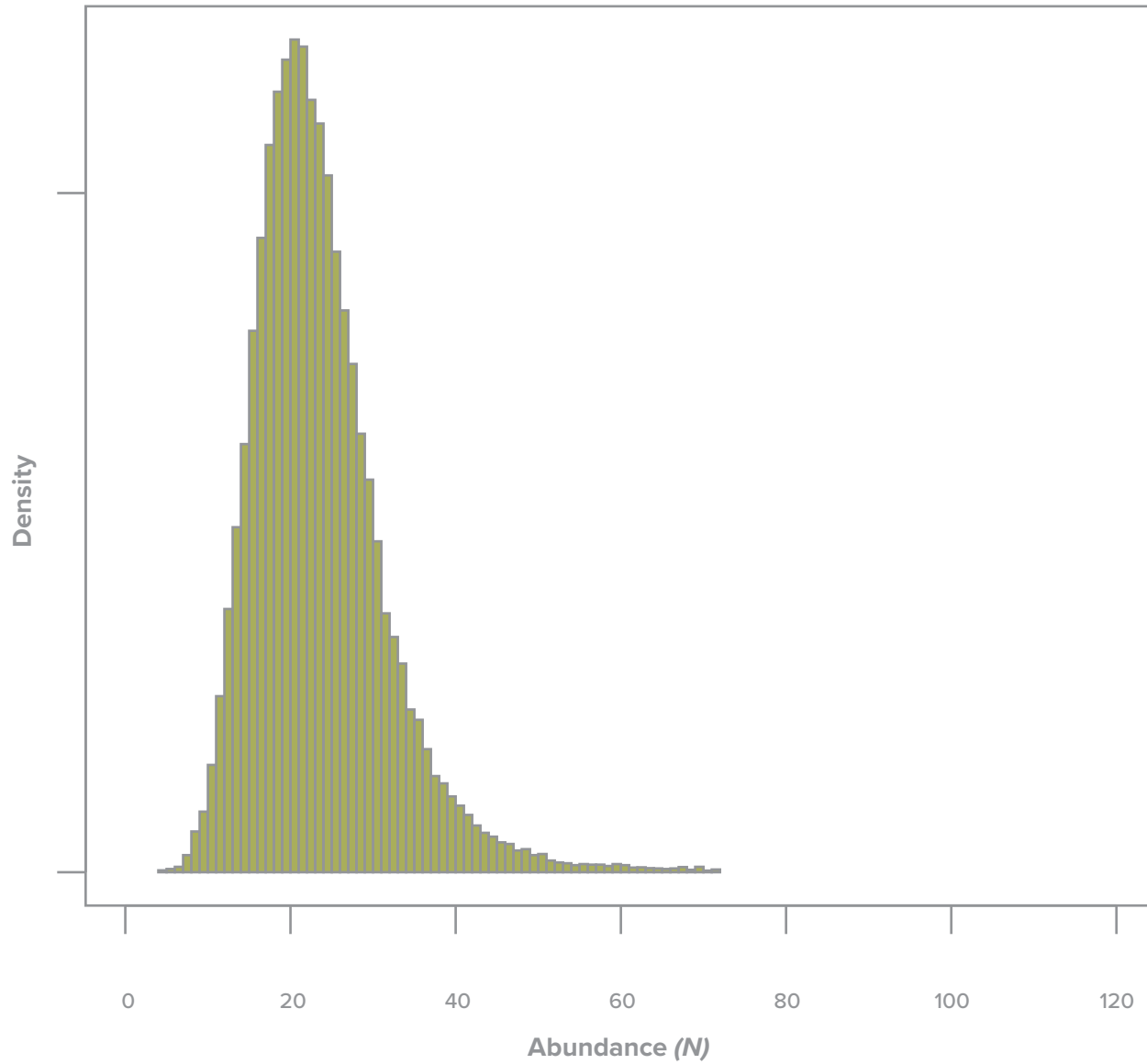


**FIGURE 3-5**  
Posterior Distribution of Estimated Giant Gartersnake Abundance in the  
Sampled Area at Sills Based on Closed Population Models in 2021



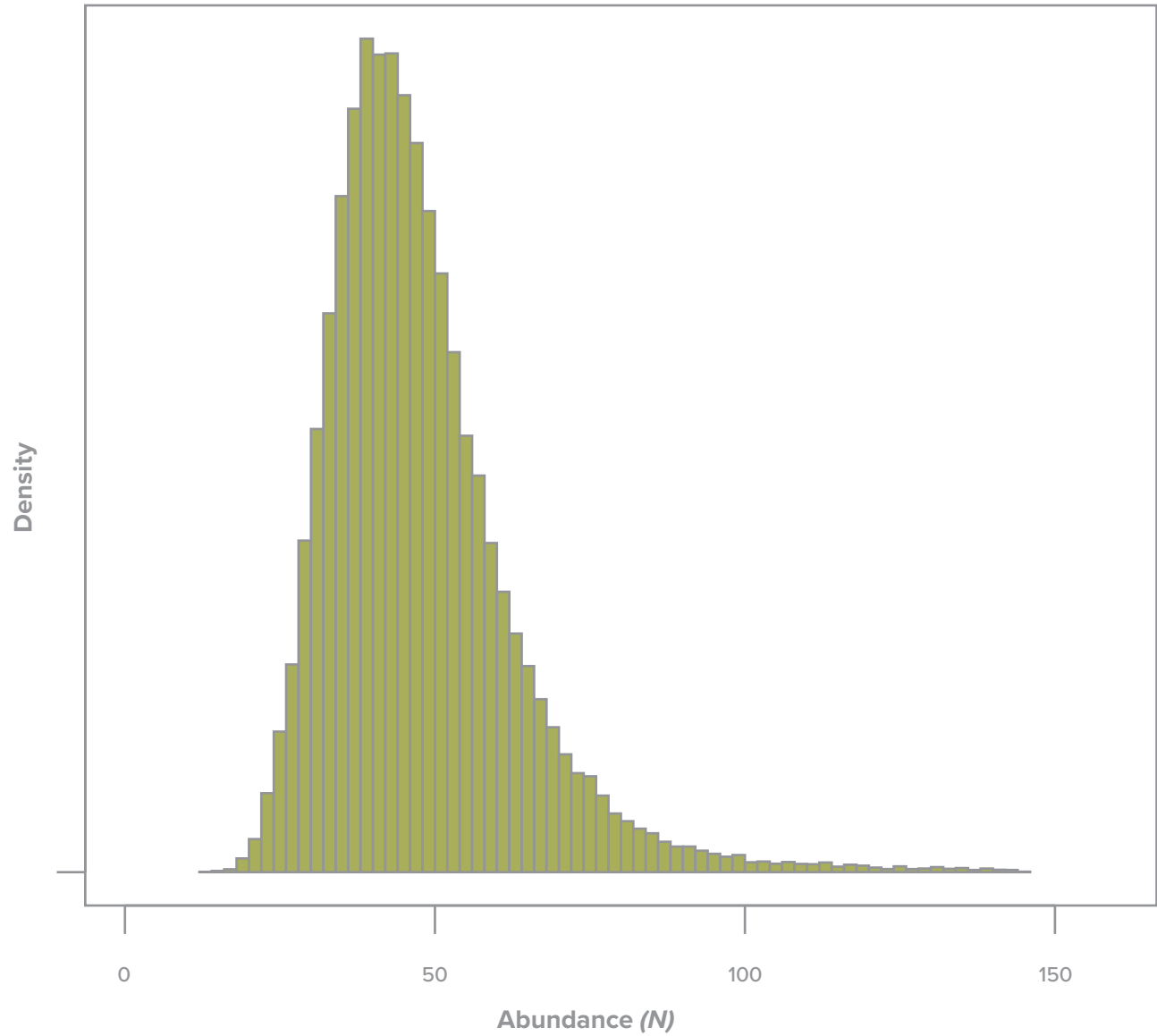


**FIGURE 3-6**  
Posterior Distribution of Estimated Giant Gartersnake Abundance in the  
Sampled Area at Lucich North Based on Closed Population Models in 2021



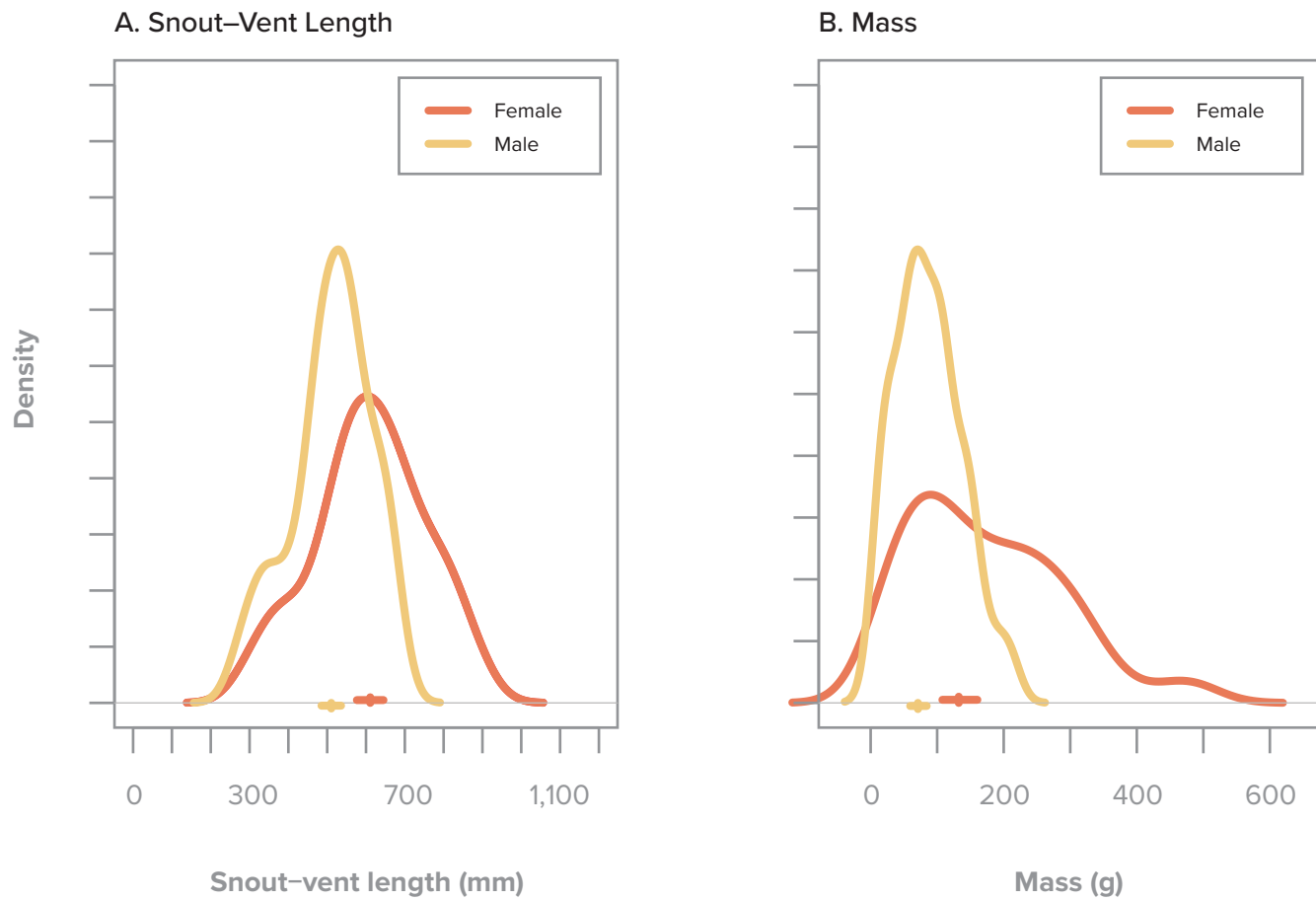
**FIGURE 3-7**

Posterior Distribution of Estimated Giant Gartersnake Abundance in the Sampled Area at Lucich South Based on Closed Population Models in 2021

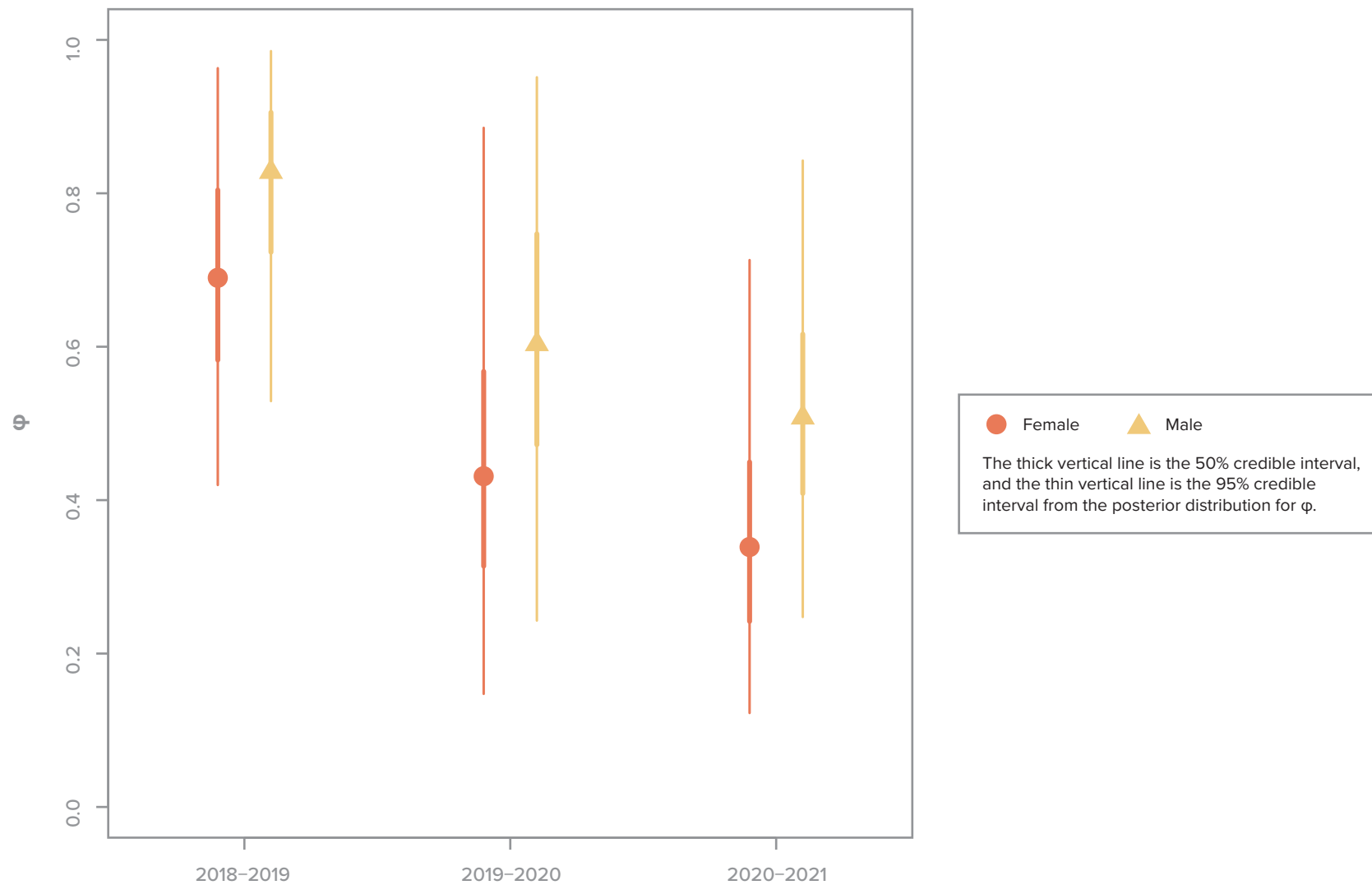


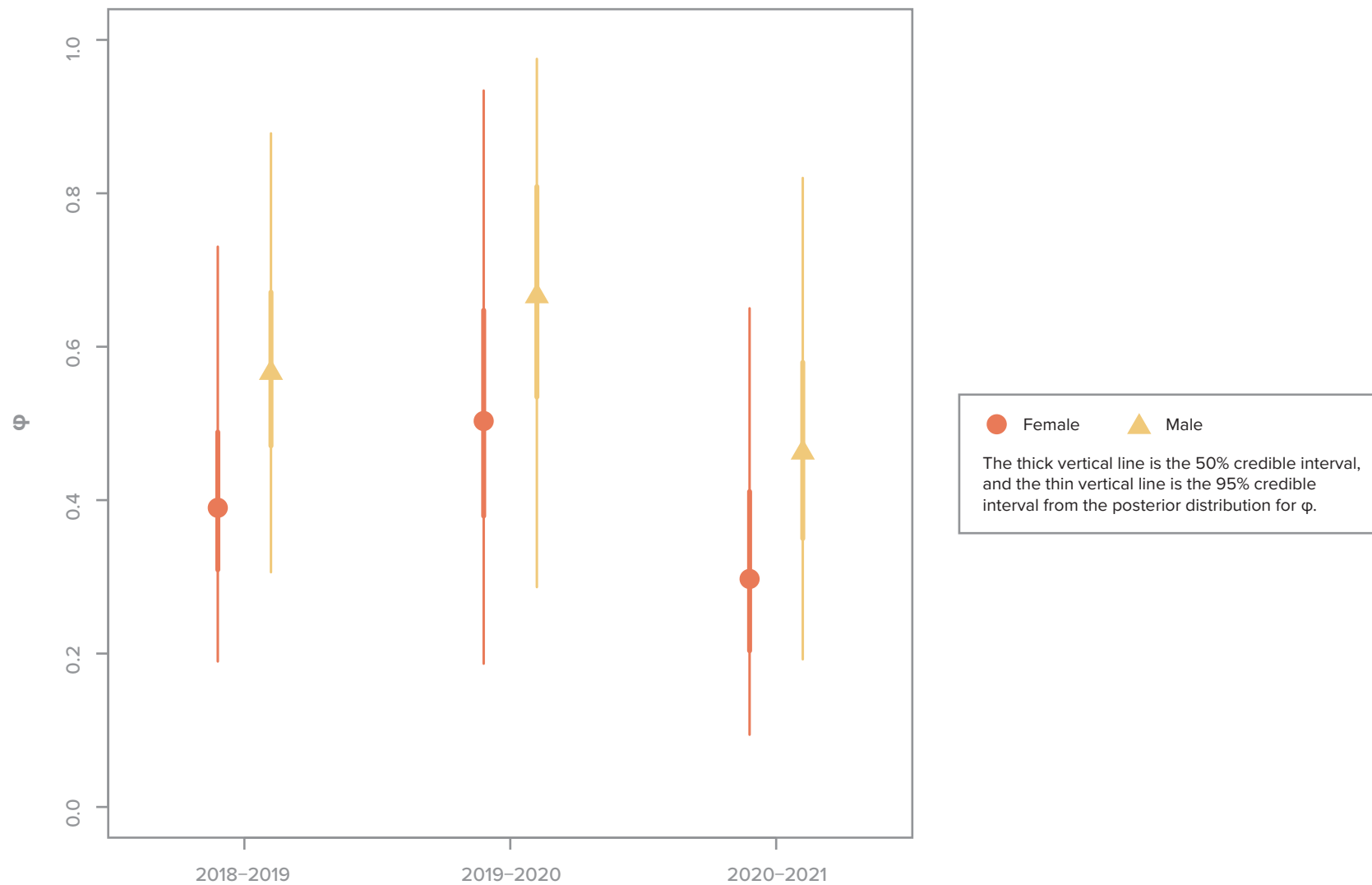
**FIGURE 3-8**  
Posterior Distribution of Estimated Giant Gartersnake Abundance in the  
Sampled Area at the SAFCA Wetlands Based on Closed Population Models in 2021

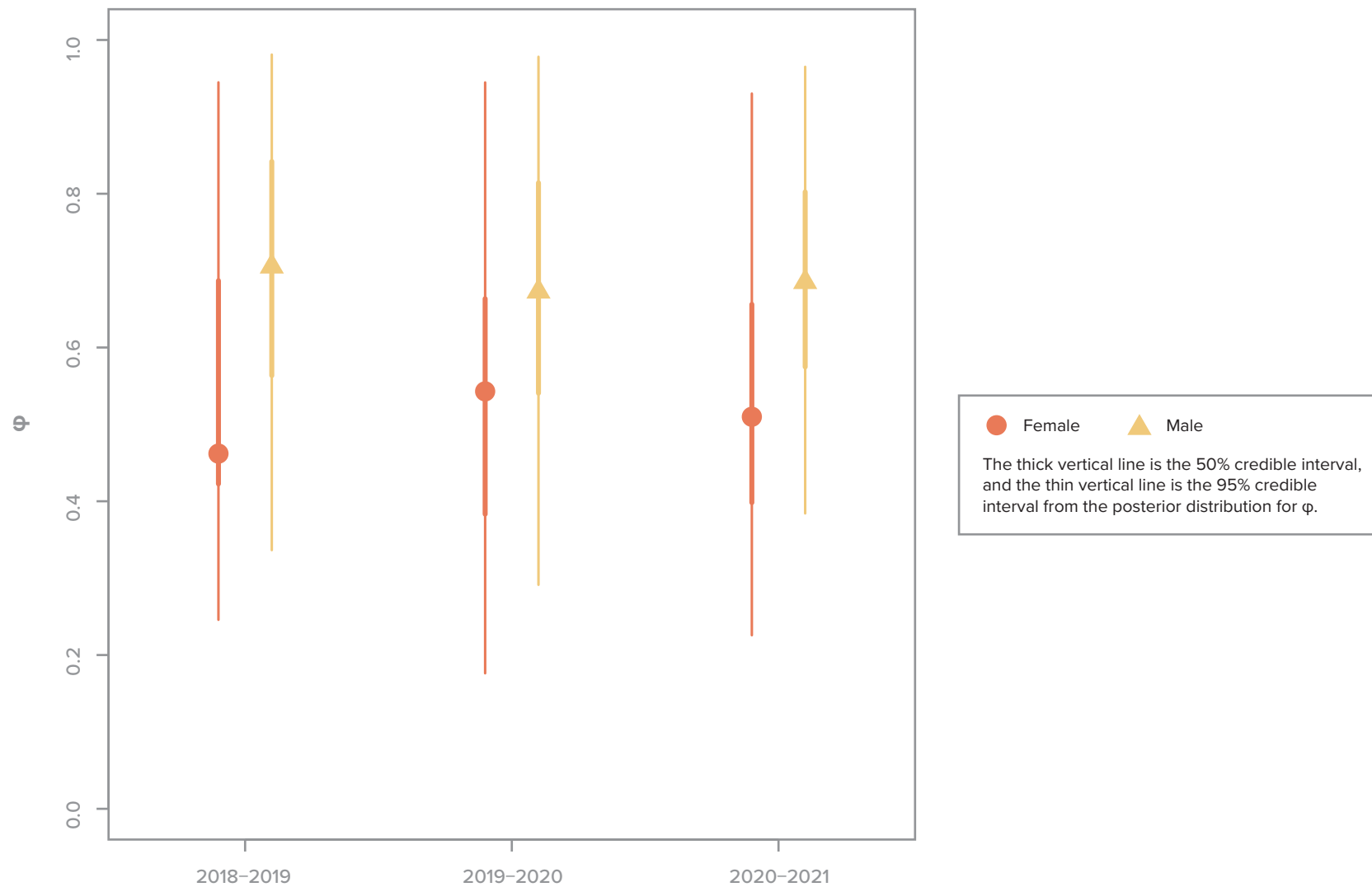
NBC104332 (3-12-2022)TG



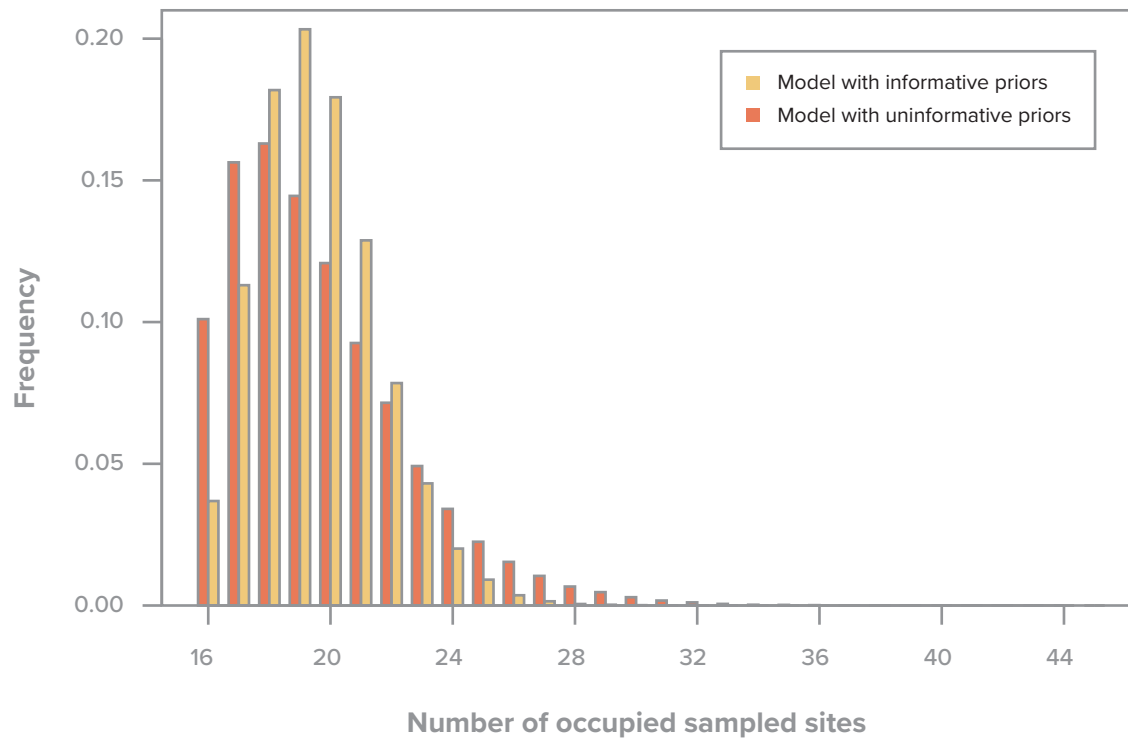
**FIGURE 3-9**  
Distribution of Male and Female Snout-Vent Length (A) and  
Mass (B) in the Natomas Basin, 2021







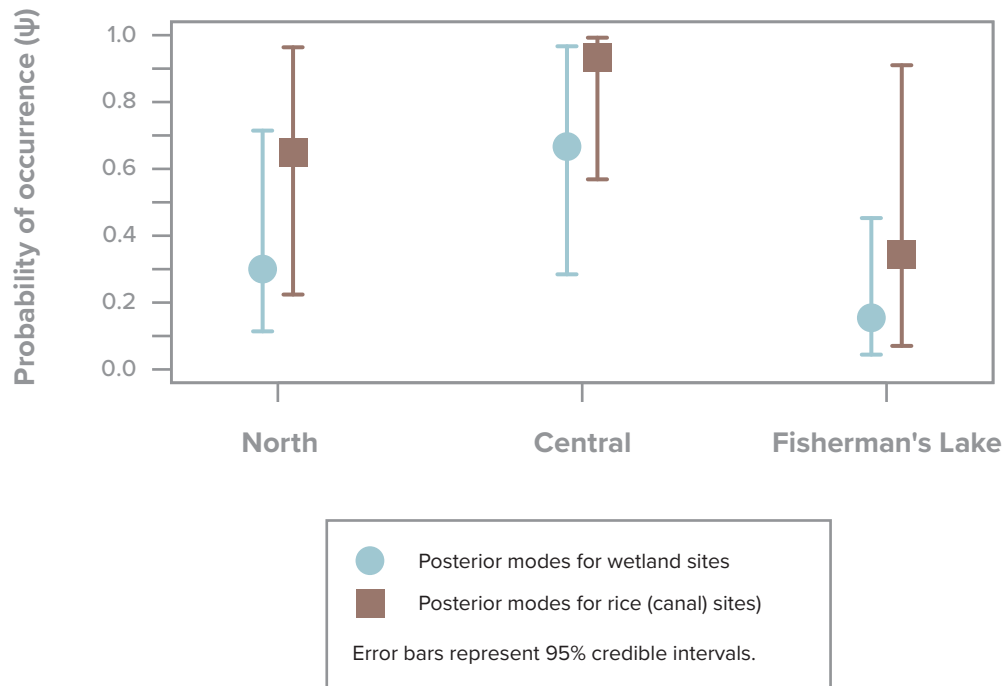




NBC104332 (3-12-2022)TG



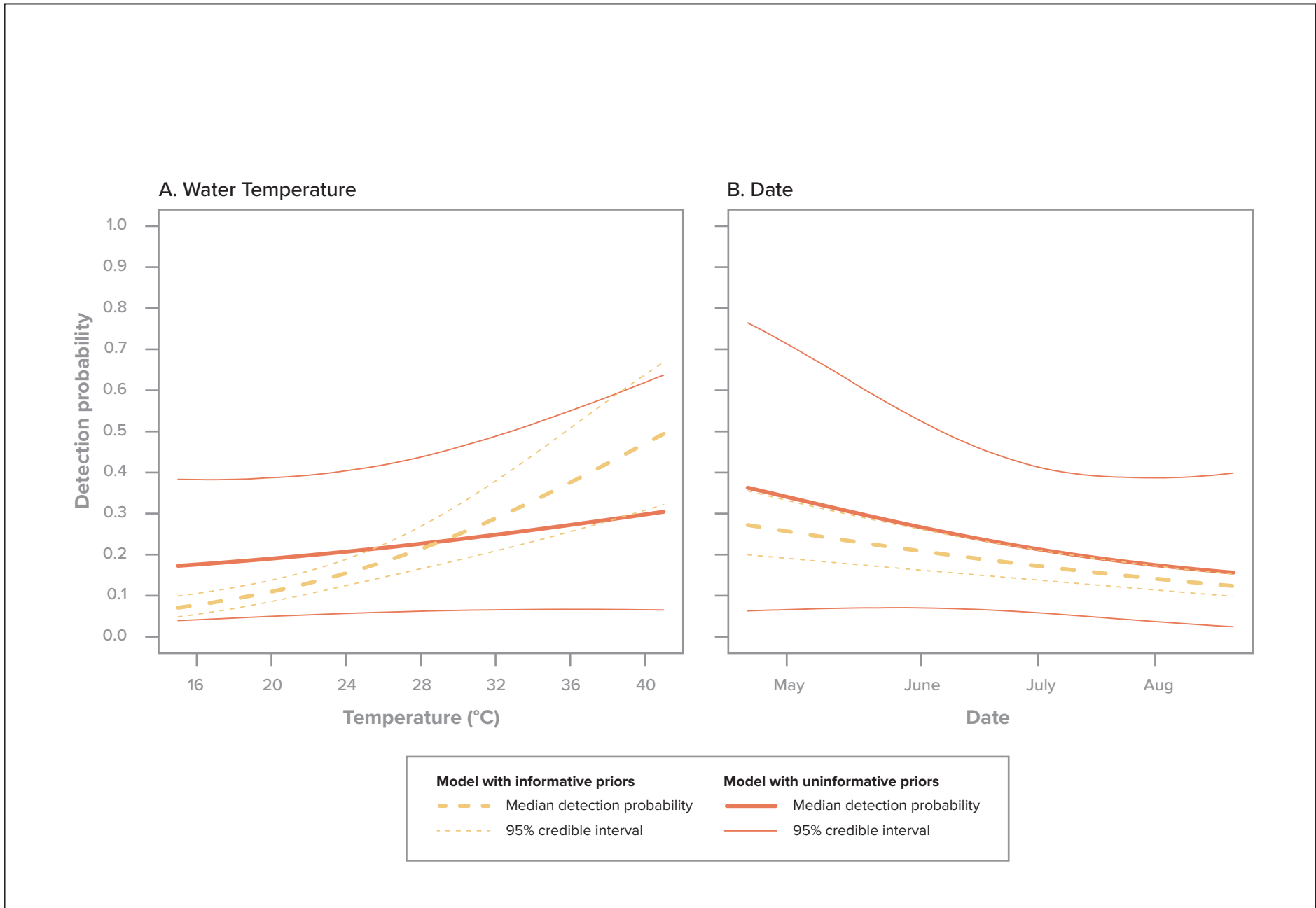
**FIGURE 3-13**  
 Number of Occupied Sites Based on  
 Static Occupancy Models for the Natomas Basin, 2021



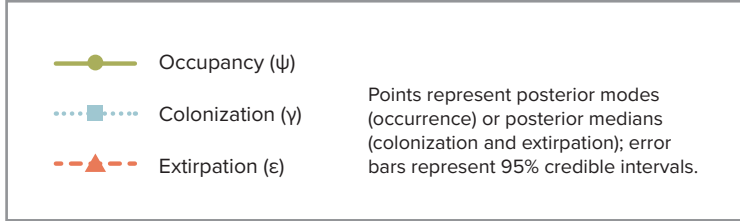
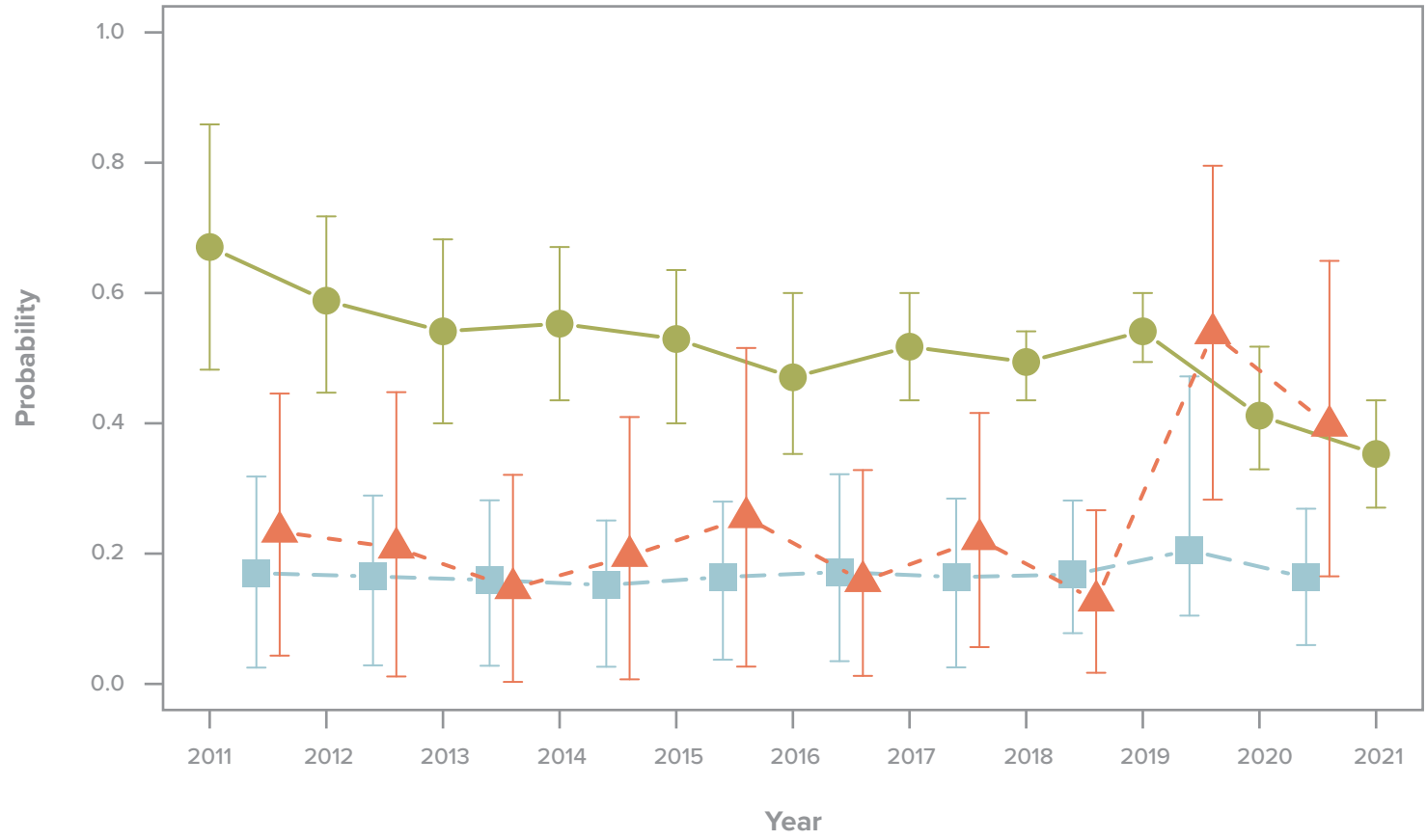
NBC104332 (3-12-2022)TG



**FIGURE 3-14**  
 Effect of Reserve Area and Presence of Rice on the Probability of Occurrence ( $\psi$ ) of  
 Giant Gartersnake in the Natomas Basin, 2021, Based on the Static Occupancy Model with Uninformative Priors



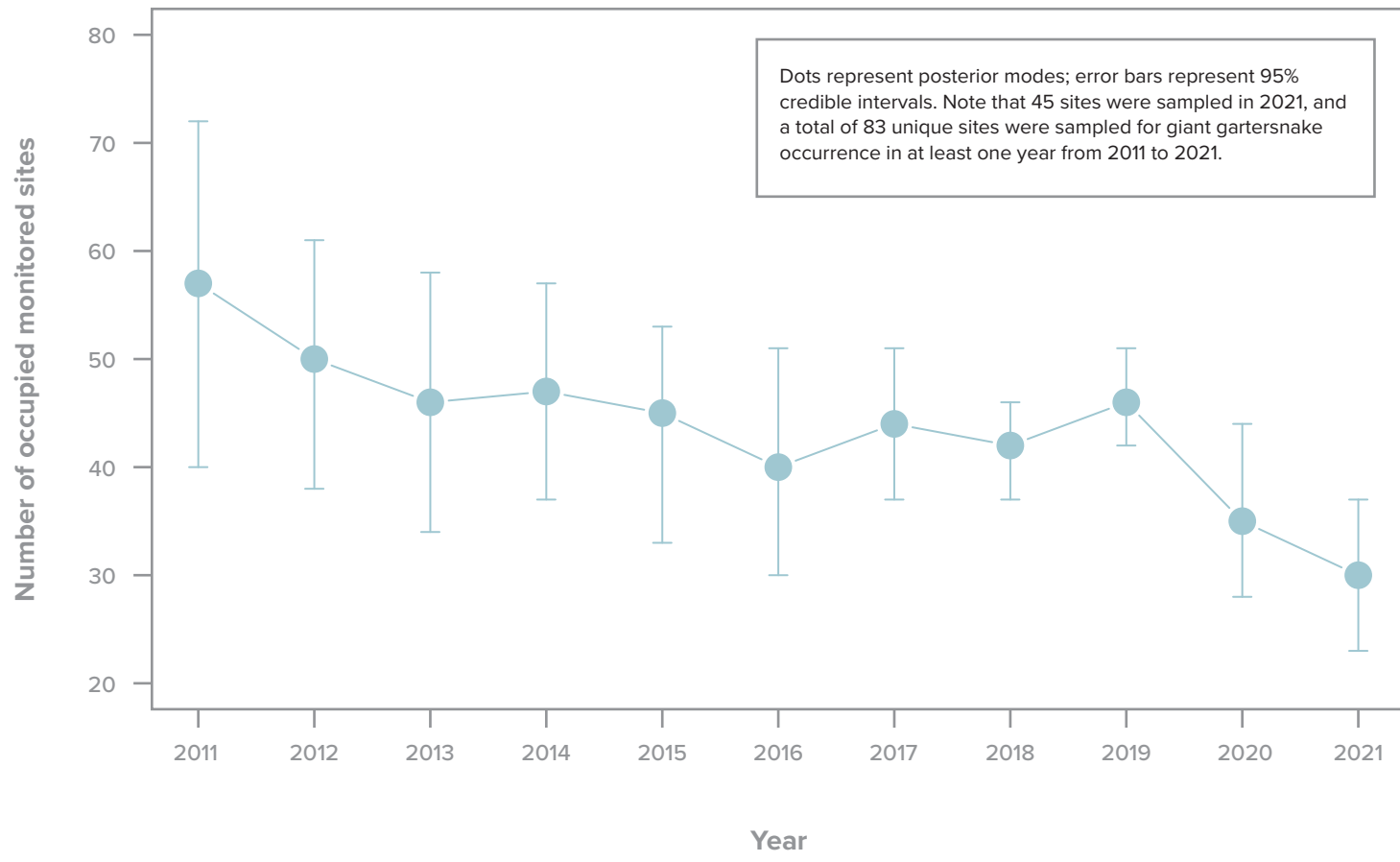
**FIGURE 3-15**  
Effect of (A) Water Temperature and (B) Date on the Detection Probability of  
Giant Gartersnake in the Natomas Basin, 2021



NBC104332 (3-12-2022)TG



**FIGURE 3-16**  
Annual Probability of Occurrence of Giant Gartersnake on Reserves Based on the Dynamic Occupancy Model

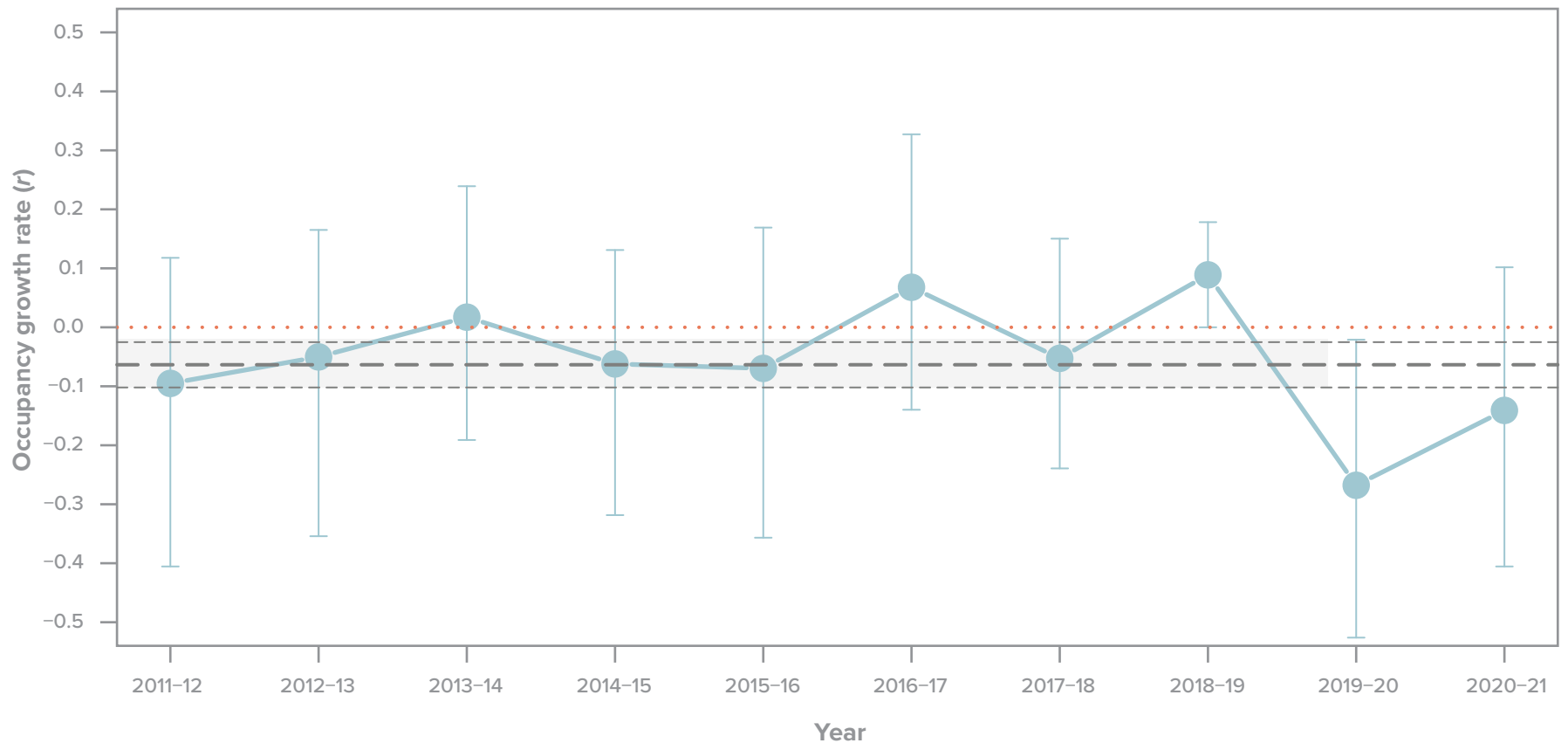
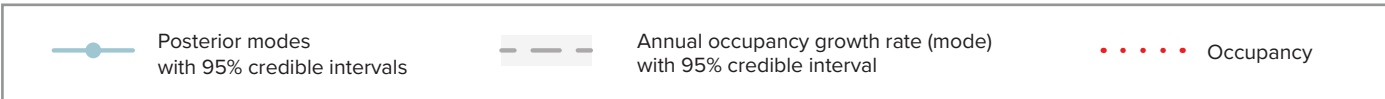


NBC104332 (3-9-2022)TG

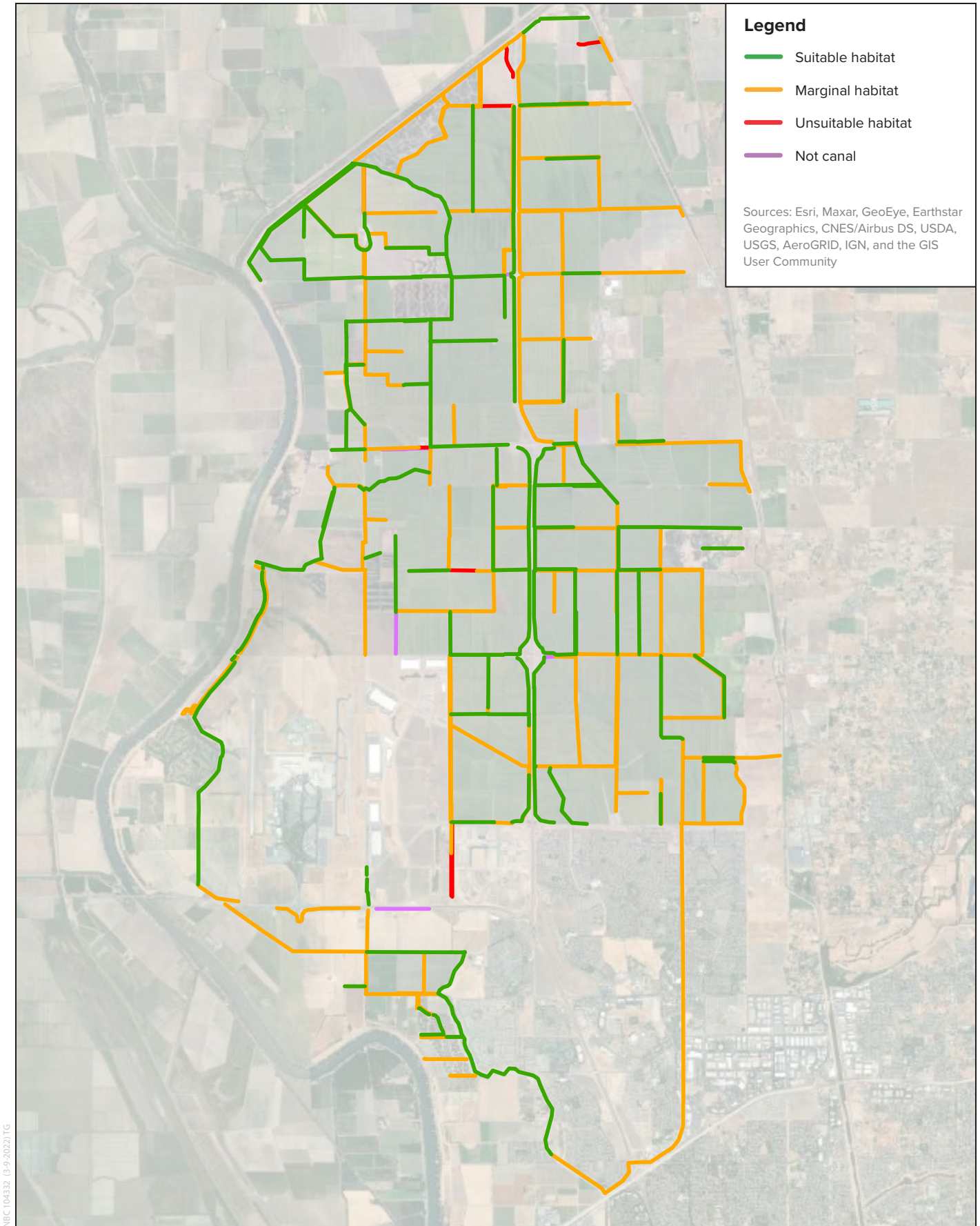


**FIGURE 3-17**  
 Estimated Number of Sampled Reserve Sites Occupied by Giant Gartersnake

NBC104332 (3-9-2022)TG



**FIGURE 3-18**  
Annual Intrinsic Rate of Occupancy Growth for Giant Gartersnake in Reserves, 2011–2021



NBC104332 (3-9-2022)TG



**FIGURE 3-19**  
 Suitability of Habitat in the Canals of the  
 Natomas Basin for Giant Gartersnake in 2021

*This Page Intentionally Left Blank*



### CHAPTER HIGHLIGHTS

- Following the second highest number of occupied territories in the Basin in 2020, the number of occupied territories dropped in 2021 to slightly above the monitoring period average.
- Following a significant rebound in 2020, measures of reproductive success dropped substantially, reporting the third lowest reproductive rate (number of young per occupied territory) during the monitoring period. A statistically significant long-term decline in the number of young produced per successful nest was still evident in 2021, 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 2021.

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 most recent (2005–2006) statewide survey conducted by CDFW and the Swainson's Hawk Technical Advisory Committee indicate the Central Valley currently supports an estimated 3,218 ( $\pm$  947) breeding pairs (Battistone et al. 2019), or between 19% and 80% of the historic population (Bloom 1980).

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 sites 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 early 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 2021. 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 148 current and historical Swainson's hawk nesting territories were monitored during 2021 (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 2021 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 ( $R^2 = 0.581$ ,  $P < 0.001$ , Figure 4-7). In total, 59 territories were occupied during 2021, just above the average of 56 occupied territories over the 21-year monitoring period.

The total number of occupied territories declined by 11 from 2020, which was the second largest drop in the number of occupied territories from year to year since comprehensive monitoring began in 2001. Although measures of reproductive success rebounded in 2020 from the lowest values recorded in 2019 since comprehensive monitoring began, most measures dropped substantially in 2021. The reproductive rate (number of young per occupied territory) dropped to the third lowest recorded over the 21-year monitoring period, and the number of young per successful nest (a measure of brood size) dropped to the lowest since monitoring began (Table 4-2, Figures 4-6 and 4-8). Forty-nine (83%) of the 59 occupied territories nested, and of these only 24 were successful while 25 failed. A total of 24 fledglings were fledged within the study area in 2021, or one young per successful nest. No successful nest had more than one young in 2021. As reported for 2019 and 2020 results, the low number of young produced per occupied territory in 2021 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.

Since 1999, there has been a statistically significant decrease in the number of young fledged per successful nest as measured by simple linear regression ( $R^2 = 0.570$ ,  $P < 0.001$ , 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 ( $R^2 = 0.226$ ,  $P = 0.046$ ).

In 2021, there were 27 active nesting territories along the Sacramento River, a decrease of four from 2020 (Table 4-3, Figure 4-10). Although the total number of nesting pairs along the Sacramento River fluctuates substantially from year to year ( $\bar{x} = 28.6$ ;  $SD = 3.8$ ), 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 59 active territories in 2021, 46 (78%) have one or more alternate nest sites. Of the 52 pairs that nested in 2021, four pairs selected alternate nest trees that had no previously documented use, and six 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.

Historic activity within the 59 active territories is variable but indicates the extent of territory fidelity and the tendency toward long-term occupancy. Twenty-three (39%) of the territories were first reported active during or before the first year of monitoring in 2001 and, although some have been inactive in some of the intervening years, most have been fairly consistently active throughout the entire 21-year monitoring period. Forty-two (71%) of the 59 active territories were first reported active prior to 2010.

No Swainson's hawk nest trees were removed in 2021; however, the nesting habitat for NB-73, which was last active in 2003, was removed in late 2019 due to the expansion of the Amazon distribution facility at Metro Airpark. 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 in 2021, 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 2021 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 2021, 20 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 more in 2018, and none from 2019–2021.

### 4.3.2 Habitat Assessment

The distribution of suitable Swainson's hawk foraging habitat in 2021 is shown on Figure 4-12. Basin-wide foraging habitat increased by 124 acres (1%) from 2020 to 2021 (Table 4-4). On-reserve suitable habitat increased by 261 acres (25%), attributable primarily to the new tracts added to the reserve system in 2021.

Changes from 2004 through 2021 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. Total Swainson's hawk foraging habitat in the Basin has remained highly variable during the monitoring period, primarily due to changes in the number of acres of fallow lands (mean = 4,106 acres, range: 823–10,101 acres). 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 ( $R^2 = 0.761$ ,  $P < 0.001$ ). 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 foraging habitat in the Basin ( $R^2 = 0.170$ ,  $P = 0.089$ ), the acreage of upland row and field crops ( $R^2 = 0.195$ ,  $P = 0.066$ ), or the total acreage of alfalfa each year ( $R^2 = 0.052$ ,  $P = 0.376$ ). However, the total number of occupied territories is negatively correlated with the total acres of grassland habitat in the Basin ( $R^2 = 0.392$ ,  $P = 0.005$ ). 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 2021. 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. Although alfalfa increased Basin-wide during 2020, the proportion of suitable foraging habitat comprising alfalfa is now substantially higher on reserve than on non-reserve lands (Table 4-5), in part because of new acquisitions in 2021 of reserve tracts composed of alfalfa. 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 slightly higher on non-reserve lands than reserve lands.

The reserve system currently accounts for approximately 8% 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 to 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. However, the extreme decline in reproductive metrics in 2019 and continuing low rate in 2020 and 2021 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 2021, and territory occupancy was relatively high, which may indicate that the extreme decline in reproductive performance is in some way 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. 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 2020 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, mostly because of urbanization, has historically contributed to the reduction in nesting territories in the south Basin. The 2008 moratorium on planned and proposed urbanization over the last several years because of levee-related restrictions from the U.S. Army Corps of Engineers (USACE) 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, and additional nesting pairs could be displaced.



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 2020. 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.

As noted above, airplane collision with birds at Sacramento International Airport (SMF) is also 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, began in 2019. The landside levee construction that will be 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. Although it is too early to reach conclusions regarding the overall effectiveness of the operating conservation program in conserving the population of Swainson's hawks that nest in the Basin, to date there have been no significant changes in the Basin-wide population beyond the expected loss of habitat and nesting pairs within development areas and the loss of potential nesting trees. However, additional population effects could become evident as urbanization of the Basin resumes 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. 2019 marked the first 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 second 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. In addition, TNBC has acted on recommendations in previous reports to experiment with growing crop types with high value to Swainson's hawks on marginal soils to further enhance the value of upland habitat for Swainson's hawks and to broaden the repertoire of management options available for providing high-quality foraging habitat.

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 will be managed to provide higher quality foraging habitat for Swainson's hawk, in keeping with past recommendations.

## 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 areas within 1 mile of the Sacramento River, 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.

## 4.7 References

- Airola, D. A., J. A. Estep, D. Krolick, D. Anderson, and J. Peters. 2019. Wintering Areas and Migration Characteristics of Swainson's Hawks that Breed in the Central Valley of California. *Journal of Raptor Research* 53(3):237-252.
- Anderson, D. A., J. L. Dinsdale, R. Schlorff, K. Fien, S. Torres, C. Chun, and J. Estep. In preparation. *Foraging Habitat Use Patterns of Swainson's Hawks in Agricultural Landscapes of the Central Valley, CA*. U.C. Davis Wildlife Health Center and the California Department of Fish and Game.
- Babcock, K. W. 1995. Home Range and Habitat Use of Breeding Swainson's Hawks in the Sacramento Valley of California. *Journal of Raptor Research* 29:193-197.
- Battistone, C. L., B. J. Furnas, R. L. Anderson, J. L. Dinsdale, K. M. Cripe, J. A. Estep, C. Chun, and S. G. Torres. 2019. Population and Distribution of Swainson's Hawk (*Buteo Swainsoni*) in California's Great Valley: A Framework for Long-Term Monitoring. *Journal of Raptor Research* 53(3):253-265.
- Bechard, M. J. 1982. Effect of Vegetative Cover on Foraging Site Selection by Swainson's Hawk. *Condor* 84:153-159.
- Bechard, M. J., C. S. Houston, J. H. Sarasola, and A. S. England. 2010. Swainson's Hawk (*Buteo swainsoni*). In A. Pool, (ed.), *The Birds of North America* online. Ithaca, NY: Cornell Lab of Ornithology. Available: <http://bna.birds.cornell.edu/bna/species/265>.

- Bloom, P. H. 1980. *The Status of the Swainson's Hawk in California*. California Department of Fish and Game, Nongame Wildlife Investigations. Project Report W-54-R-12, 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.
- County of Sacramento. 2006. *Final Environmental Report for the Yuki Pear Orchard Removal*. Sacramento, CA: Department of Environmental Review and Assessment.
- England, A. S., M. J. Bechard, and C. S. Houston. 1997. Swainson's Hawk (*Buteo swainsoni*). In A. Poole and F. Gill (eds.), *The Birds of North America*, No. 265. Philadelphia, PA: The Academy of Natural Sciences and Washington, DC: The American Ornithologists' Union.
- Estep, J. A., and J. Dinsdale. 2012. Distribution, Abundance, and Habitat Associations of Nesting Swainson's Hawks in the Central San Joaquin Valley. *Central Valley Bird Club Bulletin* 15:84–106.
- Estep unpublished data.
- Estep, J. A. 1984. *Diurnal Raptor Eyrie Monitoring Program*. California Department of Fish and Game, Nongame Wildlife Investigations. Project Report W-65-R-1, Job No. II-2.0. Sacramento, CA.
- . 1989. *Biology, Movements, and Habitat Relationships of the Swainson's Hawk in the Central Valley of California, 1986–1987*. California Department of Fish and Game, Nongame Bird and Mammal Section, Sacramento, CA.
- . 2007. *The Distribution, Abundance, and Habitat Associations of Swainson's Hawk (Buteo swainsoni) in South Sacramento County*. Prepared for the City of Elk Grove, CA.
- . 2009. *The Influence of Vegetation Structure on Swainson's Hawk (Buteo Swainsoni) Foraging Habitat Suitability in Yolo County, CA*. Prepared for the Yolo Natural Heritage Program, Woodland, CA.
- . 2020. *The 2020 Distribution, Abundance, and Habitat Associations of the Swainson's Hawk (Buteo Swainsoni) in Yolo County, CA*. Prepared for the Yolo Habitat Conservancy, Woodland, CA.
- . In preparation. *Ecology of the Swainson's Hawk in the Central Valley of California*.
- Fleishman, E., J. Anderson, B. G. Dickson, D. R. Krolick, J. A. Estep, R. L. Anderson, C. Elphick, D. S. Dobkin, and D. A. Bell. 2016. Space Use by Swainson's Hawks (*Buteo swainsoni*) in the Natomas Basin, California. *Collabra* 2:1–12.
- Houston, C. S. and J. K. Schmutz. 1995. Declining reproduction among Swainson's Hawks in prairie Canada. *J. Raptor Res.* 29:198–201.
- ICF. 2019. *Biological Effectiveness Monitoring for the Natomas Basin Habitat Conservation Plan Area 2018 Annual Survey Results*. Agency Final. April. (ICF 00890.10.) Sacramento, CA. Prepared for The Natomas Basin Conservancy, Sacramento, CA.
- Katibah, E. F. 1983. A Brief History of Riparian Forests in the Central Valley of California. Pages 23–29 in R. E. Warner, and K. M. Hendrix (eds.), *California Riparian Systems: Ecology, Conservation, and Productive Management*. Berkeley, CA: University of California Press.

- Kochert, M. N., M. R. Fuller, L. S. Schueck, L. Bond, M. J. Bechard, B. Woodbridge, G. L. Holroyd, M. S. Martell, and U. Banasch. 2011. Migration Patterns, Use of Stopover Areas, and Austral Summer Movements of Swainson's Hawks. *The Condor* 113(1):89–106.
- N. Nur, D. Jongsomjit, and S. Veloz. 2019. *Swainson's Hawk Foraging Study: Analysis of Foraging in Relation to Crop Characteristics in the Central Valley, California*. Technical Report to Swainson's Hawk Technical Advisory Committee. Point Blue Conservation Science, Petaluma, CA.
- Sacramento County Airport System. 2007. *Wildlife Hazard Management Plan*. Sacramento County Airport System, Sacramento, CA.
- Schlorff, R., and P. H. Bloom. 1984. Importance of Riparian Systems to Nesting Swainson's Hawks in the Central Valley of California. Pages 612–618 in R. E. Warner, and K. M. Hendrix (eds.), *California Riparian Systems: Ecology, Conservation, and Productive Management*. Berkeley, CA: University of California Press.
- Sharp, C. S. 1902. Nesting of Swainson's Hawk. *The Condor* 4:116–118.

**Table 4-1. Results of 2021 Swainson's Hawk Surveys, NBHCP Area**

Territory Number	Status <sup>a</sup>	Number of Young	Nesting Habitat	Nest Tree Species <sup>b</sup>
NB-1	A-X		Urban	Valley oak
NB-2	A-X		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	Cottonwood
NB-11	I		Riparian	Valley oak
NB-12	A-F	0	Riparian	Willow
NB-13	A-F	0	Riparian	Alder
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-S	1	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-S	1	Riparian	Willow
NB-30	A-S	1	Riparian	Cottonwood
NB-31	I		Riparian	Willow
NB-32	A-F	0	Riparian	Willow
NB-33	I		Riparian	Cottonwood
NB-34	I		Riparian	Cottonwood
NB-35	I		Riparian	Cottonwood
NB-36	A-F	0	Riparian	Cottonwood
NB-37	I		Riparian	Cottonwood
NB-38	I		Riparian	Cottonwood
NB-39	I		Riparian	Willow
NB-40	A-S	1	Riparian	Willow
NB-41	I		Riparian	Willow

Table 4-1 Continued

Territory Number	Status <sup>a</sup>	Number of Young	Nesting Habitat	Nest Tree Species <sup>b</sup>
NB-42	I		Riparian	Cottonwood
NB-43	A-S	1	Riparian	Cottonwood
NB-44	A-S	1	Riparian	Cottonwood
NB-45	I		Riparian	Cottonwood
NB-46	I		Riparian	Cottonwood
NB-47	I		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-F	0	Riparian	Cottonwood
NB-53	I		Riparian	Cottonwood
NB-54	I		Riparian	Cottonwood
NB-55	A-S	1	Riparian	Cottonwood
NB-56	A-S	1	Riparian	Cottonwood
NB-57	A-S	1	Riparian	Cottonwood
NB-58	I		Riparian	Cottonwood
NB-59	A-S	1	Riparian	Cottonwood
NB-60	A-X		Riparian	Cottonwood
NB-61	I		Riparian	Cottonwood
NB-62	I		Riparian	Cottonwood
NB-63	I		Isolated tree	Willow
NB-64	A-F	0	Riparian	Cottonwood
NB-65	A-S	1	Cottonwood grove	Cottonwood
NB-66	I		Riparian	Cottonwood
NB-67	I		Riparian	Cottonwood
NB-68	A-X		Riparian	Cottonwood
NB-69	I		Urban ornamental	Willow
NB-70	I		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-S	1	Riparian	Cottonwood
NB-76	NLE		Tree row—removed in 2004	Cottonwood
NB-77	I		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 <sup>a</sup>	Number of Young	Nesting Habitat	Nest Tree Species <sup>b</sup>
NB-83	I		Riparian	Willow
NB-84	I		Riparian	Cottonwood
NB-85	A-F	0	Riparian	Cottonwood
NB-86	A-F	0	Riparian	Cottonwood
NB-87	I		Riparian	Cottonwood
NB-88	A-U		Riparian	Cottonwood
NB-89	I		Riparian	Valley oak
NB-90	I		Riparian	Willow
NB-91	A-F	0	Riparian	Willow
NB-92	I		Riparian	Cottonwood
NB-93	I		Riparian	Cottonwood
NB-94	A-F	0	Riparian	Cottonwood
NB-95	I		Riparian	Valley oak
NB-96	A-F	0	Riparian	Cottonwood
NB-97	I		Tree row	Eucalyptus
NB-98	A-X		Tree row	Eucalyptus
NB-99	I		Urban	Ornamental pine
NB-100	I		Riparian	Walnut
NB-101	I		Riparian	Cottonwood
NB-102	I		Riparian	Cottonwood
NB-103	A-S	1	Riparian	Cottonwood
NB-104	A-S	1	Riparian	Cottonwood
NB-105	A-U		Riparian	Cottonwood
NB-106	A-F	0	Roadside	Cottonwood
NB-107	I		Riparian	Cottonwood
NB-108	A-F	0	Ornamental (freeway rest stop)	Cottonwood
NB-109	I		Tree row	Valley oak
NB-110	A-S	1	Riparian	Cottonwood
NB-111	I		Tree Row	Cottonwood
NB-112	I		Riparian	Valley oak
NB-113	A-X		Riparian	Cottonwood
NB-114	I		Channelized riparian/tree row	Valley oak
NB-115	I		Riparian	Willow
NB-116	I		Cottonwood grove	Cottonwood
NB-117	I		Riparian	Cottonwood
NB-118	I		Tree row	Valley oak
NB-119	A-S	1	Channelized riparian/tree row	Cottonwood
NB-120	I		Channelized riparian/tree row	Valley oak
NB-121	A-S	1	Rural residential	Walnut
NB-122	A-X		Tree row	Valley oak
NB-123	I		Isolated tree	Cottonwood



**Table 4-1 Continued**

Territory Number	Status <sup>a</sup>	Number of Young	Nesting Habitat	Nest Tree Species <sup>b</sup>
NB-124	A-F	0	Riparian	Cottonwood
NB-125	I		Riparian	Valley oak
NB-126	A-S	1	Riparian	Cottonwood
NB-127	A-F	0	Riparian	Willow
NB-128	A-F	0	Riparian	Alder
NB-129	A-F	0	Roadside tree row	Willow
NB-130	I		Isolated tree	Locust
NB-131	I		Riparian	Cottonwood
NB-132	A-S	1	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	Willow
NB-136	I		Cottonwood grove	Cottonwood
NB-137	I		Riparian	Valley oak
NB-138	A-F	0	Tree row	Valley oak
NB-139	I		Isolated roadside tree	Eucalyptus
NB-140	A-F	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	A-F	0	Rural residential	Eucalyptus
NB-147	I		Riparian	Willow
NB-148	A-F	0	Isolated roadside tree	Willow

<sup>a</sup> A = active; I = inactive; NLE = no longer extant; S = successful; F = failed; X = did not nest; U = undetermined.  
<sup>b</sup> 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, 1999–2021**

Year	Occupied Territories <sup>b</sup>	Successful Nests	Unsuccessful Nests	Occupied but Not Nesting	Un-confirmed Nesting Status	Number Young Reared to Fledging	Number Young per Occupied Territory <sup>c</sup>	Number Young per Active Nest <sup>c, d</sup>	Number Young per Successful Nest <sup>c</sup>
1999 <sup>a</sup>	15	14	1	0	0	25	1.67	1.67	1.79
2000 <sup>a</sup>	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	1.17	1.28	1.39
2018	69	48	9	5	7	70	1.01	1.23	1.46
2019	71	5	33	26	7	5	0.07	0.13	1.00
2020	70	50	8	3	9	54	0.77	0.93	1.08
2021	59	24	25	7	3	24	0.41	0.49	1.00

<sup>a</sup> Years 1999 and 2000 do not include the Sacramento River territories.

<sup>b</sup> 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.

<sup>c</sup> Does not include pairs with unconfirmed nesting status.

<sup>d</sup> Active nest = number of successful nests + number of unsuccessful nests.

**Table 4-3. Number of Active Territories on the Sacramento River, 2001–2021**

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

**Table 4-4. Swainson's Hawk Foraging Habitat in the NBHCP Area (acres), 2004–2021**

Habitat Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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
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
Grasslands <sup>a</sup>	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
<b>Total</b>	<b>16,921</b>	<b>16,957</b>	<b>23,826</b>	<b>23,621</b>	<b>23,830</b>	<b>23,355</b>	<b>21,628</b>	<b>22,031</b>	<b>20,792</b>	<b>19,088</b>	<b>18,166</b>	<b>18,007</b>	<b>17,759</b>	<b>21,890</b>	<b>19,341</b>	<b>19,348</b>	<b>16,114</b>	<b>16,239</b>

<sup>a</sup> 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, 2021**

	Alfalfa	Row, Grain, and Other Hay Crops <sup>a</sup>	Grasslands <sup>b</sup>	Fallow	Total
On-reserve acreage (acres)	321	484	290	213	<b>1,308</b>
On-reserve percentage of cover type (%)	25%	37%	22%	16%	<b>100%</b>
Off-reserve acreage (acres)	459	7,520	3,751	3,201	<b>14,931</b>
Off-reserve percentage of cover type (%)	3%	50%	25%	21%	<b>100%</b>
<b>Total</b>	<b>780</b>	<b>8,004</b>	<b>4,041</b>	<b>3,414</b>	<b>16,239</b>

<sup>a</sup> Row, grain, and other hay crops includes the grass hay and irrigated grassland land cover type.

<sup>b</sup> Grasslands include the grasslands (created), nonnative annual grassland, and ruderal land cover types.

This page intentionally left blank



NBC 104332 (3-12-2022)



**FIGURE 4-1**  
Swainson's Hawk



NBC 104332 (3-12-2022)



**FIGURE 4-2**  
Swainson's Hawk Range



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

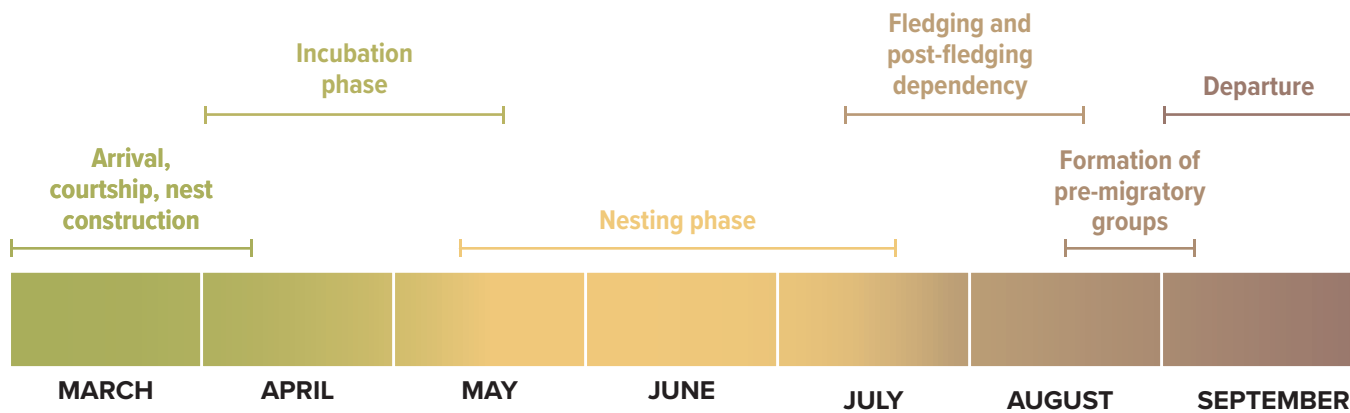


Typical Swainson's hawk nest

NBC 104332 (3-12-2022)



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



NBC 104332 (3-12-2022)



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





Swainson's hawk nest with eggs



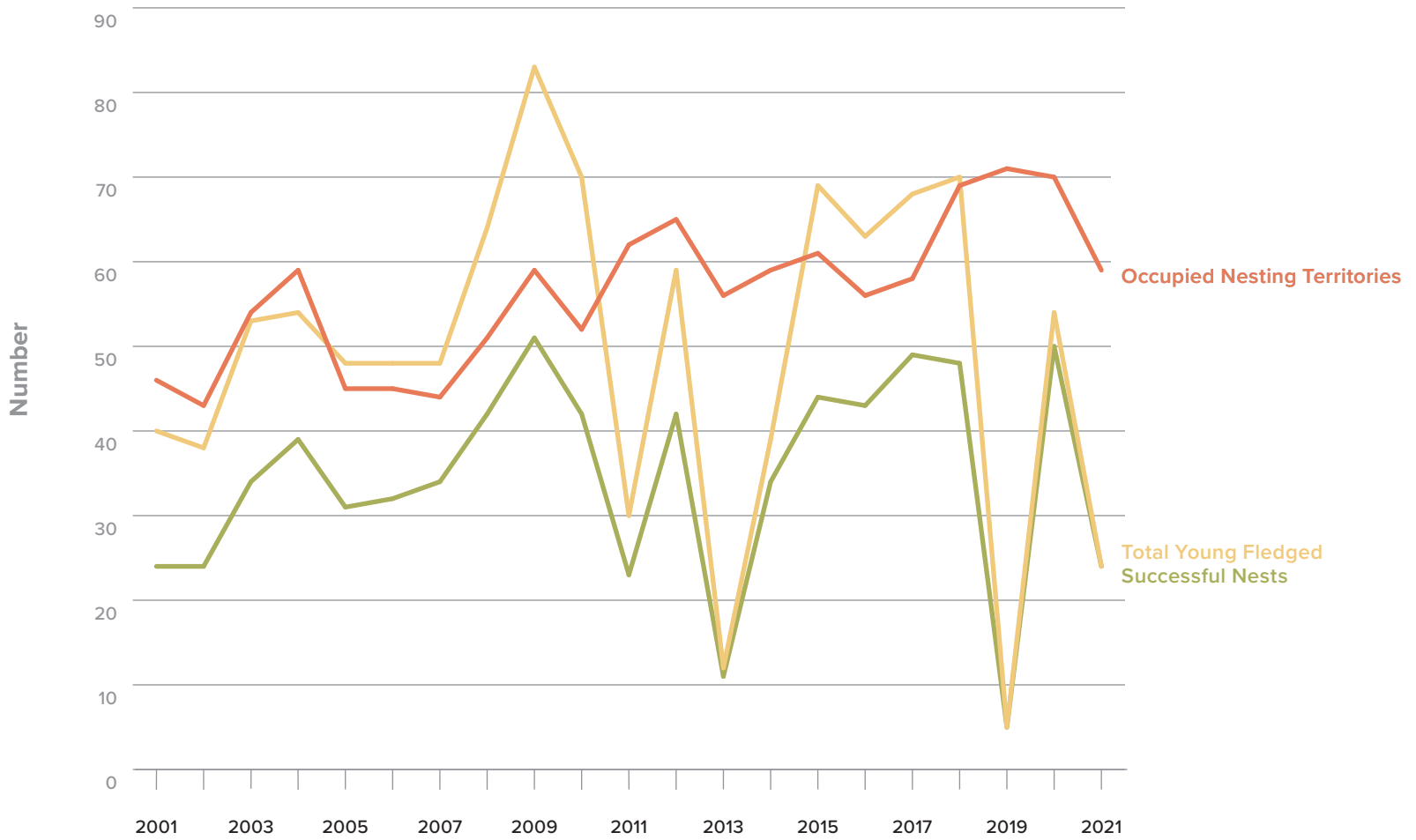
Nestling Swainson's hawks



Nearly fledged Swainson's hawks

NBC 104332 (3-12-2022)

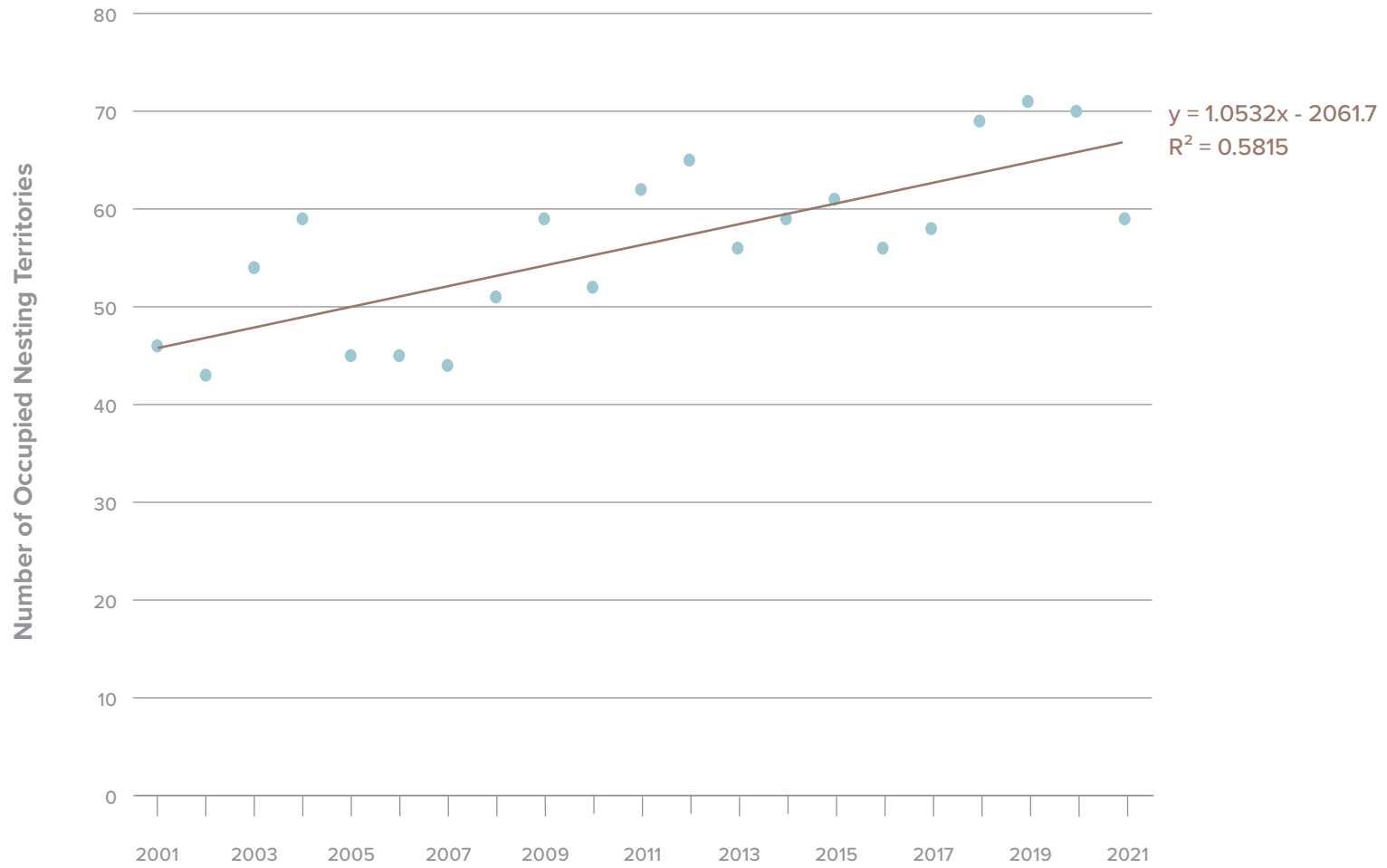
**FIGURE 4-5**  
Swainson's Hawk in the Nest



NBC 104332 (3-12-2021)



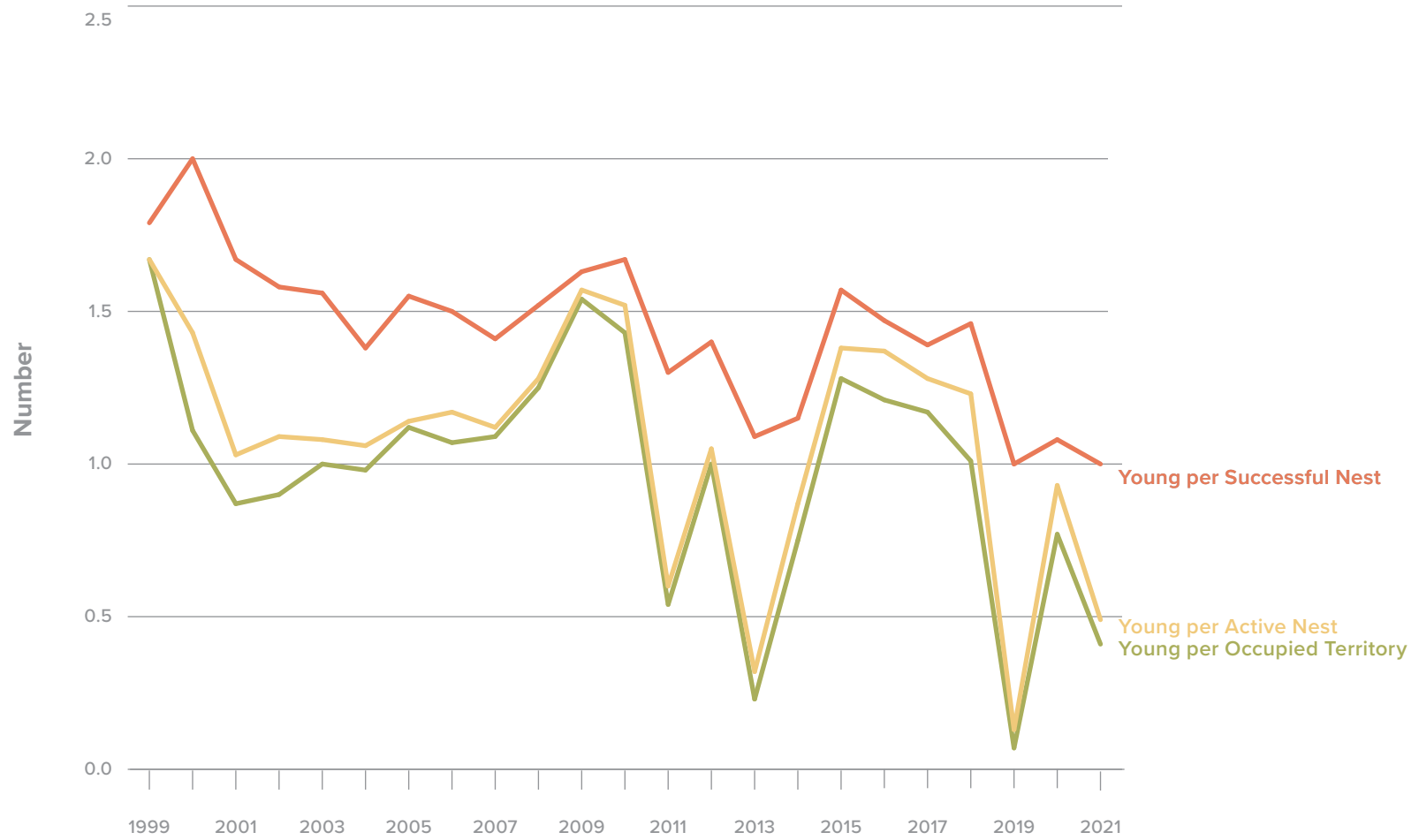
**FIGURE 4-6**  
 Number of Occupied Swainson's Hawk Nesting Territories, Successful Nests, and  
 Total Young Fledged in the Natomas Basin, 2001–2021



NBC 104332 (3-12-2022)



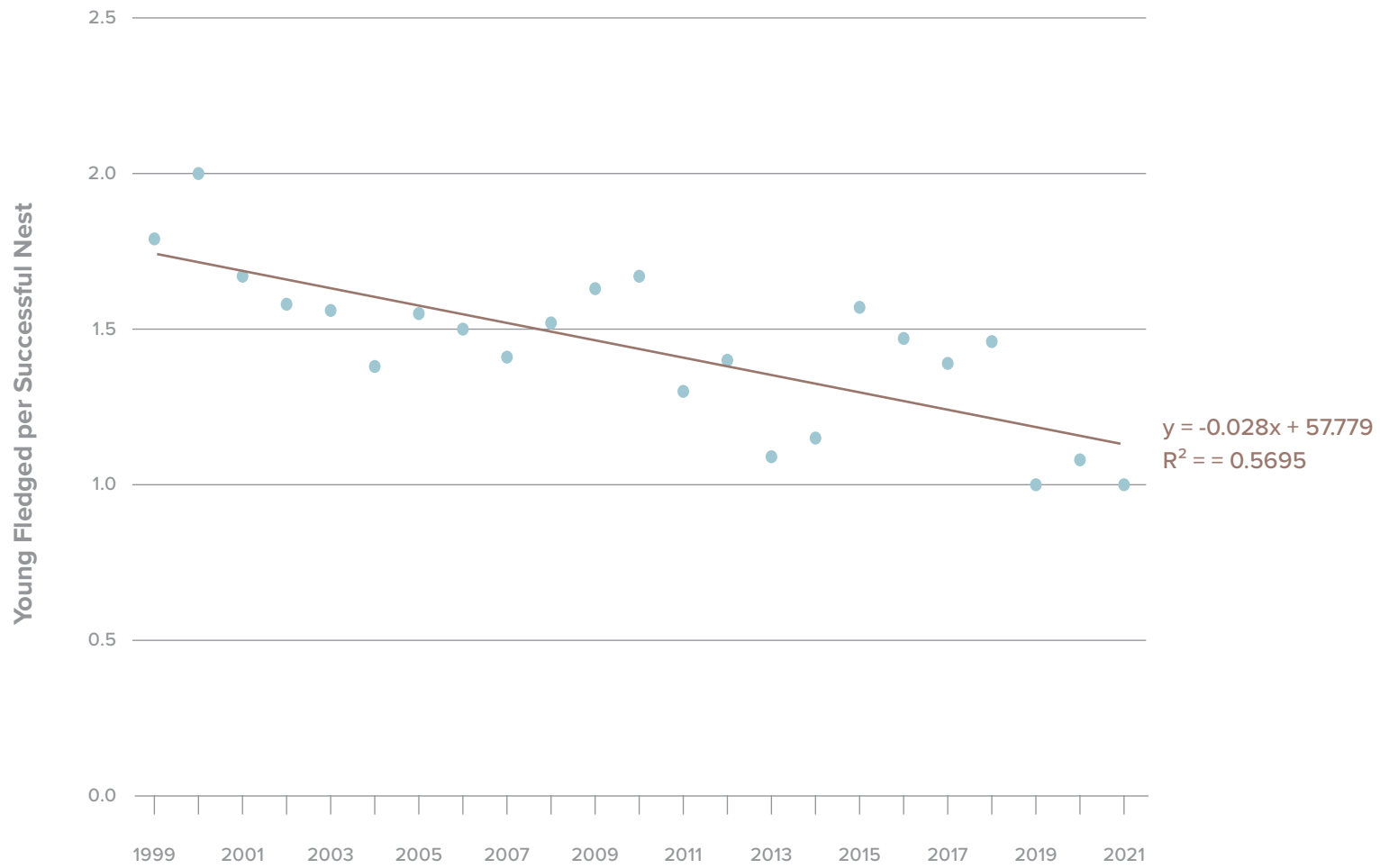
**FIGURE 4-7**  
Trends in the Number of Occupied Territories in the  
Natomas Basin Nesting Population, 2001–2021



NBC 104332 (3-12-2021)



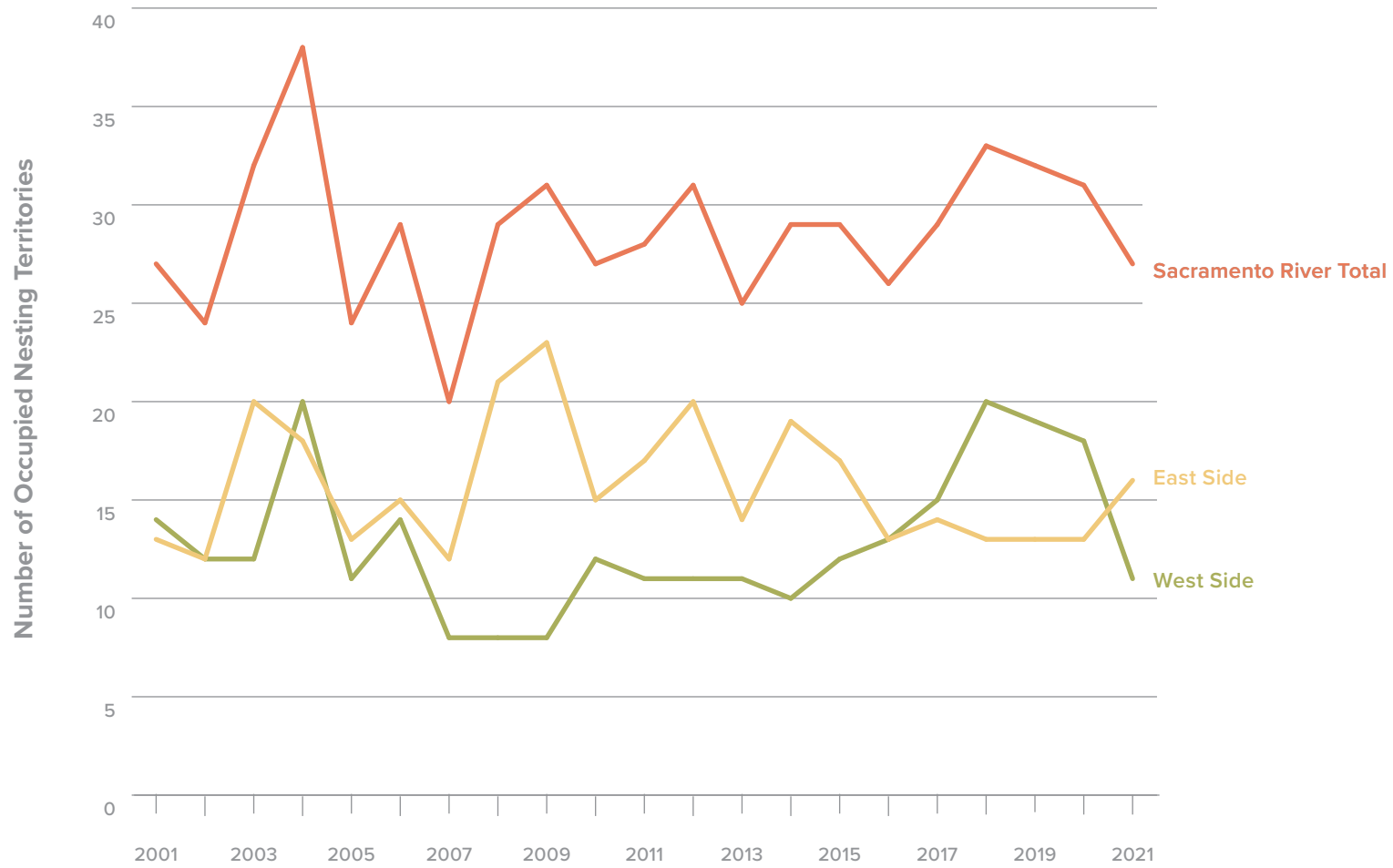
**FIGURE 4-8**  
 Various Measures of Swainson's Hawk Reproductive  
 Success in the Natomas Basin, 1999–2021



NBC 104332 (3-12-2021)



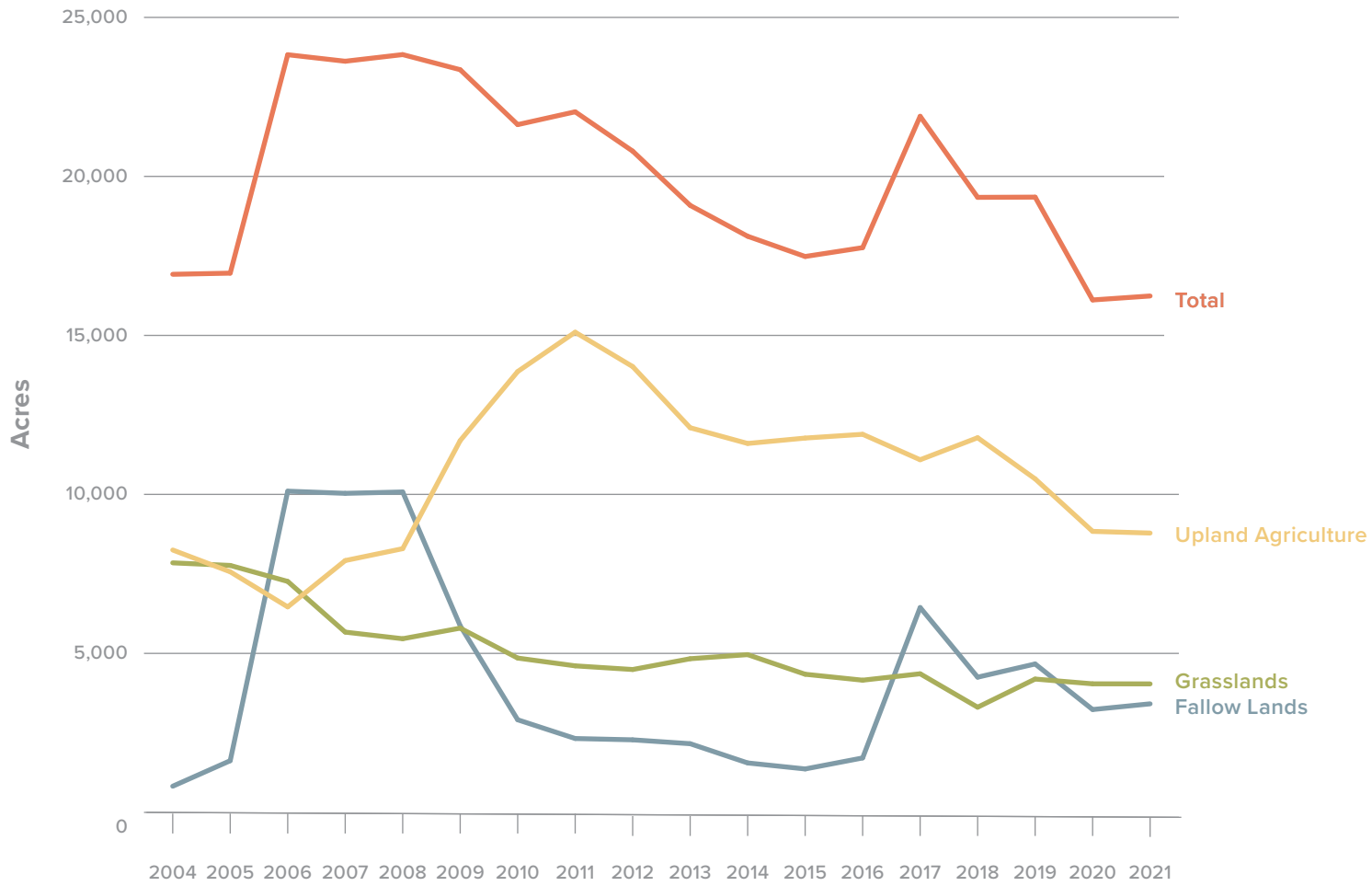
**FIGURE 4-9**  
Trends in the Number of Young Fledged per Successful Nest in the Breeding Population of Swainson's Hawk in the Natomas Basin, 1999–2021



NBC 104332 (3-12-2021)



**FIGURE 4-10**  
 Number of Occupied Swainson's Hawk Nesting Territories  
 along the Sacramento River in the Natomas Basin, 2001–2021

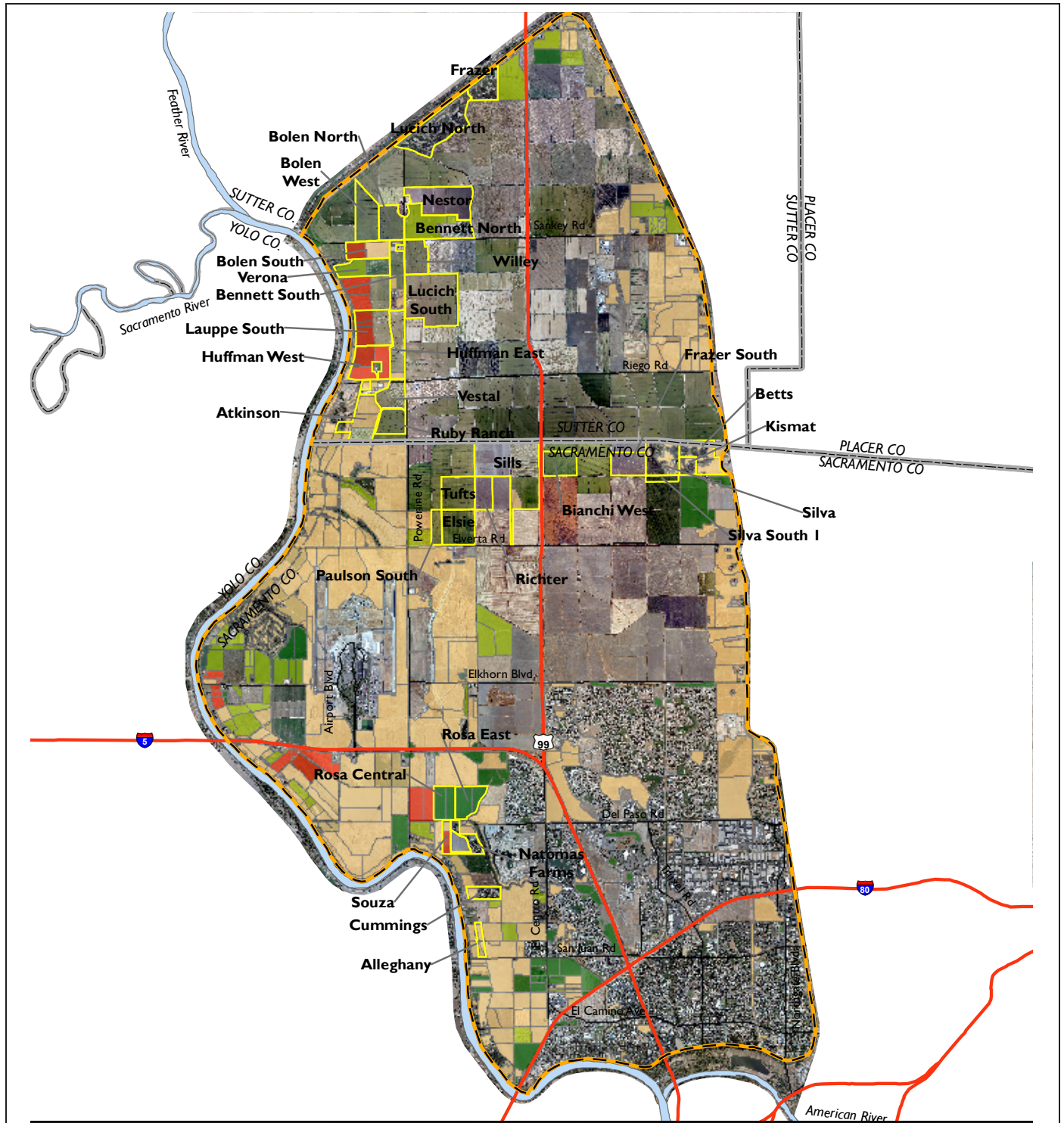


NBC 104332 (3-12-2022)



**FIGURE 4-11**  
 Changes in the Abundance of Three Categories of Swainson's Hawk Foraging Habitat in the Natomas Basin, 2004–2021





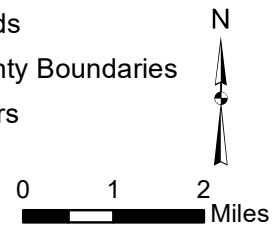
**Legend**

**Swainson's Hawk Foraging Habitat**

- High Value
- Moderate Value
- Moderate/Low Value
- Low Value

- Reserve Lands
- NBHCP Area Boundary
- Major Roads

- Roads
- County Boundaries
- Rivers



NBC104332 (3-14-2022).TG



**FIGURE 4-12**  
Distribution of Suitable Swainson's Hawk Foraging Habitat, 2021



# 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 at least 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 to the point where they now rarely occur. Providing potential nesting habitat in areas with little to no disturbance and any management action that could increase insect prey are management actions most likely to contribute to the effectiveness of reserve lands in supporting loggerhead shrikes in the Basin.
- White-faced ibis continue to use reserve lands and non-reserve lands in the Basin extensively. A large nesting colony was established in 2021 on the Willey Wetlands. 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 difficult 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 trends in that proportion 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).

Surveys were conducted on newly acquired reserve tracts in 2021. Surveys on the Willey tract in the North Basin Reserve and the Paulsen South and Richter tracts in the Central Basin Reserve began in January. Surveys on the Verona and Lauppe South tracts of the North Basin Reserve began in April.

Observations of Covered Species on non-reserve lands or outside of formal survey periods were recorded separately as incidental observations. Pacific pond turtle detections are recorded during

avian surveys, in particular along marsh shorelines with suitable basking habitat and other areas where turtles congregate to bask.

## 5.2.2 Surveys on SAFCA Reserves

Monitoring of SAFCA mitigation lands began in 2015. These lands consist primarily of fresh emergent marsh constructed in soil-mined areas as part of the NLIP. Two of the three tracts also contain an upland agriculture field. One of the primary differences between the SAFCA marshes and other marsh complexes created and managed by TNBC is that these marshes were constructed below grade. Another difference is that the new marshes are considerably younger and have been fully functional in terms of habitat development for a shorter period of time. However, the survey methods used are identical to the survey methods used on TNBC reserve lands.

## 5.2.3 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.

## 5.2.4 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 species detected on reserves since comprehensive monitoring began is provided in Appendix C-1. The numbers of each species detected by tract and reserve during surveys for Other Covered Species in 2021 are provided in Appendix C-2.

### 5.3.1 Generalized Avian Surveys

In 2021, 123 avian species were detected on reserves compared to 118 in 2020, 114 in 2019 and 119 in 2018. 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 2021. A long-tailed weasel was observed on the Lucich South tract in April and a Baird's sandpiper was detected on the Nestor tract in late July. Table 5-1 summarizes the total number of individuals and number of avian species recorded from 2019 through 2021 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 chain 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). A significant overall decline in raptor detections has occurred over the course of the monitoring period ( $R^2=0.374$ ,  $P=0.009$ ) but not over the last 11 years ( $R^2=0.004$ ,  $P=0.837$ ). The decline in raptors as a group is due primarily to declines in the number of detections of northern harrier ( $R^2=0.592$ ,  $P<0.001$ ) and American kestrel ( $R^2=0.609$ ,  $P<0.001$ ). Although no decline is evident for American kestrel over the last 11 years, the decline in northern harriers since 2010 is statistically significant ( $R^2=0.505$ ,  $P=0.010$ ).

The largest mean numbers of raptors detected per survey across all years were observed on the BKS (0.325 raptor per survey) and Atkinson tracts (0.217 raptor per survey), followed by Lucich South (0.130 raptor per survey) and Lucich North (0.126 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.

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 ( $R^2=0.071$ ,  $P=0.300$ ). However, numbers of greater white-fronted goose have increased significantly over the last 11 years ( $R^2=0.615$ ,  $P=0.003$ ) while the number of mallards has declined significantly over the last 10 years ( $R^2=0.541$ ,  $P=0.006$ ) (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 (the Verona tract, first surveyed in 2021, had the third highest number of waterfowl). 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 2021, there has been no significant increase or decrease in the numbers of neotropical migrant detections over the monitoring period ( $R^2=0.030$ ,  $P=0.508$ ). 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.

Similar to cliff swallows, there has been no significant increase or decrease in western kingbird detections over the last 11 years ( $R^2=0.014$ ,  $P=0.711$ ) (Figure 5-4). Conversely, the numbers of detections of barn swallows and tree swallows have decreased significantly over the last 11 years ( $R^2=0.738$ ,  $P<0.001$  and  $R^2=0.709$ ,  $P=0.001$ , respectively) (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 and western sandpipers are the most abundant shorebirds on reserve lands. Shorebird detections have decreased significantly over the last 11 years ( $R^2=0.384$ ,  $P=0.032$ ). Long-billed dowitcher, dunlin, and least and western sandpiper numbers show no evidence of an increase or decrease over the last 11 years. In contrast, killdeer exhibit a significant decline in the mean number detected per survey over the last 11 years ( $R^2=0.832$ ,  $P<0.001$ ) (Figure 5-5).

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

### 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 ( $R^2=0.834$ ,  $P<0.001$ ) as well as over the last 11 years ( $R^2=0.776$ ,  $P<0.001$ ). The number of detections has stabilized since 2016 at a value 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 individuals observed per survey over the last 11 years ( $R^2=0.543$ ,  $P=0.006$ ).

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 ( $R^2=0.589$ ,  $P<0.001$ ) and over the last 10 years ( $R^2=0.651$ ,  $P=0.002$ ; Figure 5-6). Canada geese now regularly nest on several reserve tracts, including the BKS, Lucich North, Frazer, Bennett North, and Bennet South tracts.

### 5.3.1.6 Surveys on SAFCA Reserves

Monthly reserve surveys began on the AKT, Sharma, and Natomas Farms West tracts—which were created by SAFCA in July 2015. These newly created marshes were considered fully functional in terms of habitat values at the end of 2014. Here, we report on the 6 full years of monitoring from 2016 through 2021. We compared species richness and abundance between these sites (referred to as *SAFCA sites*) and the TNBC tracts with created marsh habitats in the Fisherman’s Lake Reserve (i.e., the Cummings and Natomas Farms tracts, referred to as *TNBC sites*).

In total, 76 bird species and five mammals were detected on SAFCA sites, compared to 86 bird species and seven mammal species on TNBC sites from 2016 through 2020. Species found on TNBC sites that were not found on SAFCA sites tended to be riparian species that are regularly detected in the oak woodland and riparian habitats on TNBC sites that are not found on SAFCA sites.

The mean number of waterfowl detections per survey was significantly higher on SAFCA sites than on TNBC sites ( $t_{9,984} = 6.904$ ,  $P<0.001$ ). Waterfowl species that tended to be more abundant on SAFCA than TNBC sites are mallard ( $t_{317} = 3.79$ ,  $P<0.001$ ) and wood duck ( $t_{317} = 3.673$ ,  $P<0.001$ ). SAFCA sites also tended to have more American coot ( $t_{317} = 4.355$ ,  $P<0.001$ ) and common gallinule ( $t_{317} = 9.471$ ,  $P<0.001$ ) detections per survey.

TNBC sites tended to have greater numbers of shorebirds than SAFCA sites, although not significantly so ( $t_{4,603} = 1.711$ ,  $P=0.087$ ).

There were significantly more neotropical migrant detections per survey as a group on SAFCA sites than TNBC sites ( $t_{7,07348} = 2.418$ ,  $P=0.016$ ). However, this was due in part to the large number of cliff swallows nesting under the water control feature on the canal between the AKT and Sharma tracts that controls water flow into Fisherman’s Lake. Several species such as barn swallows and ruby crowned kinglets were more abundant on TNBC sites than on SAFCA sites.

There were significantly more raptors detected per survey on TNBC than on SAFCA sites ( $t_{5,958} = 8.124$ ,  $P<0.001$ ). The mean number of detections per survey for most raptor species was higher on TNBC than on SAFCA sites, significantly so for American kestrels ( $t_{317} = 2.437$ ,  $P=0.015$ ), Cooper’s hawk ( $t_{317} = 2.196$ ,  $P=0.029$ ), red-shouldered hawk ( $t_{317} = 4.263$ ,  $P<0.001$ ), red-tailed hawks ( $t_{317} = 6.139$ ,  $P<0.001$ ), White-tailed kite ( $t_{317} = 3.695$ ,  $P<0.001$ ), and Swainson’s hawk ( $t_{317} = 2.619$ ,  $P=0.009$ ).

## 5.3.2 Other Covered Species

Of the 20 Other Covered Species, 5 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*).

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 is a year-round resident in the Natomas Basin and can be 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 decreased again in 2021. The decline in shrike detections on reserve lands since 2010 have been significant ( $R^2=0.490$ ,  $P<0.011$ ).

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 ( $R^2=0.820$ ,  $P<0.001$  and  $R^2=0.892$ ,  $P<0.001$ , respectively; Table 5-4; Figure 5-7).

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. No shrikes were detected during Basin-wide surveys in 2020.

In 2021, a single shrike was detected once on the Ruby Ranch tract of the North Basin Reserve. No shrikes were detected during Basin-wide surveys in 2021.



### 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. Over the monitoring period, 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 or over the last 11 years. The mean number of ibis detected per survey has remained relatively stable since the nesting colony at BKS was abandoned, although 2021 saw a significant increase in the mean number observed per survey and the proportion of surveys in which ibis were detected (Table 5-3, Figure 5-8).

Conversely, there appears to be a slight increase in the mean number of ibis detected per survey on non-reserve lands, although it is not statistically significant ( $R^2=0.192$ ,  $P=0.079$ ), and the proportion of surveys on which ibis was detected exhibits a significant increase over the monitoring period and the last 11 years ( $R^2=0.424$ ,  $P=0.005$  and  $R^2=0.530$ ,  $P=0.007$ , respectively) (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 occasionally 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. This 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. In 2021, Tricolored blackbirds did not nest in the Basin.

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.

Neither the mean number of tricolored blackbirds detected per survey nor the proportion of surveys on which tricolored blackbirds were detected on reserve lands exhibits any significant increase or decrease over time (Figure 5-9).

Similarly, the mean number of tricolored blackbirds detected per survey on non-reserve lands exhibits no significant increase or decrease over time (Figure 5-9). However, the proportion of surveys on which tricolored blackbirds were detected on non-reserve lands has increased significantly over the monitoring period and over the last 11 years ( $R^2=0.424$ ,  $P=0.005$  and  $R^2=0.530$ ,  $P=0.007$ , respectively) (Figure 5-9).

### 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. However, owls were not detected again on reserve lands until December, when a single owl was detected 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 occupies 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 9 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 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 3 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 7 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.

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.

The mean number of burrowing owls detected per survey and the proportion of surveys on which owls were detected on reserve lands exhibit statistically significant decreases over the last 11 years ( $R^2=0.457$ ,  $P=0.016$  and  $R^2=0.527$ ,  $P=0.007$ , respectively) (Table 5-3, Figure 5-10).

Similarly, the mean number of burrowing owls detected per survey on non-reserve lands exhibits a statistically significant decrease over the last 11 years ( $R^2=0.705$ ,  $P<0.001$ ), although no such decline is evident in the proportion of surveys on which owls were detected ( $R^2=0.242$ ,  $P=0.104$ ) (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 South, and Frazer tracts of the North Basin Reserve.

Although the mean number of pond turtles detected per survey on reserve lands no longer exhibits a significant increase over the last 11 years ( $R^2=0.203$ ,  $P=0.142$ ), the proportion of surveys on which pond turtles were detected does still exhibit a significant increase ( $R^2=0.410$ ,  $P=0.025$ ) (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 0 for the fifth year in row. The seasonal pattern in 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. Although detections of tricolored blackbird on reserves and Basin-wide do not exhibit a significant increase or decrease over the course of the monitoring period, the created marsh habitats

on TNBC reserves and elsewhere have undoubtedly contributed to the conservation of tricolored blackbirds. The re-establishment of the tricolored blackbird nesting colony on the Willey Wetlands Preserve in 2020 is an encouraging development.

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 has declined due to increased disturbance in the part of the facility 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 blackbirds, western burrowing owls, Pacific pond turtles, and loggerhead shrikes 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 creation 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.

- 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.
- Limit the use of insecticides to the maximum extent practicable on all reserve lands to allow insect prey populations to recover.

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.

- 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 vegetation management activities (i.e., grazing) to control marsh vegetation outside the white-faced ibis and tricolored blackbird nesting season (May through August) to minimize 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.



## 5.7 References

- Beedy, E. C., and W. J. Hamilton III. 1999. Tricolored Blackbird. In *The Birds of North America*, No. 423 (A. Poole and F. Gill, editors). Philadelphia, PA: The Academy of Natural Sciences and Washington, DC: The American Ornithologists' Union.
- Ernest, H. B., L. W. Woods, and B. R. Hoar. 2010. Pathology Associated with West Nile Virus Infections in the Yellow-Billed Magpie (*Pica Nutalli*): A California endemic bird. *Journal of Wildlife Diseases* 46(2):401–408.
- George, T. L., R. J. Harrigan, J. A. LaManna, D. F. DeSante, J. F. Saracco, and T. Smith. 2015. Persistent Impacts of West Nile virus on North American bird populations. *Proceedings of the National Academy of Sciences of the United States of America* 112(46):14290–14294.
- Hallmann C. A., M. Sorg, J. E. Ongejans, H. Siepel, N. Hofland, and H. Schwan. 2017. More than 75 Percent Decline over 27 Years in Total Flying Insect Biomass in Protected Areas. *PLoS ONE* 12(10): e0185809. <https://doi.org/10.1371/journal.pone.0185809>
- Heitmeyer, M. E., D. P. Connelly, and R. L. Pederson. 1989. The Central, Imperial, and Coachella Valleys of California. Pages 475–505 in *Habitat Management for Migrating and Wintering Waterfowl in North America* (L. M. Smith, R. L. Pederson, and R. M. Kiminski, editors). Lubbock, TX: Texas Technical University Press.
- ICF. 2017. *Natomas Basin Habitat Conservation Plan Biological Effectiveness Monitoring Program*. Draft. July. (ICF 00486.15.) Sacramento, CA. Prepared for The Natomas Basin Conservancy, Sacramento, CA.
- ICF Jones & Stokes. 2009. *Natomas Basin Habitat Conservation Plan Area Biological Effectiveness Monitoring Program*. October. (ICF J&S 00164.07.). Sacramento, CA. Prepared for the Natomas Basin Conservancy, Sacramento, CA.
- Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. *Handbook of Field Methods for Monitoring Landbirds*. General Technical Report PSW-GTR-144. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.
- Ryder, R. A., and D. E. Manry. 1994. White-faced Ibis. In *The Birds of North America*, No. 130 (A. Poole and F. Gill, editors). Philadelphia, PA: The Academy of Natural Sciences and Washington, DC: The American Ornithologists' Union.
- Shuford, D. W., G. W. Page, and J. E. Kelmyr. 1998. Patterns and Dynamics of Shorebird Use of California's Central Valley. *Condor* 100:227–244.
- Wheeler, S., C. M. Barker, Y. Fang, M. V. Armijos, B. D. Carroll, S. Husted, W. O. Johnson, and W. K. Reisen. 2009. Differential Impact of West Nile Virus on California Birds. *Condor* 111 (1):1–20.

**Table 5-1. Summary of Results of Monthly Avian Surveys by Reserve and Tract,<sup>a</sup> 2018–2021**

Reserve	Waterfowl			Raptors			Neotropical Migrants			Shorebirds			All Bird Species		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
<b>North Basin Reserve</b>															
Atkinson	23 (1)	- (-)	179 (4)	28 (7)	52 (9)	41 (8)	170 (8)	159 (9)	116 (9)	32 (2)	2 (1)	6 (2)	2,308 (63)	2,166 (56)	2,405 (65)
Bennett North	1671 (9)	2,601 (17)	3,414 (12)	10 (4)	17 (5)	29 (6)	5 (1)	23 (4)	15 (3)	66 (3)	103 (2)	8 (2)	4,148 (36)	4,735 (52)	5,087 (41)
Bennett South	133 (5)	133 (6)	627 (4)	14 (5)	17 (6)	28 (7)	6 (1)	18 (3)	16 (5)	78 (4)	177 (6)	34 (4)	7,428 (38)	5,499 (44)	3,702 (42)
Bolen North	85 (4)	390 (3)	2,483 (3)	4 (3)	6 (2)	5 (2)	2 (1)	1 (1)	2 (1)	21 (3)	111 (4)	48 (3)	1,315 (30)	1,245 (24)	3,793 (24)
Bolen South <sup>b</sup>	4 (1)	- (-)	- (-)	12 (4)	6 (3)	5 (2)	35 (5)	49 (3)	55 (4)	- (-)	- (-)	- (-)	240 (27)	323 (25)	1,911 (26)
Bolen West	36 (2)	21 (2)	676 (5)	5 (2)	11 (3)	7 (4)	- (-)	11 (3)	11 (3)	9 (2)	8 (3)	413 (4)	700 (14)	611 (25)	5,092 (37)
Frazer	7,037 (13)	1,720 (11)	1,078 (9)	10 (3)	8 (4)	9 (4)	33 (4)	64 (4)	8 (1)	103 (2)	22 (2)	15 (1)	8,534 (42)	3,219 (45)	2,669 (38)
Huffman East	385 (1)	43 (2)	173 (3)	6 (4)	12 (5)	13 (4)	7 (4)	4 (2)	4 (2)	5 (1)	516 (6)	8 (2)	938 (21)	2,589 (36)	2,341 (24)
Huffman West <sup>b</sup>	- (-)	- (-)	- (-)	12 (3)	35 (3)	25 (5)	22 (3)	20 (3)	32 (4)	14 (1)	22 (2)	13 (2)	597 (30)	897 (24)	1,163 (28)
Laupe South			2 (1)			1 (1)			12 (4)			61 (2)			399 (25)
Lucich North	3,171 (11)	5,948 (15)	2,608 (17)	25 (4)	21 (6)	26 (5)	61 (3)	51 (3)	32 (3)	8 (2)	159 (4)	429 (4)	7,062 (47)	12,807 (56)	6,010 (55)
Lucich South	10,577 (11)	1,401 (9)	5,630 (13)	36 (4)	30 (5)	32 (7)	3 (1)	4 (3)	2 (1)	269 (3)	370 (7)	99 (7)	17,499 (41)	7,118 (50)	8,055 (49)
Nestor	2 (1)	20 (4)	30 (3)	9 (2)	20 (6)	9 (2)	2 (2)	10 (4)	3 (2)	277 (4)	19 (2)	43 (5)	918 (23)	920 (30)	1,452 (28)
Ruby Ranch	33 (1)	25 (1)	28 (2)	7 (3)	4 (3)	7 (3)	25 (2)	100 (3)	18 (4)	14 (2)	18 (2)	20 (3)	3,126 (25)	1,119 (32)	3,525 (34)
Verona			2,507 (3)			1 (1)			19 (4)			5 (1)			2,780 (26)
Vestal	18 (2)	9 (1)	20 (2)	5 (3)	5 (4)	6 (5)	7 (4)	23 (5)	19 (4)	3 (1)	4 (1)	15 (1)	323 (30)	988 (36)	887 (32)
Willy			756 (5)			5 (3)			3 (2)			- (-)			1,088 (21)
<b>Central Basin Reserve</b>															
BKS	6,219 (17)	8,913 (18)	8,342 (19)	49 (7)	56 (8)	58 (8)	657 (5)	339 (5)	143 (5)	251 (7)	150 (5)	105 (5)	16,557 (73)	18,958 (73)	15,771 (72)
Bianchi West	640 (2)	6 (1)	676 (5)	5 (2)	5 (3)	4 (2)	- (-)	- (-)	3 (1)	55 (3)	79 (5)	57 (4)	1,184 (21)	872 (25)	1,167 (26)
Elsie	29 (2)	8 (2)	108 (3)	9 (4)	15 (5)	25 (4)	- (-)	13 (1)	2 (1)	6 (2)	11 (2)	18 (2)	1,567 (18)	472 (21)	1,932 (26)
Frazer South	158 (8)	1,949 (9)	603 (10)	14 (4)	7 (2)	8 (3)	1 (1)	3 (2)	6 (3)	225 (6)	214 (5)	102 (4)	1,220 (36)	3,802 (40)	1,308 (37)
Paulsen South			196 (6)			1 (1)			6 (1)			9 (2)			374 (20)
Richter			2 (1)			7 (3)			1 (1)			10 (2)			236 (15)
Sills	35 (1)	324 (4)	54 (5)	12 (5)	23 (4)	29 (4)	- (-)	23 (2)	8 (2)	14 (3)	100 (4)	76 (5)	1,765 (26)	2,902 (30)	2,048 (33)
Tufts	11 (1)	18 (1)	20 (3)	11 (2)	3 (3)	18 (3)	2 (1)	12 (3)	2 (1)	290 (3)	119 (3)	14 (2)	755 (18)	746 (21)	759 (22)
<b>Fisherman's Lake Reserve</b>															
Allegheny <sup>b</sup>	-	- (-)	- (-)	3 (2)	2 (2)	- (-)	7 (3)	43 (5)	9 (2)	- (-)	1 (1)	- (-)	136 (23)	226 (27)	107 (11)
Cummings	206 (7)	111 (6)	162 (5)	29 (6)	18 (6)	11 (4)	40 (5)	76 (5)	33 (4)	5 (1)	2 (1)	5 (1)	1,126 (59)	1,061 (51)	626 (34)
Natomas Farms	180 (7)	322 (8)	323 (5)	7 (5)	14 (6)	17 (8)	9 (3)	47 (4)	8 (3)	9 (1)	- (-)	7 (1)	682 (41)	949 (44)	1,038 (43)
Rosas <sup>b</sup>	24 (2)	11 (3)	24 (4)	3 (2)	7 (3)	11 (2)	35 (4)	37 (5)	32 (4)	- (-)	2 (1)	2 (1)	990 (34)	924 (35)	405 (31)
Souza <sup>b</sup>	- (-)	6 (1)	5 (1)	- (-)	5 (2)	6 (3)	3 (1)	13 (3)	29 (2)	- (-)	- (-)	1 (1)	53 (11)	164 (19)	164 (20)

**Table 5-1 Continued**

Reserve	Waterfowl			Raptors			Neotropical Migrants			Shorebirds			All Bird Species		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
<b>SAFCA Wetlands</b>															
AKT	423 (8)	491 (10)	451 (10)	4 (4)	6 (4)	9 (5)	432 (3)	354 (4)	124 (3)	- (-)	1 (1)	5 (1)	1,172 (39)	1,483 (41)	920 (42)
Sharma	421 (9)	537 (11)	618 (10)	7 (5)	5 (4)	8 (4)	38 (4)	96 (5)	37 (5)	1 (1)	4 (1)	2 (1)	858 (39)	1,269 (48)	1,132 (44)
Natomas Farms West	166 (8)	320 (10)	263 (10)	4 (2)	- (-)	6 (5)	30 (4)	34 (4)	48 (5)	- (-)	- (-)	6 (1)	647 (37)	596 (35)	745 (43)

<sup>a</sup> Numbers in this table reflect the total number of individuals of each group observed followed by the number of species observed (in parentheses).

<sup>b</sup> 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, 2004–2021**

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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
Loggerhead shrike	4 (3 BKS, 1 Brennan)	3 (2 BKS, 1 Brennan)	3 (1 BKS, 1 Alleghany, 1 Brennan)	3 (1 BKS, 1 Huffman West)	1 (Alleghany)	1 (Atkinson)	1 (Atkinson)	1 (Atkinson)	3 <sup>a</sup>	3 <sup>a</sup> (1 Lucich North, 1 Rosa, 1 Souza)	4 <sup>a</sup> (Lucich North, Bennett North, Atkinson, Rosa)	1 <sup>a</sup> (Rosa)	0	1 (Rosa)	1 (Rosa)	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
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

<sup>a</sup> 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, 2005–2021**

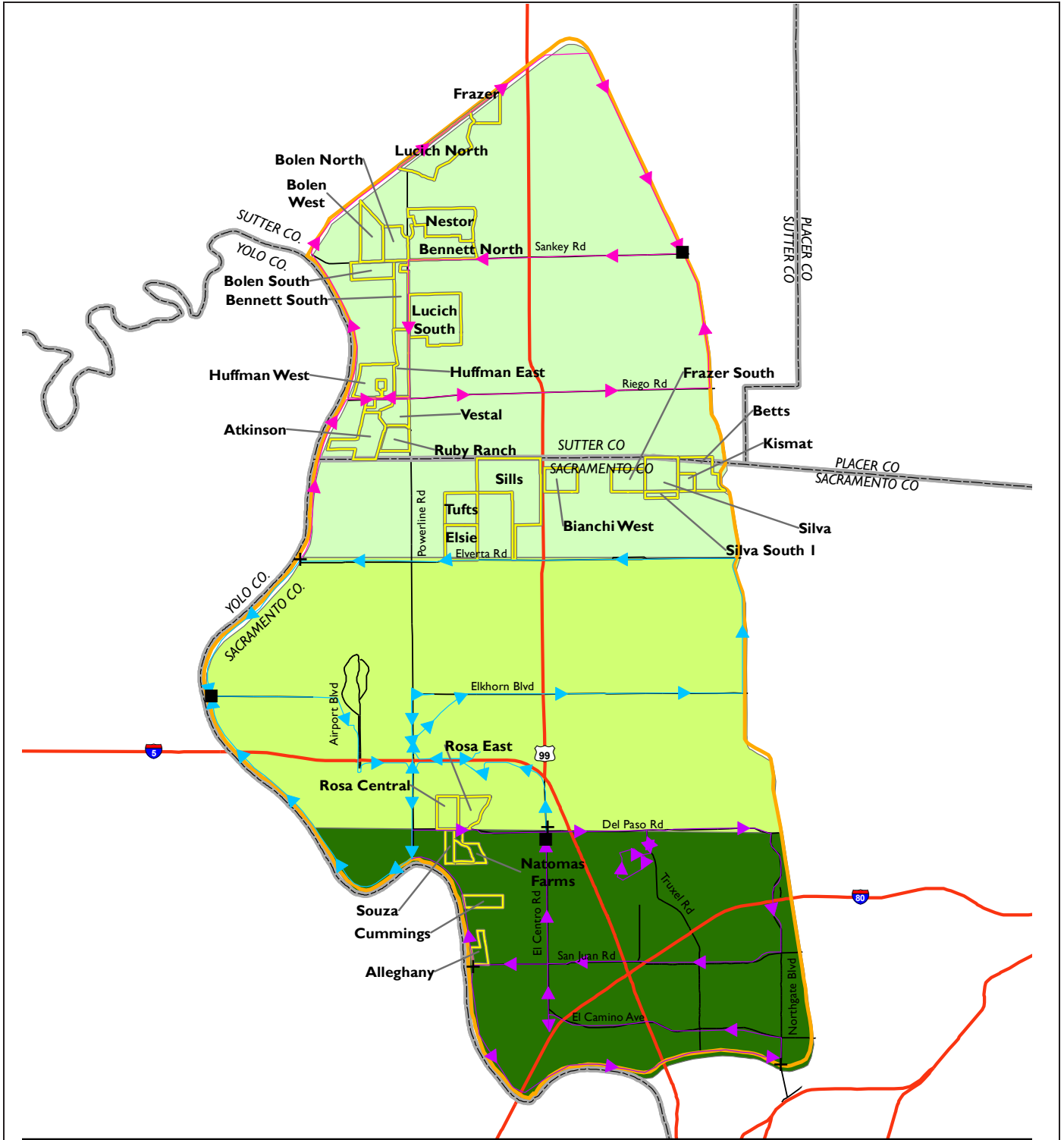
Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
White-faced ibis <sup>a</sup>	0.042	0.050	0.062	0.241	0.222	0.160	0.129	0.124	0.187	0.156	0.160	0.102	0.018	0.111	0.051	0.146	0.266
Burrowing owl	0.028	0.039	0.000	0.098	0.196	0.175	0.138	0.058	0.022	0.036	0.004	0.009	0.004	0.020	0.043	0.029	0.018
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
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
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

<sup>a</sup> 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, 2005–2021**

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
White-faced ibis <sup>a</sup>	0.250	0.088	0.265	0.233	0.229	0.143	0.059	0.156	0.156	0.226	0.267	0.308	0.172	0.444	0.250	0.428	0.750
Burrowing owl	0.313	0.588	0.029	1.600	3.286	3.810	4.647	6.719	5.031	3.548	1.833	1.423	1.103	1.222	0.125	0.857	0.625
Loggerhead shrike	3.000	2.529	2.235	1.800	3.314	2.000	2.059	2.125	1.438	0.710	0.467	0.077	0.034	0.000	0.000	0.000	0.000
Tricolored blackbird	5.813	0.971	2.235	200.667	222.286	0.000	14.706	3.750	5.063	26.806	49.667	4.154	9.724	28.333	25.625	41.889	13.75

<sup>a</sup> 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.



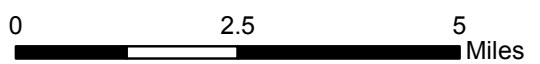
**Legend**

- Roads
- Major Roads
- ▭ County Boundaries
- ▭ NBHCP Area Boundary
- ▭ Reserve Lands

- Survey Areas**
- ▭ North
  - ▭ Central
  - ▭ South

- Survey Routes**
- North
  - Central
  - South

- Survey Start and End Points**
- + Start
  - End

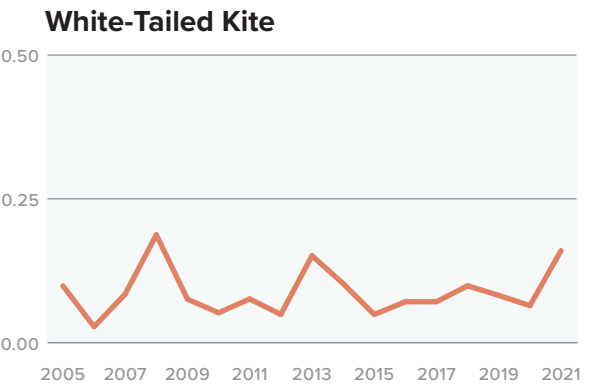
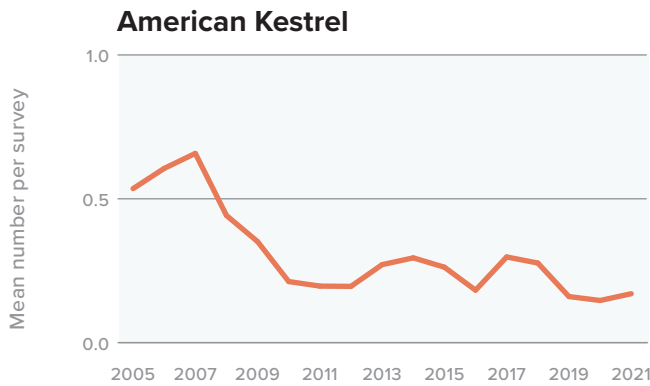
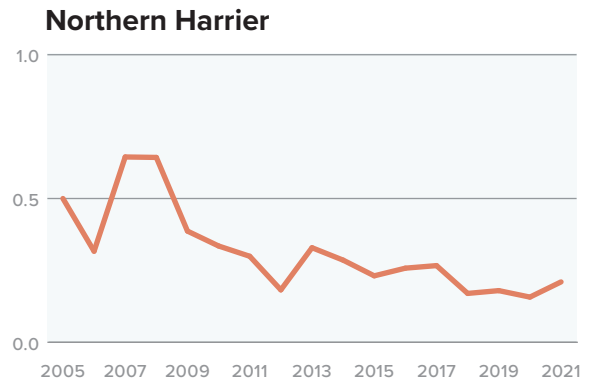
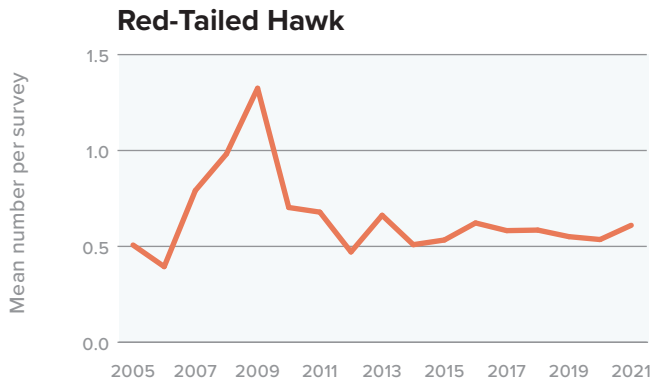
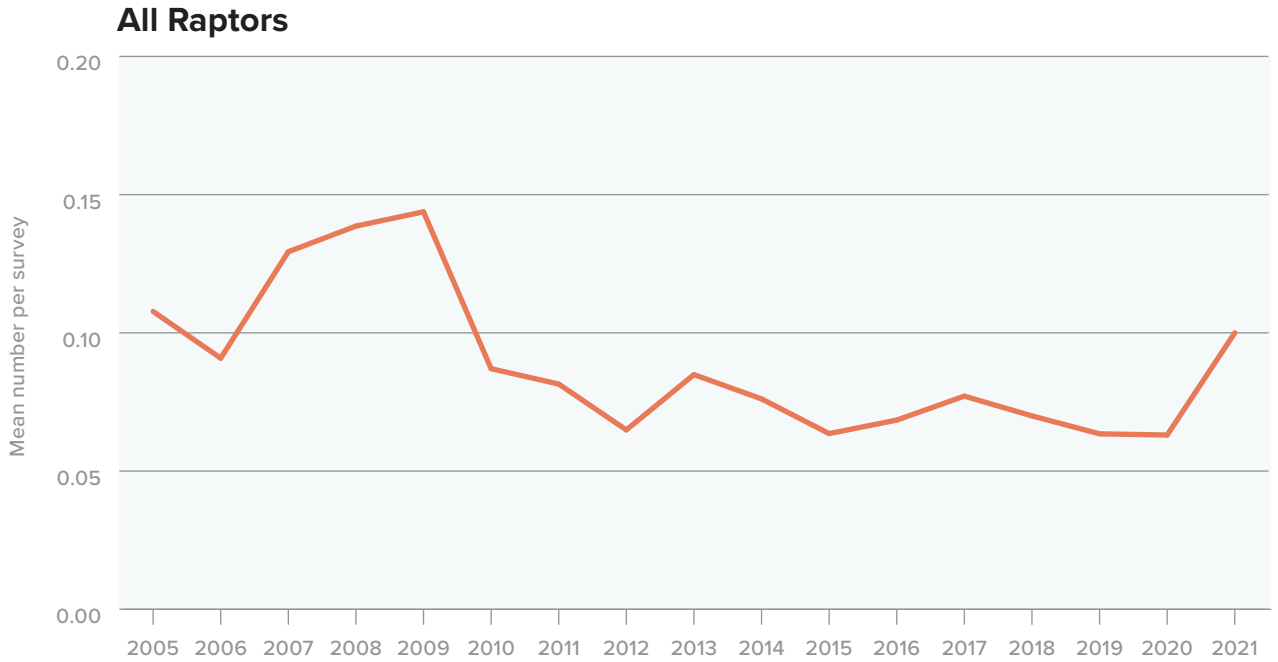


Graphics ... 662,17 NBC (3-9-2021) TG

NBC Monitoring Program data sources: ICF International (2010)



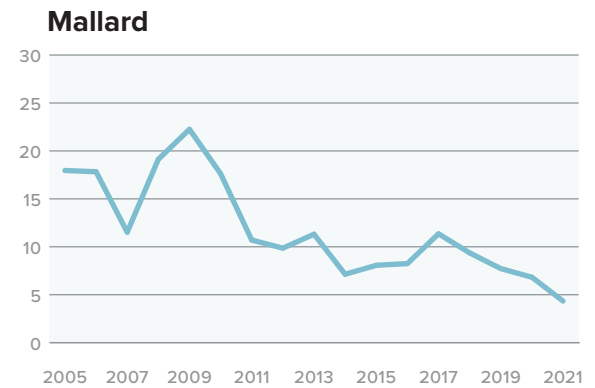
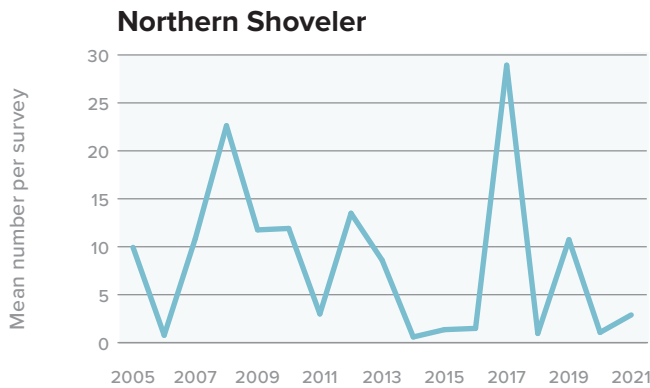
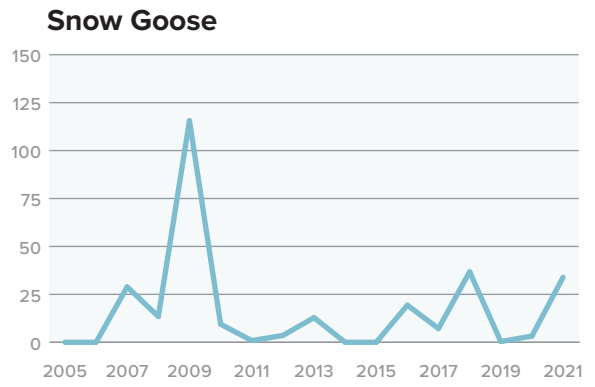
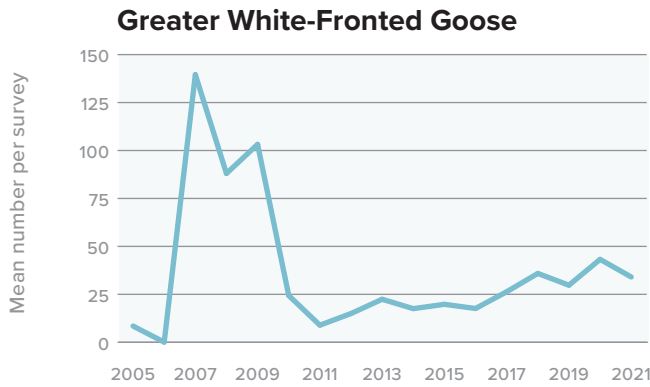
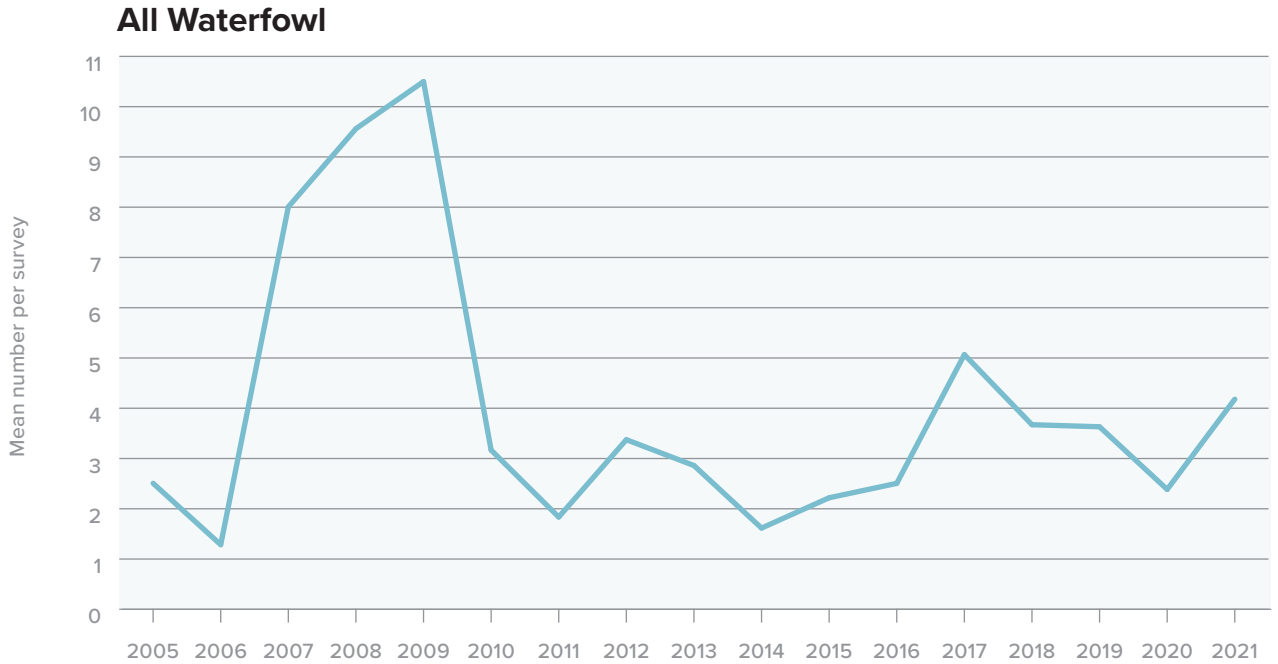
**FIGURE 5-1**  
Monthly Basin-Wide Survey Routes



NBC 104332 (3-12-2022)



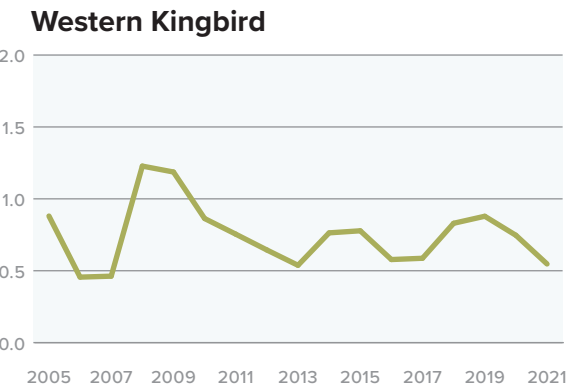
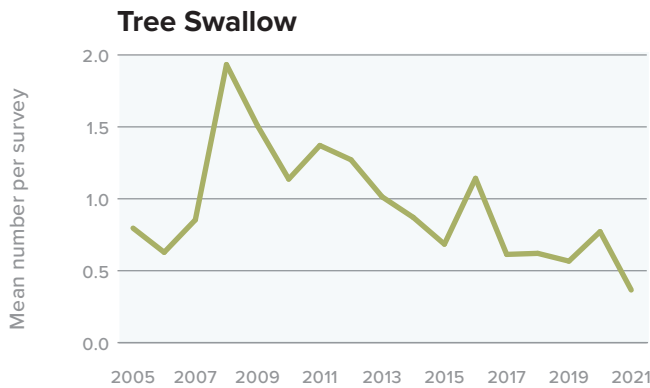
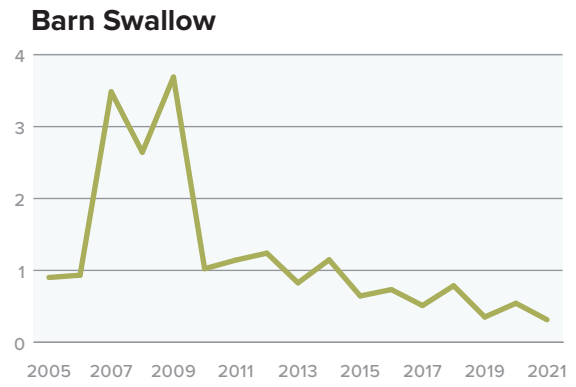
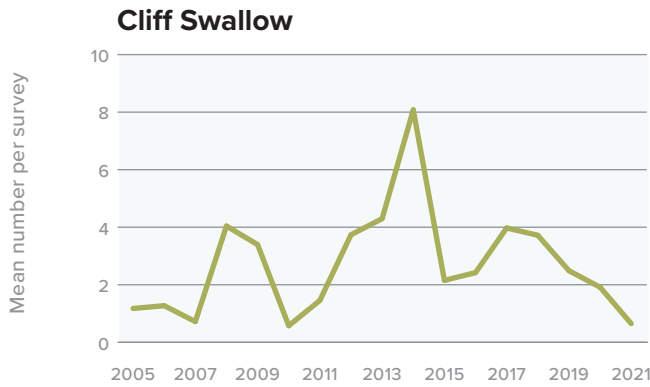
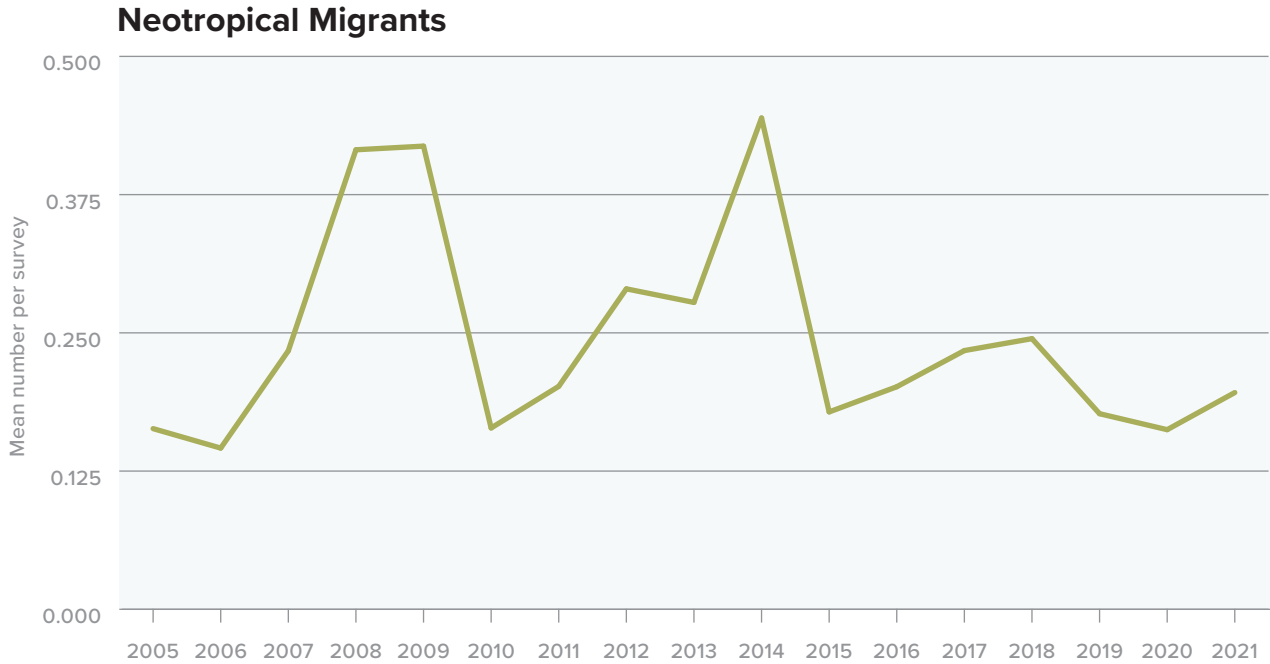
**FIGURE 5-2**  
Mean Number of Raptors Detected per Survey on  
TNBC Reserves in the Natomas Basin, 2005–2021



NBC 104332 (3-12-2021)



**FIGURE 5-3**  
Mean Number of Waterfowl Detected per Survey on  
TNBC Reserves in the Natomas Basin, 2005–2021

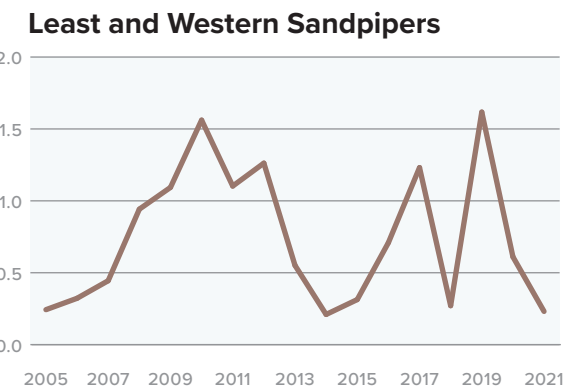
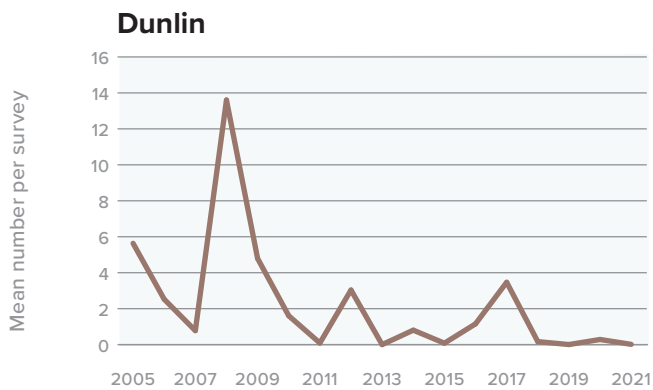
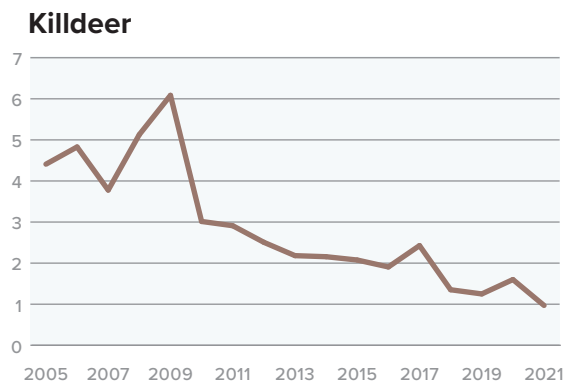
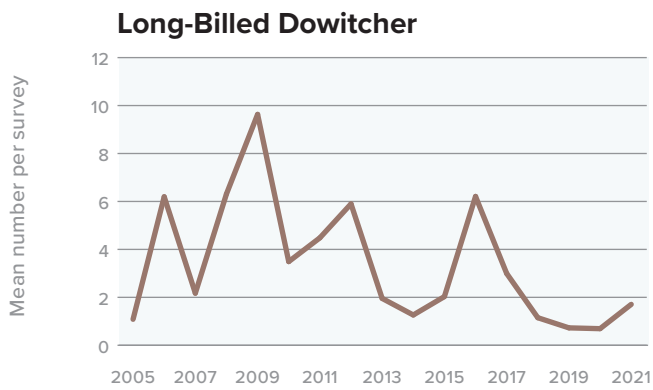
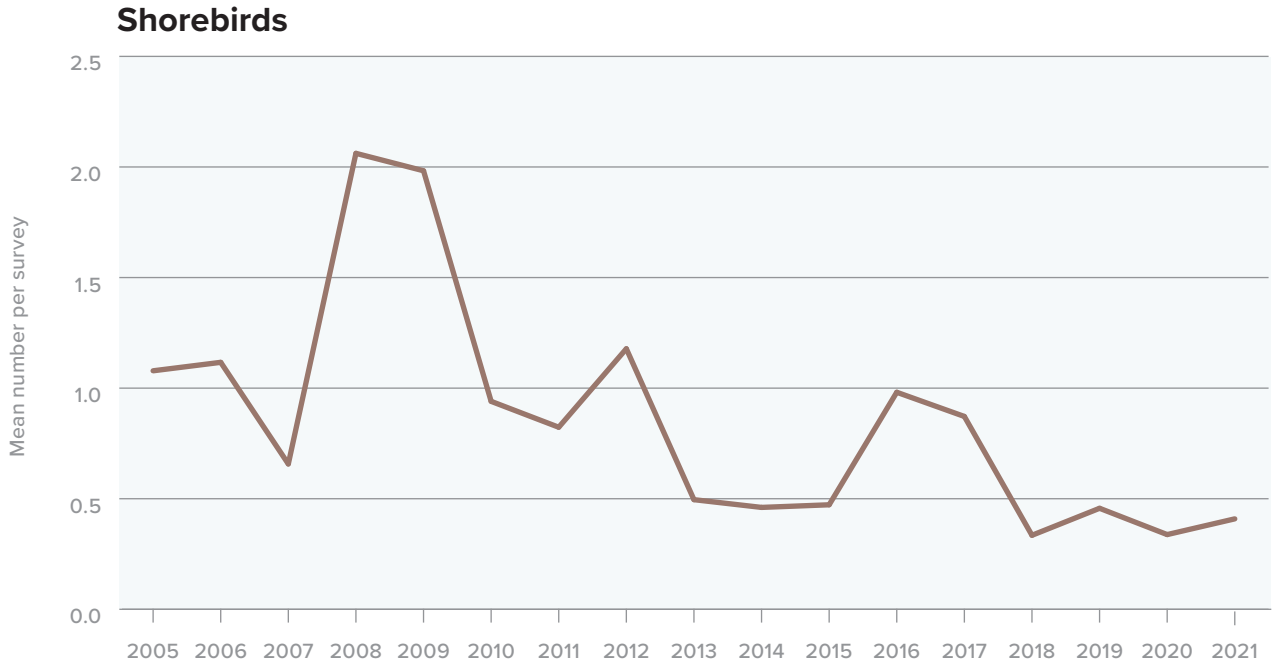


NBC104332 (3-12-2022)



**FIGURE 5-4**  
 Mean Number of Neotropical Migrants Detected per Survey on  
 TNBC Reserves in the Natomas Basin, 2005–2021

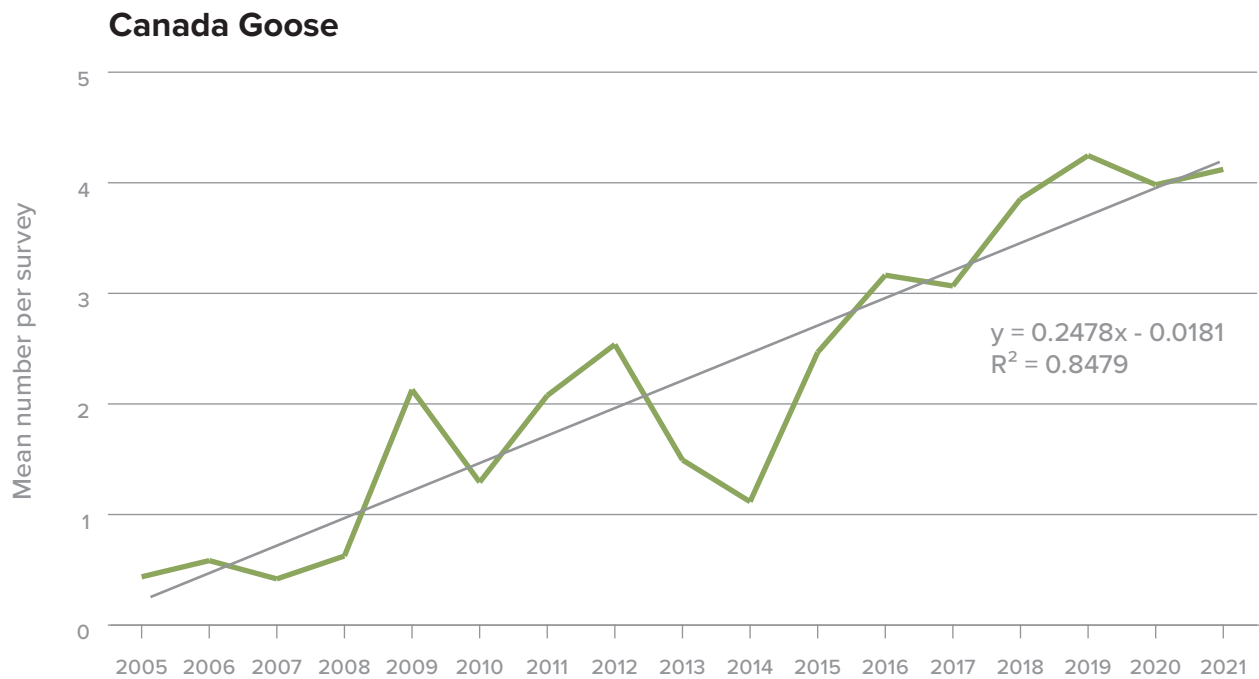
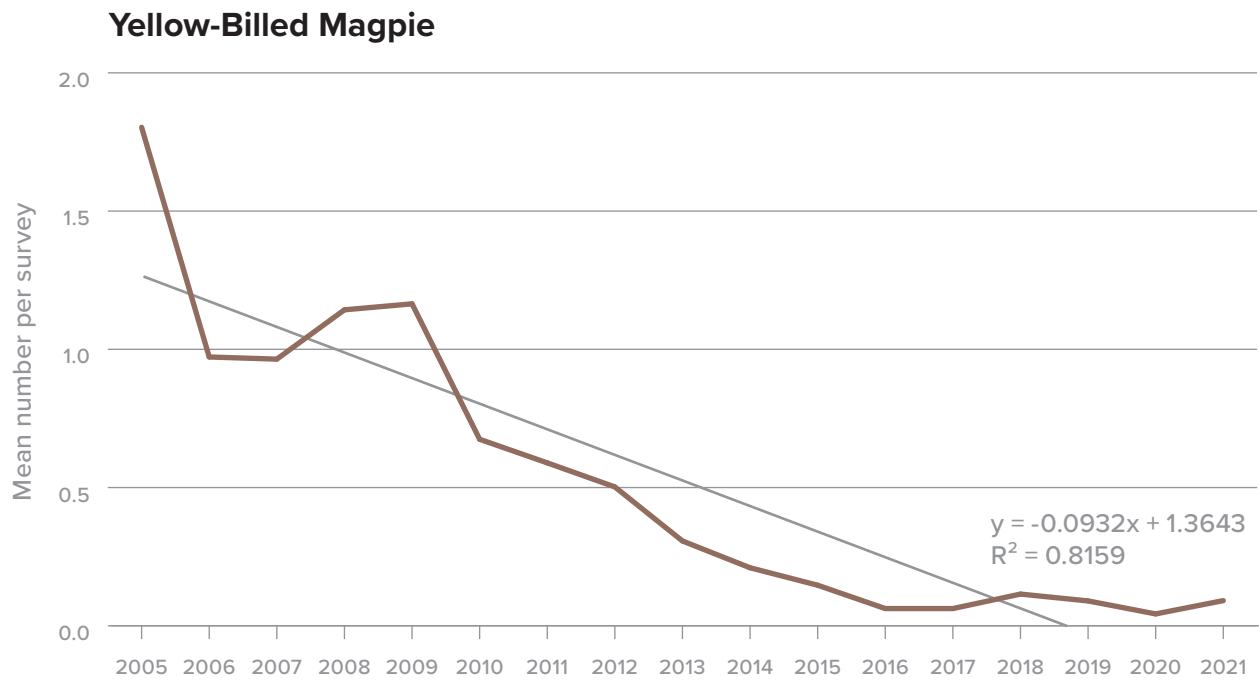




NBC 104332 (3-12-2022)



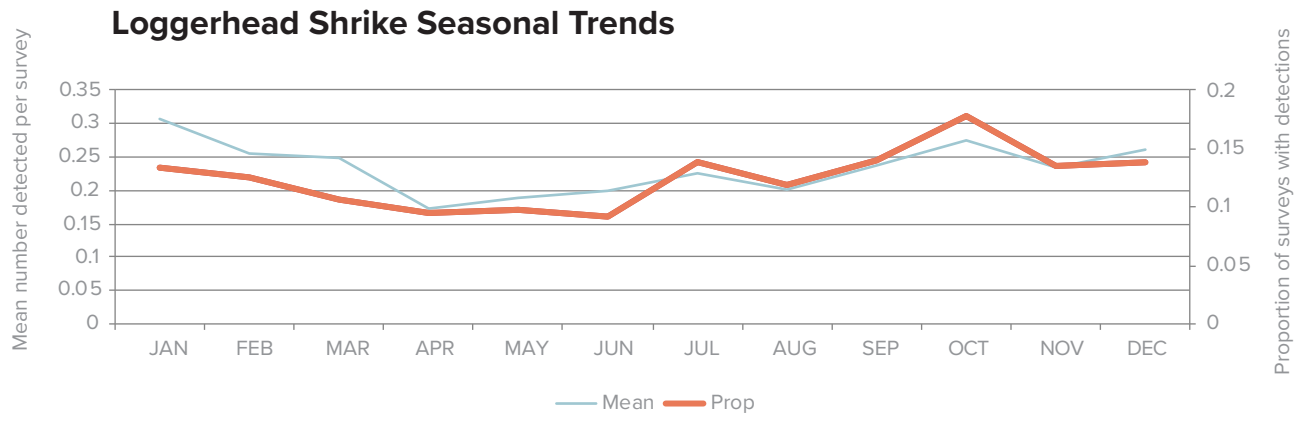
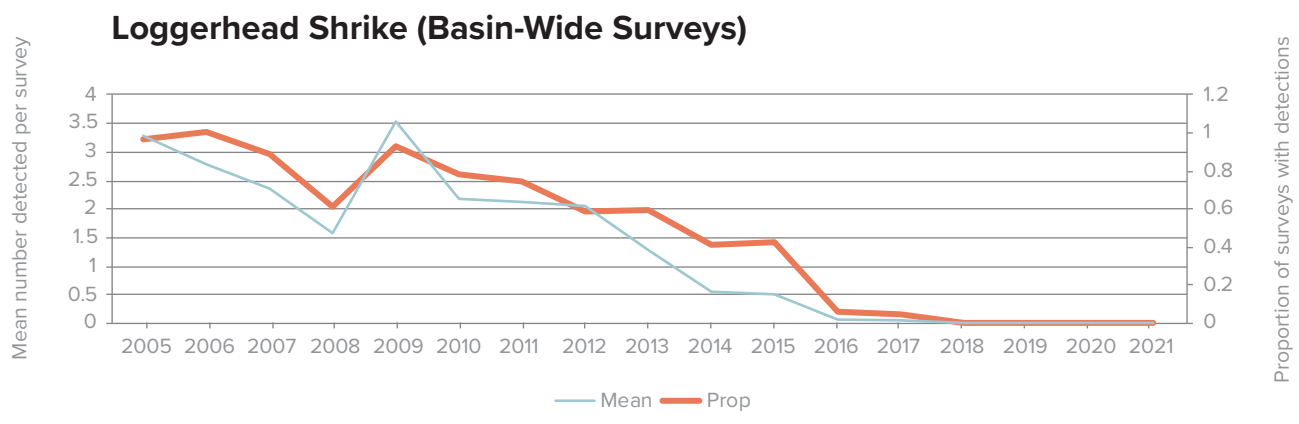
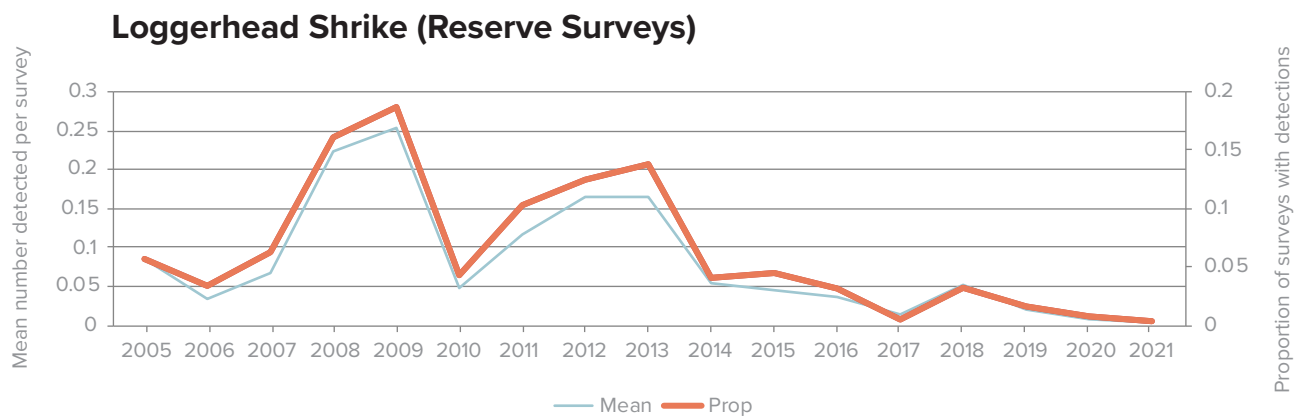
**FIGURE 5-5**  
Mean Number of Shorebirds Detected per Survey on  
TNBC Reserves in the Natomas Basin, 2005–2021



NBC 104332 (3-12-2022)



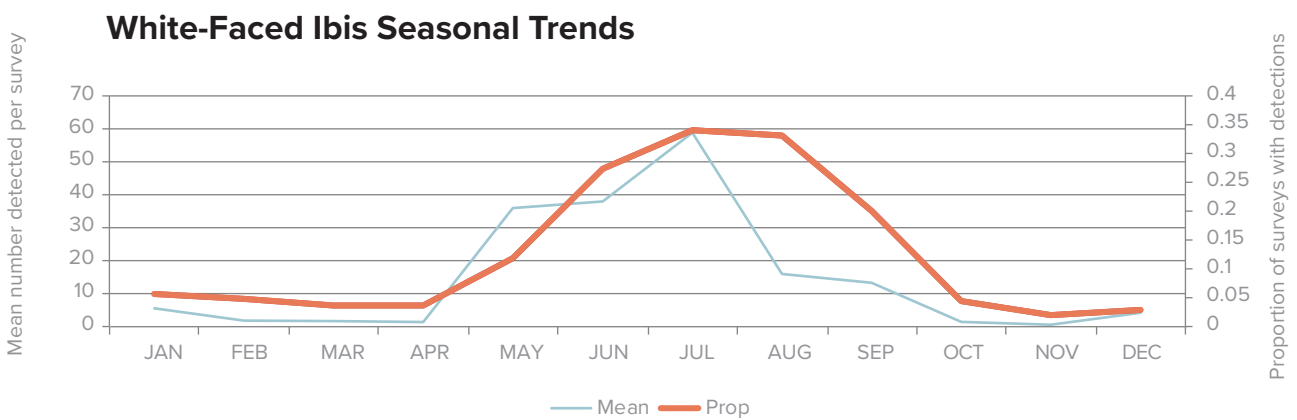
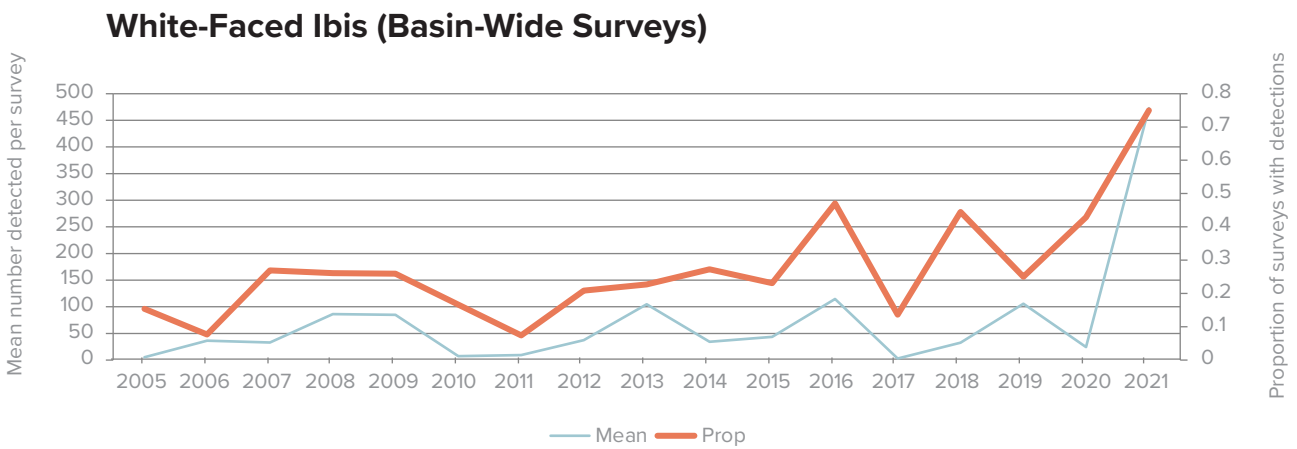
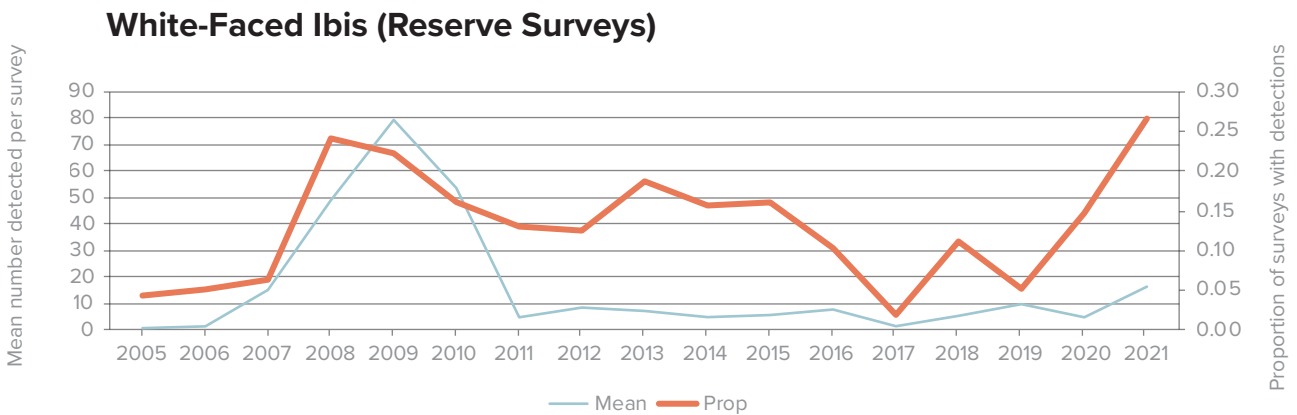
**FIGURE 5-6**  
Mean Number of Yellow-Billed Magpies and Canada Geese Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2021



NBC104332 (3-12-2022)



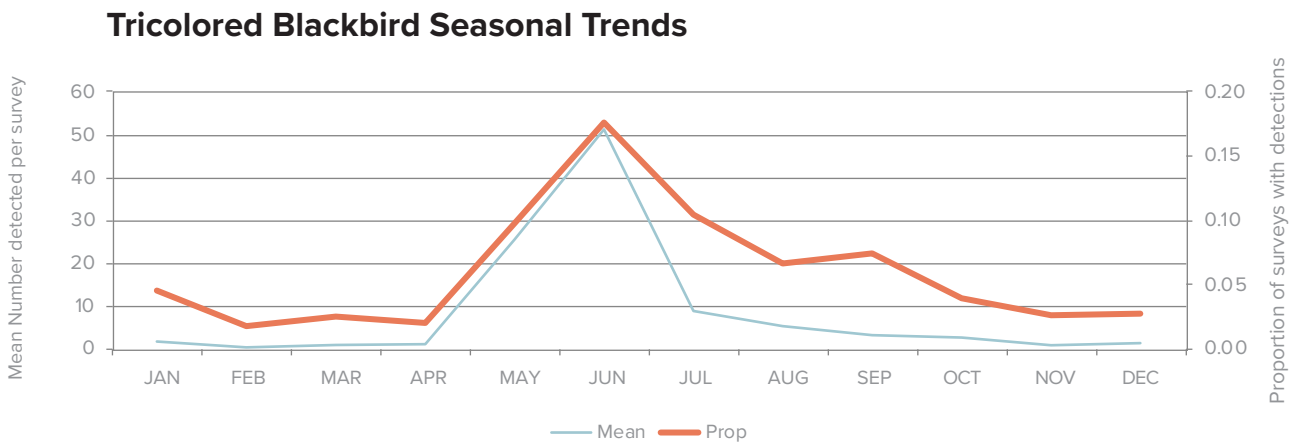
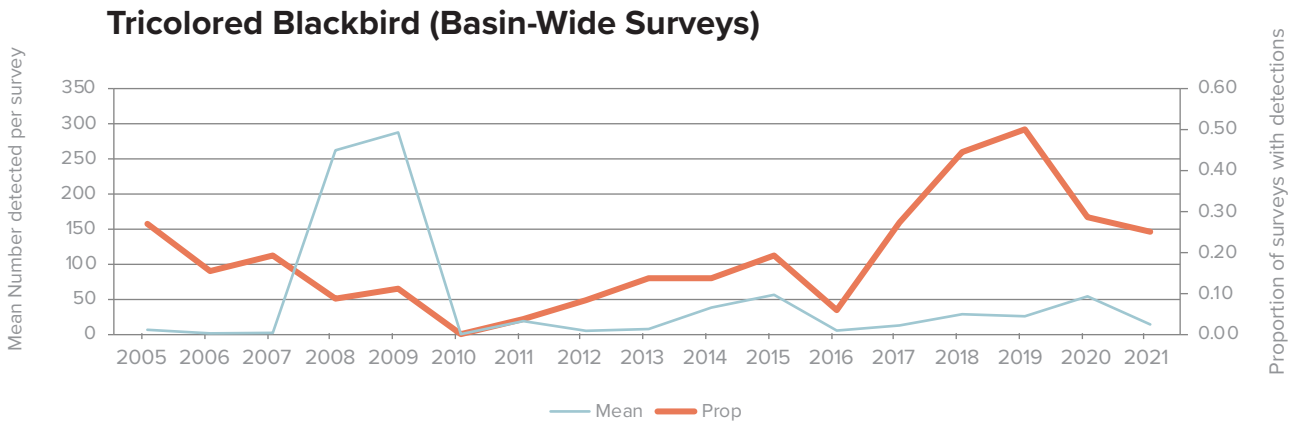
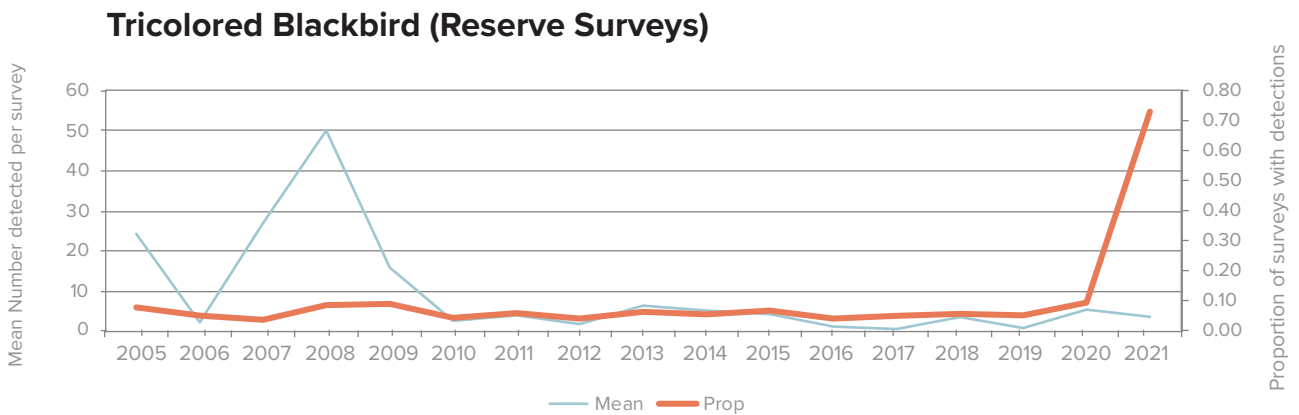
**FIGURE 5-7**  
 Mean Number of Loggerhead Shrikes Detected and the Proportion of Surveys on which Shrikes were Detected on TNBC Reserves in the Natomas Basin, 2005–2021



NBC104332 (3-12-2022)



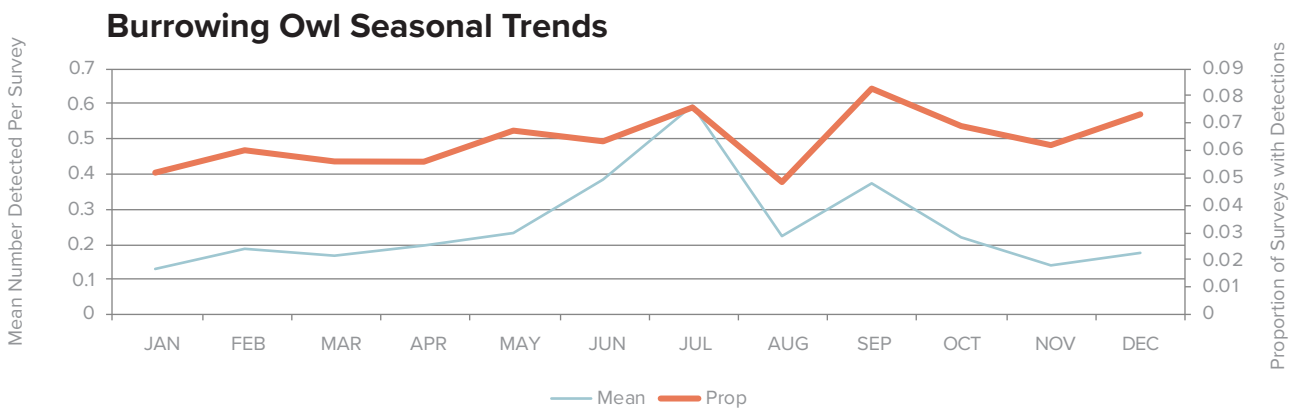
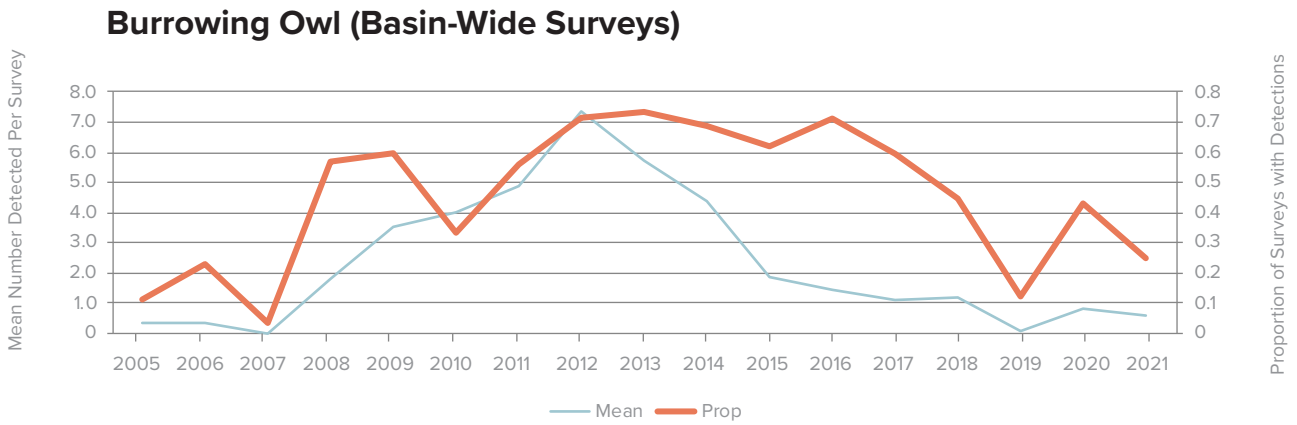
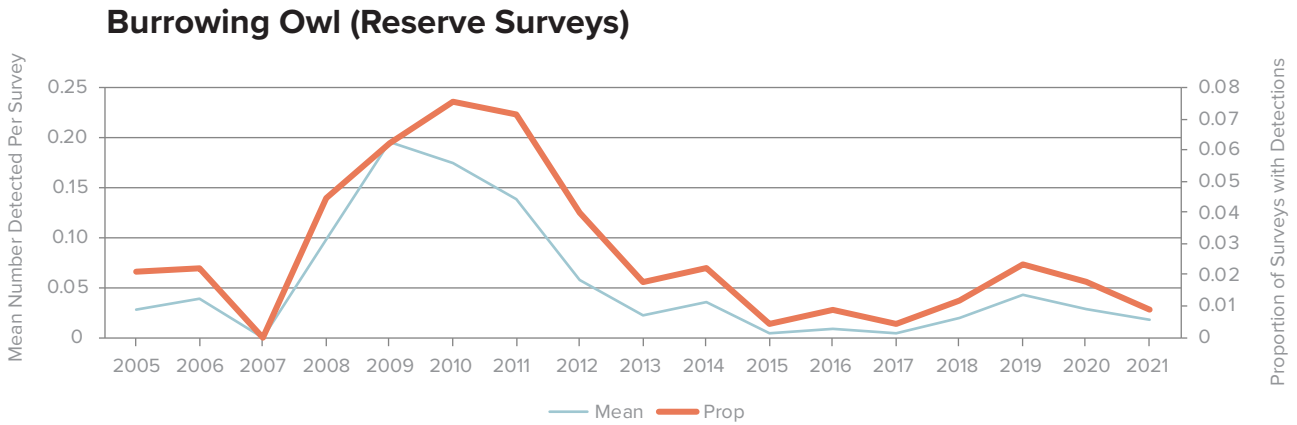
**FIGURE 5-8**  
 Mean Number of White-Faced Ibis Detected and the Proportion of Surveys on which Ibis Were Detected on TNBC Reserves in the Natomas Basin, 2005–2021



NBC104332 (3-12-2022)



**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, 2005–2021



NBC104332 (3-12-2022)



**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, 2005–2021



**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, 2005–2021

*This Page Intentionally Left Blank*



Appendix A

**NBHCP Reserve Land Cover Data**

---



**Table A-1. Reserve Lands: Extent (acres) of Each Land Cover Type, 2005–2021**

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
<b>North Basin Reserve</b>																	
<b>Atkinson<sup>a</sup></b>																	
Fallow (including fallow rice)	108.0	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
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
Grass hay	-	-	21.3	-	-	-	-	-	-	15.5	15.5	15.5	9.7	9.7	20.1	62.2	54.0
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	1.0	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
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
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
Riparian woodland	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.1	9.1	9.1	9.1	9.1	9.1	6.3
Ruderal	3.6	3.6	0.7	0.7	0.7	-	-	-	-	-	-	-	11.2	11.2	-	-	-
Seasonal wetland	0.1	0.1	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
Valley oak woodland	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Wheat	21.3	-	-	21.3	-	-	-	-	-	-	-	-	-	-	-	-	52.5
<b>Bennett North</b>																	
Fallow	-	67.0	147.8	10.8	10.8	-	-	-	-	-	-	-	-	-	-	-	147.8
Fresh emergent marsh (created)	7.0	7.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
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
Rice	213.8	146.9	-	137.0	137.0	147.8	147.8	147.8	147.8	147.8	147.7	147.8	147.8	147.8	147.8	147.8	-

**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
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
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
<b>Bennett South</b>																	
Fallow (including fallow rice)	87.2	-	-	-	-	4.4	26.9	-	13.2	-	-	13.7	-	-	72.7		13.7
Fresh emergent marsh (created)	19.10	19.10	19.10	19.10	19.10	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
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
Rice	-	81.8	82.0	86.4	82.0	59.7	59.5	86.4	73.2	86.4	86.4	72.7	59.5	72.7	13.7	86.4	72.7
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
Ruderal	0.8	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Bolen North</b>																	
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
<b>Bolen South</b>																	
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
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
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
Wheat	-	101.7	57.8	57.8	57.8	57.8	-	-	-	-	-	-	-	-	-	-	-

**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
<b>Bolen West</b>																	
Fallow (including fallow rice)	-	-	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	-	-	-	-	-	-	-	-
<b>Frazer<sup>b</sup></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
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
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
Open water	-	-	-	-	-	-	-	-	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
<b>Huffman East</b>																	
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
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
Wheat	-	15.6	-	-	15.6	15.6	-	-	-	-	-	-	-	-	-	-	-
<b>Huffman West<sup>c</sup></b>																	
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	99.5	44.5	99.5
Fallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	58.4	-
Grass hay	-	-	-	-	-	-	58.4	58.4	58.4	-	58.4	58.4	58.4	58.4	58.4	-	58.4
Milo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other row and grain crops	-	-	58.4	58.4	-	-	-	-	-	-	-	-	-	-	-	-	-
Tomatoes	-	-	54.7	54.7	-	-	-	-	-	-	-	-	-	-	-	-	-

**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
Wheat	113.1	113.1	-	-	58.4	113.3	-	-	-	58.4	-	-	-	-	54.9	-	-
<b>Lucich North<sup>d</sup></b>																	
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
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
Nonnative annual grassland	23.9	24.0	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
Ruderal	15.8	15.0	15.0	15.0	15.0	15.0	15.0	14.9	14.9	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
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
<b>Lucich South</b>																	
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
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
Ruderal	3.1	3.1	3.1	3.1	3.1	3.1	-	-	-	-	-	-	-	-	-	-	-
<b>Nestor</b>																	
Fallow	-	-	-	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
<b>Ruby Ranch</b>																	
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
Fallow	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

**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
<b>Vestal</b>																	
Milo	-	-	-	-	-	-	-	-	-	93.9	-	-	-	-	-	-	-
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
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
<b>Central Basin Reserve</b>																	
<b>Betts-Kismat-Silva</b>																	
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
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
Irrigated grassland	0.0	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
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
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
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
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
<b>Bianchi West</b>																	
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
<b>Elsie</b>																	
Fallow	-	-	158.0	-	-	158.0	158.0	-	-	-	-	-	-	-	-	-	-
Rice	-	-	-	158.0	158.0	-	-	158.0	158.0	158.0	158.0	158.0	158.0	158.0	158.0	158.0	158.0
<b>Frazer South</b>																	
Fallow	-	-	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

**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
<b>Sills</b>																	
Fallow	11.9	294.5	-	-	-	-	25.6	25.6	25.6	134.6	-	-	-	-	-	-	-
Grass hay	-	-	-	-	-	-	-	-	-	25.6	25.6	25.6	25.6	93.7	38.2	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	355.0	410.6	423.1	423.1
Sunflower	-	-	-	-	-	-	12.6	12.6	-	-	-	-	-	-	-	-	-
<b>Silva South 1</b>																	
Nonnative annual grassland									0.2	0.2	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
<b>Tufts</b>																	
Fallow	-	-	-	-	146.7	-	-	-	-	-	-	-	-	-	-	-	-
Rice	147.7	147.7	147.7	147.7	1.0	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7	147.7
<b>Fisherman's Lake Reserve</b>																	
<b>Alleghany<sup>e</sup></b>																	
Alfalfa	27.5	27.5	27.5	27.5	27.5	27.5	-	-	-	-	-	-	-	-	-	-	-
Fallow	-	-	-	18.9	6.00	18.9	6.0	0.7	-	-	-	-	-	18.9	-	39.5	10.0
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	6.0	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
Sunflower	-	-	-	-	-	-	0.7	26.8	0.7	27.5	-	-	18.9	-	-	-	-
Valley oak woodland	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	1.1
Wheat	-	-	18.9	-	-	-	-	-	-	-	18.9	45.7	-	-	-	-	18.9



**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
<b>Cummings<sup>e</sup></b>																	
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
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
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	1.0	-
Wheat (hay crop)	-	17.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21.8	14.3
<b>Natomas Farms<sup>e</sup></b>																	
Disturbed/bare	-	-	-	-	-	-	44.8	0.7	-	-	-	-	-	-	-	-	-
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
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
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
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
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
Wheat	44.1	44.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Rosa Central</b>																	
Alfalfa	-	-	-	-	-	-	-	-	-	100.1	100.1	100.1	-	-	-	-	-
Fallow	100.1	-	100.1	-	-	-	44.6	-	-	-	-	-	-	-	-	-	-

**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
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
Wheat	-	100.1	-	-	-	-	-	-	-	-	-	-	-	-	100.1	100.1	-
Other Row and Grain Crops	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Rosa East</b>																	
Alfalfa	-	-	-	-	-	-	-	104.3	104.3	104.3	104.3	104.3	-	-	-	-	-
Fallow	104.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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
Safflower	-	-	-	-	104.3	-	67.2	-	-	-	-	-	-	-	-	-	-
Sunflower	-	-	-	-	-	104.3	36.7	-	-	-	-	-	-	104.3	-	-	104.3
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
Wheat	-	104.3	-	-	-	-	-	-	-	-	-	-	-	-	104.3	104.3	-
<b>Souza</b>																	
Alfalfa	10.8	10.8	10.8	10.8	10.8	10.9	10.9	11.0	-	-	-	-	-	-	-	18.0	27.7
Disturbed/bare	-	-	-	-	-	-	17.7 <sup>c</sup>	17.7	-	-	-	-	-	-	-	-	-
Fallow	-	12.0	12.0	-	-	-	-	-	-	-	-	11.0	-	16.7	-	-	-
Grass hay	-	-	-	-	-	-	-	-	39.7	16.7	-	-	-	-	-	21.6	12.0
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
Other row and grain crops	-	16.7	16.7	28.7	28.7	28.7	-	-	-	-	11.0	-	-	-	-	-	-
Ruderal	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Safflower	-	-	-	-	-	-	-	11.0	-	-	-	-	-	-	-	-	-
Sunflower	-	-	-	-	-	-	11.0	-	-	22.9	-	-	28.7	-	-	-	-
Wheat	28.7	-	-	-	-	-	-	-	-	-	28.7	28.7	11.0	22.9	39.6	-	-

**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
<sup>a</sup> 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).																	
<sup>b</sup> Open water was mapped in 2013 due to the enlargement of an existing linear water conveyance feature.																	
<sup>c</sup> Acreage of reserve decreased in 2010 due to SAFCA acquiring property for the NLIP.																	
<sup>d</sup> Open water mapped in 2013 due to the construction of new linear water conveyance feature.																	
<sup>e</sup> Acreage of reserve decreased in 2011 due to SAFCA acquiring property for the NLIP.																	

---


\\PDC\ITRDS\GIS\1\Projects\_1\NBC\04002\_04\arcmap\report\_2021\Appendix\_A\figureA-1\_frazer\_lucich\_hab.mxd Date: 11 Feb 2022/




### Legend

 NBHCP Area Boundary

#### Land Cover

 Fresh Emergent Marsh (Created)

 Grassland (Created)

 Non-native Annual Grassland

 Open Water

 Ruderal

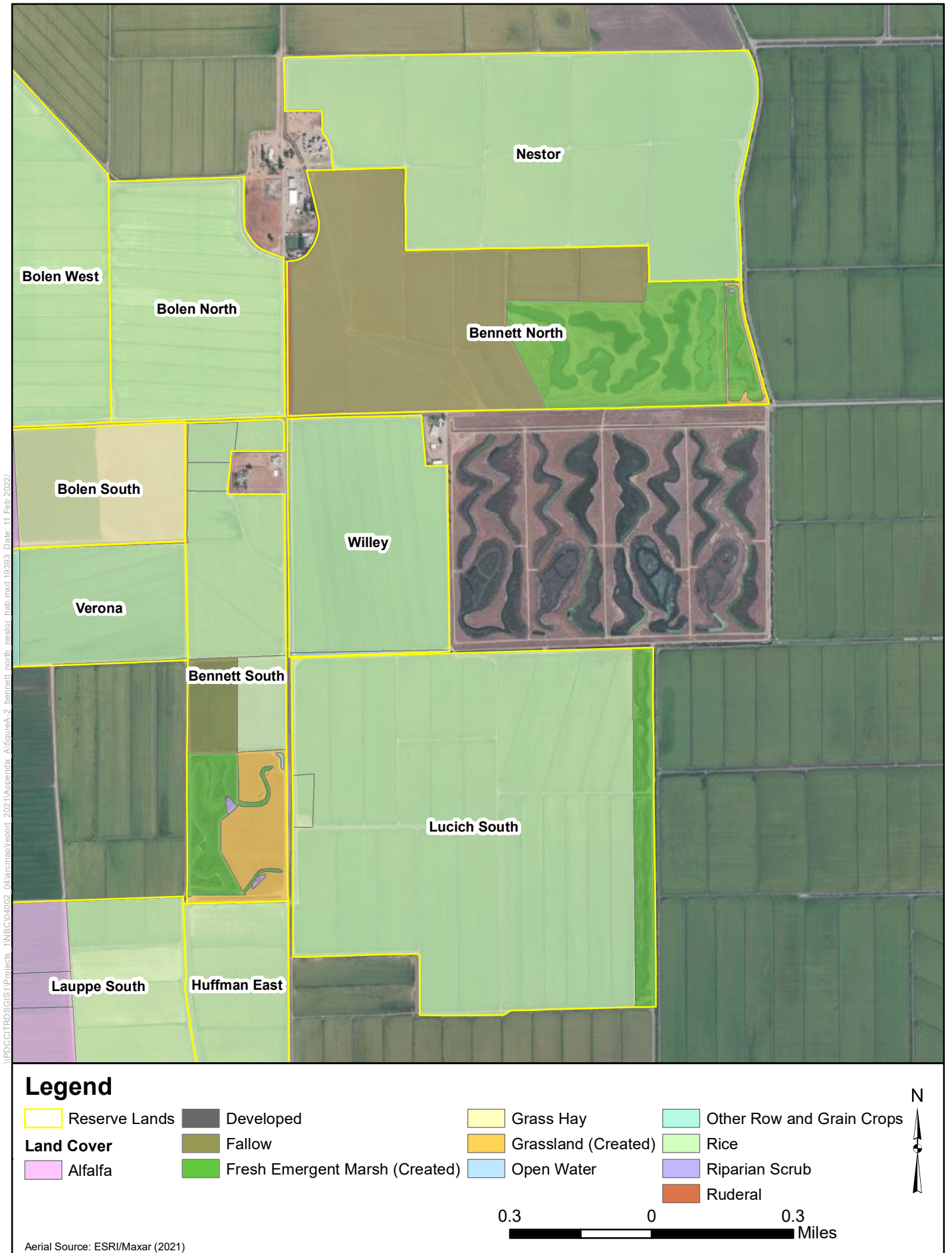
0.3 0 0.3 Miles



Aerial Source: ESRI/Maxar (2021)



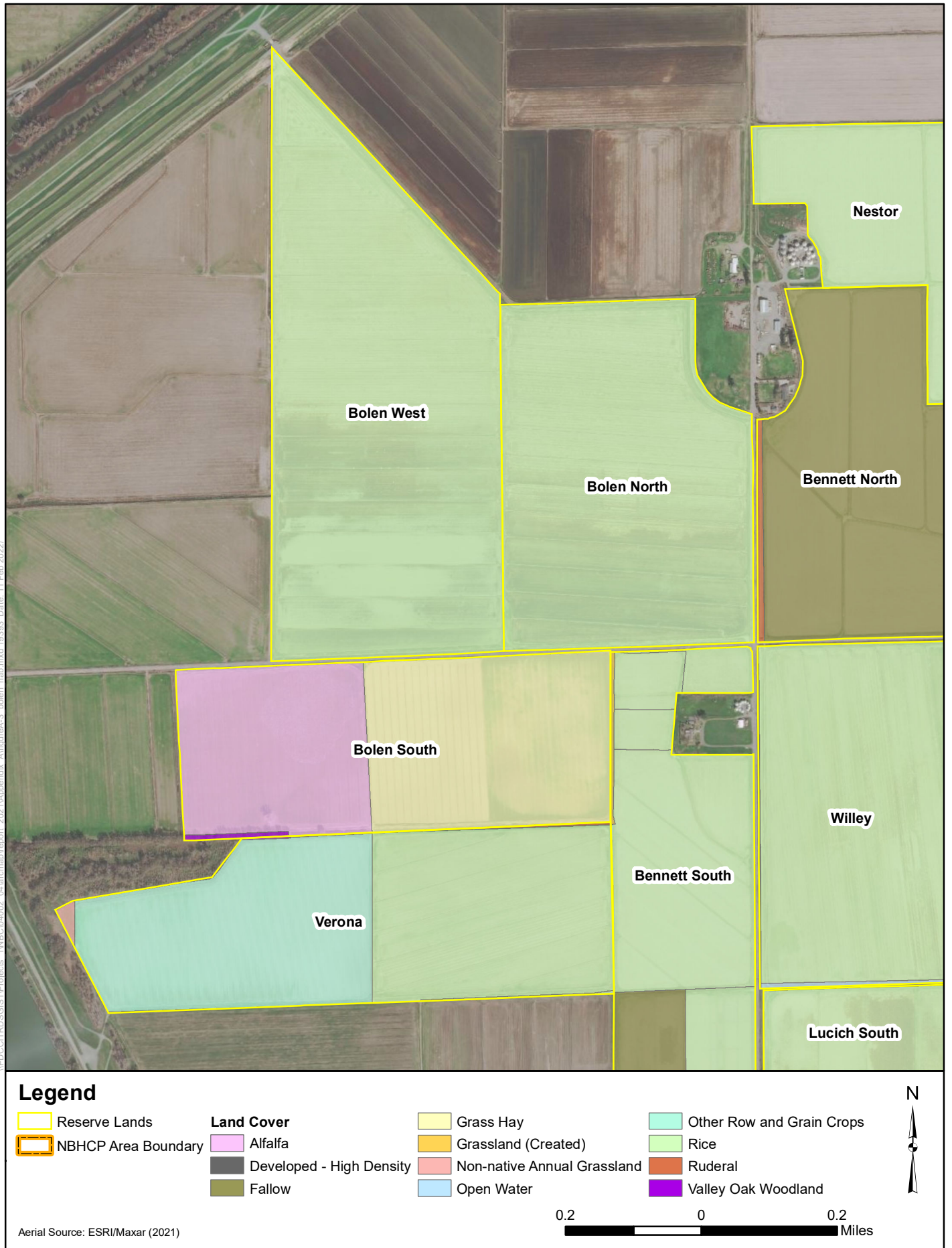
**Figure A-1**  
**North Basin Reserve—Frazer and Lucich North Tracts, 2021**



**Figure A-2**  
**North Basin Reserve—Nestor, Bennett North,**  
**Bennett South, Willey, and Lucich South Tracts, 2021**



\\PDC\IT\GIS\1\Projects - 1\NBC\04002\_04\arcmap\report\_2021\Appendix A\FigureA-3\_bolen\_hab.mxd 19393 Date: 11 Feb 2022



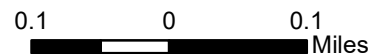
**Figure A-3**  
**North Basin Reserve—**  
**Bolen West, Bolen North, Bolen South, and Verona Tracts, 2021**



\P\DC\ITR\DSGIS\Projects\_1\NBC\04\002\_04\arcmap\report\_2021\Appendix A\FigureA-4\_huffmanE\_lucichsouth\_bennetsouthA.mxd 19393 Date: 11 Feb 2022

**Legend**

- |                     |                                |                            |                     |
|---------------------|--------------------------------|----------------------------|---------------------|
| Reserve Lands       | <b>Land Cover</b>              | Grass Hay                  | Riparian Scrub      |
| NBHCP Area Boundary | Alfalfa                        | Grassland (Created)        | Riparian Woodland   |
| County Boundary     | Fallow                         | Nonnative Annual Grassland | Ruderal             |
|                     | Fresh Emergent Marsh (Created) | Rice                       | Valley Oak Woodland |

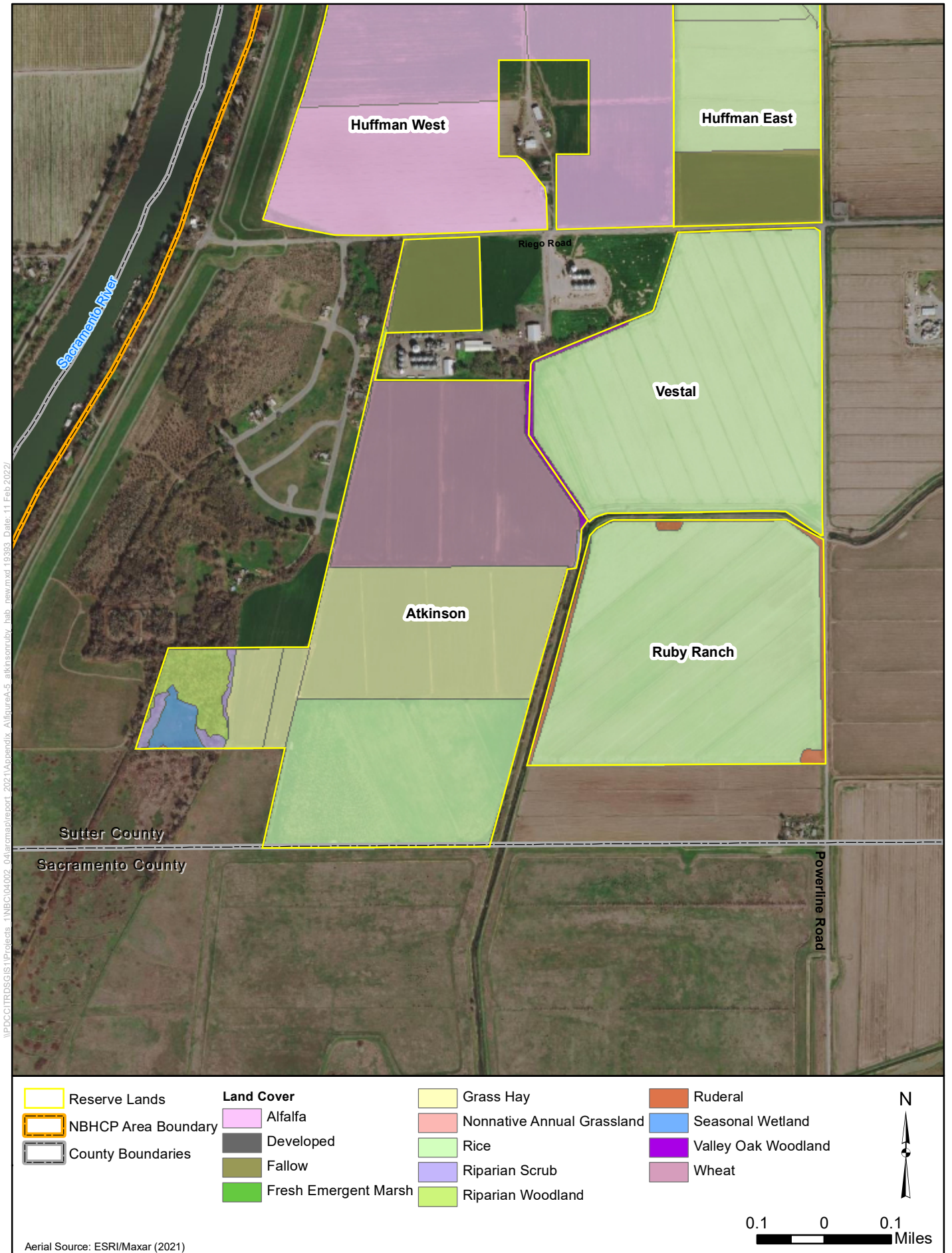


Aerial Source: ESRI/Maxar (2019)



**Figure A-4**  
 North Basin Reserve—Lauppe South, Huffman West, and Huffman East Tracts, 2021





**Figure A-5**  
**North Basin Reserve—Atkinson, Vestal,**  
**and Ruby Ranch Tracts, 2021**





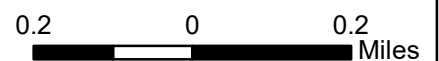
**Figure A-6**  
**Central Basin Reserve—Elsie, Sills,**  
**Bianchi West, Paulsen South, Richter, and Tufts Tracts, 2021**

\\PDC\ITRDS\GIS\1\Projects\_1\WBC\04002\_04\arcmap\report\_2021\Appendix\_A\figureA-7\_bks\_hab.mxd, Date: 11 Feb 2022/



### Legend

- |                     |                                |                   |
|---------------------|--------------------------------|-------------------|
| Reserve Lands       | <b>Land Cover</b>              | Rice              |
| County Boundary     | Developed                      | Riparian Scrub    |
| NBHCP Area Boundary | Fresh Emergent Marsh (Created) | Riparian Woodland |
|                     | Nonnative Annual Grassland     | Seasonal Wetland  |
|                     | Nonriparian Woodland           |                   |

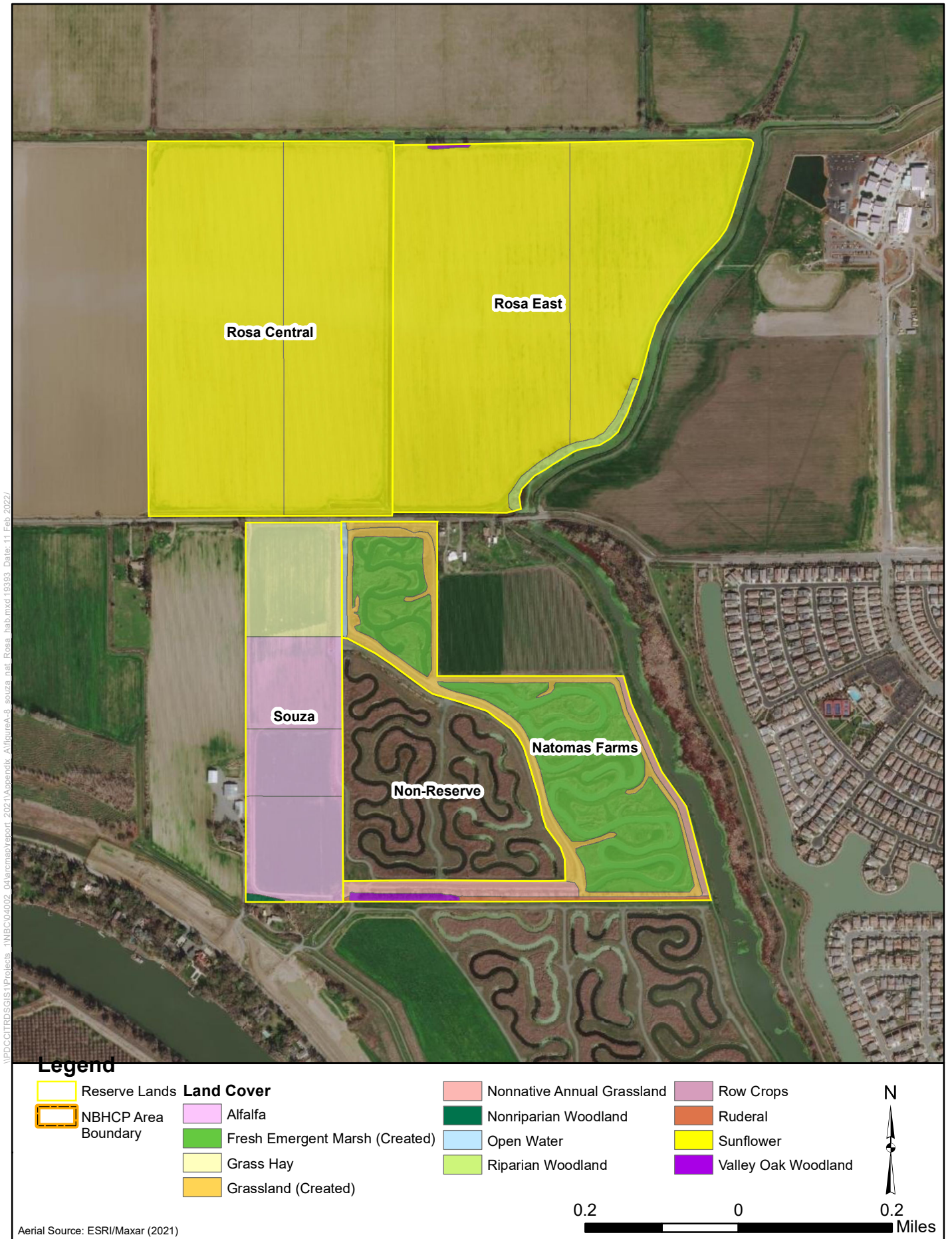


Aerial Source: ESRI/Maxar (2021)



**Figure A-7**  
**Central Basin Reserve—Frazer South, Betts, Kismat, Silva, and Silva South 1 Tracts, 2021**





\PDC\GIS\Projects\_1\NBC\04002\_04\arcmap\report\_2021\Appendix\_A\FigureA-8\_souza\_nat\_Rosa\_hab.mxd 1/3/2021 Date: 11 Feb 2021



**Figure A-8**  
**Fisherman's Lake Reserve—Rosa Central, Rosa East, Souza, and Natomas Farms Tracts, 2021**





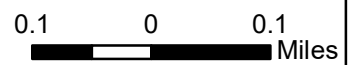
\\PDC\CTRO\S\GIS\1\Projects\_1\WB\04002\_04\arcmap\report\_2021\Appendix\_A\figureA-9\_all50\_cummings\_habA.mxd 133383 Date: 23 Dec 2021/

**Legend**

- Reserve Lands
- NBHCP Area Boundary

**Land Cover**

- |  |   |
|--|---|
| <span style="display: inline-block; width: 15px; height: 10px; background-color: #808000; margin-right: 5px;"></span> Fallow                         | <span style="display: inline-block; width: 15px; height: 10px; background-color: #FF8C00; margin-right: 5px;"></span> Ruderal             |
| <span style="display: inline-block; width: 15px; height: 10px; background-color: #32CD32; margin-right: 5px;"></span> Fresh Emergent Marsh (Created) | <span style="display: inline-block; width: 15px; height: 10px; background-color: #800080; margin-right: 5px;"></span> Valley Oak Woodland |
| <span style="display: inline-block; width: 15px; height: 10px; background-color: #FFD700; margin-right: 5px;"></span> Grassland (Created)            | <span style="display: inline-block; width: 15px; height: 10px; background-color: #FFA07A; margin-right: 5px;"></span> Wheat               |



Aerial Source: ESRI/Maxar (2021)



**Figure A-9**  
**Fisherman's Lake Reserve—Cummings and Alleghany Tracts, 2021**

Appendix B

## **Botanical Survey Results**

---



**Table B-1. Cumulative List of Plant Species Observed on the Natomas Basin Conservancy Reserves, 2005–2021**

Scientific Name (previous scientific name) <sup>a</sup>	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
<b>Ferns and Fern Allies</b>																										
<b>Azollaceae</b>	<b>Mosquito Fern Family</b>																									
<i>Azolla filiculoides</i>	Waterfern		X	X	X			X	X	X	X	X			X				X				X	X		
<b>Equisetaceae</b>	<b>Horsetail Family</b>																									
<i>Equisetum telmateia</i> ssp. <i>braunii</i>	Giant horsetail	X																			X					
<b>Marsileaceae</b>	<b>Marsilea Family</b>																									
<i>Marsilea vestita</i> ssp. <i>vestita</i>	Hairy watercress			X						X													X			
<b>Monocotyledons</b>																										
<b>Alismataceae</b>	<b>Water-Plantain Family</b>																									
<i>Alisma lanceolatum</i> *	Lance-leaved water-plantain	X	X	X	X		X	X	X	X	X	X		X		X	X	X	X	X		X	X			
<i>Alisma triviale</i> ( <i>Alisma plantago-aquatica</i> )	Common water-plantain																						X			
<i>Echinodorus berteroi</i>	Burhead	X						X	X		X	X		X												
<i>Sagittaria longiloba</i>	Gregg arrowhead								X		X													X		
<i>Sagittaria montevidensis</i> ssp. <i>calycina</i>	California arrowhead	X	X	X	X		X	X	X	X	X		X									X	X			
<b>Araceae (Lemnaceae)</b>	<b>Arum Family (Duckweed Family)</b>																									
<i>Lemna</i> sp.	Duckweed	X	X	X				X	X	X	X	X			X							X	X			
<b>Cyperaceae</b>	<b>Sedge Family</b>																									
<i>Bolboschoenus maritimus</i> ( <i>Scirpus maritimus</i> )	Prairie bulrush			X				X			X															
<i>Cyperus esculentus</i>	Nutsedge	X	X	X	X		X	X			X			X											X	

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<i>Cyperus difformis</i> *	Variable flatsedge			X			X			X	X		X		X									X	X	
<i>Cyperus eragrostis</i>	Umbrella sedge	X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
<i>Cyperus odoratus</i>	Fragrant flatsedge						X			X																
<i>Eleocharis acicularis</i>	Needle spikerush	X																								
<i>Eleocharis macrostachya</i>	Creeping spikerush					X	X			X		X			X	X	X	X						X		
<i>Eleocharis engelmannii</i> ( <i>Eleocharis obtusa</i> var. <i>engelmannii</i> )	Blunt spikerush/ Engelmann's spikerush			X			X			X														X		
<i>Schoenoplectus acutus</i> ( <i>Scirpus acutus</i> var. <i>occidentalis</i> )	Common tule	X	X	X			X			X	X		X		X	X		X	X		X	X	X	X	X	
<i>Schoenoplectus mucronatus</i> ( <i>Scirpus mucronatus</i> )*	Ricefield bulrush			X	X		X	X		X	X				X									X		
<b>Hydrocharitaceae</b>	<b>Waterweed Family</b>																									
<i>Elodea canadensis</i>	Canadian pondweed							X																		
<b>Juncaceae</b>	<b>Rush Family</b>																									
<i>Juncus balticus</i>	Baltic rush			X											X						X					
<i>Juncus bufonius</i>	Toad rush	X		X		X		X		X	X		X	X	X	X		X	X				X	X	X	
<i>Juncus effusus</i>	Soft rush	X		X	X	X									X											
<b>Poaceae</b>	<b>Grass Family</b>																									
<i>Agrostis avenacea</i> *	Pacific bentgrass	X	X	X			X			X	X													X		
<i>Alopecurus carolinianus</i>	Tufted foxtail						X			X											X					
<i>Alopecurus saccatus</i>	Foxtail	X	X	X							X		X					X								
<i>Arundo donax</i> *	Giant reed														X											
<i>Avena barbata</i> *	Slender wild oats	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) <sup>a</sup>	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
<i>Avena fatua</i> *	Common wild oats		X													X		X	X		X	X	X		X
<i>Briza minor</i> *	Little quaking grass	X													X										
<i>Bromus catharticus</i> *	Rescue brome	X	X		X					X												X			
<i>Bromus diandrus</i> *	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
<i>Bromus hordeaceus</i> *	Soft chess	X	X	X		X	X	X		X	X	X			X	X	X	X	X		X	X	X		
<i>Bromus madritensis</i> ssp. <i>rubens</i> *	Foxtail chess					X	X																		
<i>Cortaderia jubata</i>	Pampas grass																					X			
<i>Crypsis schoenoides</i> *	Swamp grass							X		X					X										
<i>Cynodon dactylon</i> *	Bermuda grass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
<i>Deschampsia danthonioides</i>	Annual hairgrass	X	X					X		X	X				X								X		
<i>Digitaria sanguinalis</i> *	Hairy crabgrass	X		X		X	X			X	X	X			X	X	X	X							
<i>Distichlis spicata</i>	Saltgrass					X	X			X				X	X		X		X	X	X	X			
<i>Echinochloa crus-galli</i> *	Barnyardgrass	X	X	X	X	X	X	X		X	X		X		X							X	X	X	
<i>Eleusine tristachya</i> *	Threespike goosegrass														X										
<i>Elymus glaucus</i>	Blue wildrye		X	X			X			X	X											X	X		
<i>Elymus triticoides</i> ( <i>Leymus triticoides</i> )	Creeping wildrye					X	X			X															
<i>Eragrostis pectinacea</i> var. <i>pectinacea</i>	Tufted lovegrass														X										
<i>Eragrostis</i> sp.*	Lovegrass														X										
<i>Festuca arundinacea</i> *	Reed fescue	X																					X		
<i>Festuca bromoides</i> ( <i>Vulpia bromoides</i> )*	Foxtail fescue			X				X							X							X			
<i>Festuca microstachys</i> ( <i>Vulpia microstachys</i> )	Small fescue		X				X			X	X											X	X		

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<i>Festuca myuros (Vulpia myuros)*</i>	Rattail fescue		X					X							X											
<i>Festuca perennis (Lolium multiflorum)*</i>	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
<i>Glyceria occidentalis</i>	Sweet flotegrass			X				X			X	X		X	X		X	X							X	
<i>Holcus lanatus*</i>	Velvetgrass										X												X			
<i>Hordeum brachyantherum</i>	Meadow barley		X					X			X	X			X							X	X			
<i>Hordeum marinum ssp. gussoneanum*</i>	Mediterranean barley							X			X					X		X	X				X			
<i>Hordeum murinum*</i>	Foxtail barley	X	X	X			X	X		X	X	X	X		X	X	X	X	X		X	X	X	X	X	X
<i>Leersia oryzoides</i>	Rice cutgrass							X			X															
<i>Leptochloa fusca</i> subsp. <i>Fascicularis</i> ( <i>Leptochloa fascicularis</i> )	Bearded sprangletop	X	X	X	X	X	X	X	X	X	X	X	X	X	X							X	X	X		
<i>Muhlenbergia rigens</i>	Deergrass														X											
<i>Oryza sativa*</i>	Rice	X	X	X	X		X		X			X	X	X		X	X	X	X	X					X	
<i>Paspalum dilatatum*</i>	Dallisgrass	X	X	X	X		X	X			X	X	X	X	X	X	X	X		X					X	
<i>Paspalum distichum</i>	Knotgrass	X	X	X	X						X	X		X	X								X	X		
<i>Phalaris aquatica*</i>	Harding grass							X								X					X					
<i>Phalaris minor*</i>	Littleseed canarygrass	X	X					X	X	X	X							X				X	X	X	X	X
<i>Phalaris paradoxa*</i>	Paradox canarygrass			X							X	X			X						X		X			
<i>Poa annua*</i>	Annual bluegrass		X		X		X	X		X	X	X		X	X			X			X	X	X			
<i>Polypogon interruptus*</i>	Ditch beard grass	X	X			X		X			X											X	X			
<i>Polypogon monspeliensis*</i>	Rabbit's-foot grass	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X		X	X	X	X		
<i>Setaria pumila*</i>	Yellow bristle grass		X							X		X			X								X			
<i>Sorghum bicolor*</i>	Milo	X								X																

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<i>Sorghum halepense</i> *	Johnsongrass	X	X	X	X	X	X	X	X		X		X	X	X		X	X	X	X		X	X	X	X	
<i>Sporobolus indicus</i>	Small smutgrass														X											
<i>Stipa pulchra (Nassella pulchra)</i>	Purple needlegrass		X												X											
<i>Triticum aestivum</i> *	Wheat					X																		X		X
<b>Pontederiaceae</b>	<b>Mud Plantain Family</b>																									
<i>Heteranthera limosa</i> *	Ducksalad				X			X			X			X												
<b>Typhaceae</b>	<b>Cattail Family</b>																									
<i>Typha angustifolia</i>	Narrow-leaved cattail			X					X										X							
<i>Typha domingensis</i>	Southern cattail	X	X	X	X	X	X	X			X	X		X		X	X	X		X	X	X	X	X	X	
<i>Typha latifolia</i>	Broadleaf cattail		X	X				X	X		X	X	X	X	X		X	X	X	X	X	X				
<b>Dicotyledons</b>																										
<b>Aceraceae</b>	<b>Maple Family</b>																									
<i>Acer negundo</i>	Box-elder					X																X	X			
<b>Adoxaceae</b>	<b>Muskroot Family</b>																									
<i>Sambucus nigra</i> subsp. <i>canadensis</i> ( <i>Sambucus mexicana</i> )	Blue elderberry	X																				X				
<b>Amaranthaceae</b>	<b>Amaranth Family</b>																									
<i>Asclepias fascicularis</i>	Narrow-leaf milkweed										X															
<b>Amaranthaceae</b>	<b>Amaranth Family</b>																									
<i>Amaranthus albus</i> *	Pigweed amaranth														X											
<i>Amaranthus</i> sp.	Amaranth				X	X				X												X				
<b>Anacardiaceae</b>	<b>Sumac Family</b>																									
<i>Toxicodendron diversilobum</i>	Poison-oak	X				X																				

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<b>Apiaceae</b>	<b>Carrot Family</b>																									
<i>Ammi visnaga</i> *	Bisnaga		X			X		X			X															
<i>Conium maculatum</i> *	Poison hemlock																								X	
<i>Daucus carota</i> *	Wild carrot								X																	
<i>Foeniculum vulgare</i> *	Sweet fennel									X												X	X	X	X	
<i>Torilis arvensis</i> *	Hedge parsley	X																				X				
<b>Araliaceae</b>	<b>Ginseng Family</b>																									
<i>Hedera helix</i> *	English ivy																									X
<b>Asclepiadaceae</b>	<b>Milkweed Family</b>																									
<i>Asclepias fascicularis</i>	Narrow-leaf milkweed														X									X		
<b>Asteraceae</b>	<b>Sunflower Family</b>																									
<i>Achyrachaena mollis</i>	Blow-wives			X							X				X			X						X		
<i>Ambrosia</i> sp.	Ragweed					X		X		X																
<i>Anthemis cotula</i> *	Mayweed							X		X																
<i>Baccharis pilularis</i>	Coyote brush	X	X								X				X								X	X		
<i>Baccharis salicifolia</i>	Mulefat														X											
<i>Carduus pycnocephalus</i> *	Italian thistle										X	X		X	X							X	X			
<i>Centaureum pulchellum</i>	Branched centaury										X	X														
<i>Centaurea solstitialis</i> *	yellow star-thistle	X	X	X	X			X	X	X	X	X	X	X	X	X	X		X	X		X				
<i>Centromadia fitchii</i>	Fitch's spikeweed			X		X									X											
<i>Cichorium intybus</i> *	Chicory			X				X	X		X				X							X		X		
<i>Cirsium vulgare</i> *	Bull thistle	X	X	X	X	X	X	X		X	X	X		X	X							X	X	X	X	X
<i>Dittrichia graveolens</i> *	Stinkwort	X						X			X				X			X				X				

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<i>Eclipta prostrata</i>	False daisy				X			X			X	X													X	
<i>Erigeron canadensis (Conyza)*</i>	Horseweed	X		X	X	X	X	X	X		X	X	X		X	X	X	X			X	X			X	
<i>Gnaphalium luteoalbum*</i>	Cudweed everlasting	X	X	X	X	X		X	X	X	X	X	X		X					X			X			
<i>Helianthus annuus</i>	Annual sunflower	X																								
<i>Helminthotheca echioides (Picris echioides)*</i>	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
<i>Heterotheca grandiflora</i>	Telegraphweed			X											X											
<i>Holocarpha virgata ssp. virgata</i>	Common tarweed	X													X											
<i>Hypochaeris glabra*</i>	Soft cat's-ear														X											
<i>Lactuca saligna*</i>	Willow lettuce										X												X			
<i>Lactuca serriola*</i>	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
<i>Lasthenia glaberrima</i>	Smooth goldfields														X											
<i>Leontodon saxstilis (taraxacoides)*</i>	Hairy hawkbit											X														
<i>Logfia gallica (Filago gallica)*</i>	Narrow-leaved filago														X											
<i>Matricaria discoidea (Chamomila suaveolens)*</i>	Pineapple weed		X									X			X											
<i>Microseris elegans</i>	Elegant microseris														X											
<i>Psilocarphus brevisissimus var. brevisissimus</i>	Woollyheads														X											
<i>Psilocarphus tenellus</i>	Slender woollyheads														X											
<i>Senecio vulgaris*</i>	Common groundsel		X	X				X		X	X		X		X				X		X				X	
<i>Silybum marianum*</i>	Milk thistle	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X
<i>Soliva sessilis*</i>	Lawn burweed														X											

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<i>Sonchus asper</i> ssp. <i>asper</i> *	Prickly sow thistle	X	X	X				X			X	X	X	X	X				X		X	X				
<i>Sonchus oleraceus</i> *	Common sow-thistle	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X		X	X	X	X	X	X
<i>Symphotrichum subulatum</i> ( <i>Aster subulatus</i> var. <i>ligulatus</i> )	Annual water-aster	X	X	X	X	X		X			X	X		X								X	X	X		
<i>Taraxacum officinale</i>	Dandelion														X								X			
<i>Tragopogon porrifolius</i> *	Salsify	X																								
<i>Xanthium spinosum</i>	Spiny cocklebur														X											
<b>Bignoniaceae</b>	<b>Bignonia Family</b>																									
<i>Catalpa bignonioides</i> *	Catalpa														X											
<b>Boraginaceae</b>	<b>Borage Family</b>																									
<i>Amsinckia menziesii</i> var. <i>intermedia</i>	Common fiddleneck	X		X				X	X	X	X	X	X		X						X					
<i>Heliotropium curassavicum</i>	Heliotrope	X									X	X											X	X		
<i>Plagiobothrys stipitatus</i> var. <i>micranthus</i>	Stipitate popcornflower														X											
<b>Brassicaceae</b>	<b>Mustard Family</b>																									
<i>Brassica nigra</i> *	Black mustard	X	X					X		X	X	X	X								X	X	X			
<i>Brassica rapa</i> *	Field mustard			X	X		X		X		X		X		X	X	X	X				X		X		
<i>Capsella bursa-pastoris</i> *	Shepherd's-purse				X		X	X	X		X		X	X	X	X	X	X			X	X	X		X	
<i>Cardamine oligosperma</i>	Idaho bittercress														X											
<i>Hirschfeldia incana</i> *	Shortpod mustard		X							X	X	X														
<i>Lepidium dictyotum</i>	Alkali pepperweed																									
<i>Lepidium didymus</i> ( <i>Cornopus didymus</i> )*	Lesser swinecress	X	X					X		X	X	X			X							X	X		X	

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<i>Lepidium latifolium</i> *	Perennial pepperweed	X		X	X	X					X				X							X		X	
<i>Planodes virginicum</i> ( <i>Sibara virginica</i> )	Common rockcress														X							X			
<i>Raphanus sativus</i> *	Wild radish	X	X	X		X		X		X	X	X			X						X	X	X	X	X
<i>Rorippa curvisiliqua</i>	Westwen yellowcress	X	X					X		X	X								X						
<i>Sinapis arvensis</i> *	Charlock mustard		X			X				X									X				X		
<i>Sisymbrium officinale</i> *	Hedge mustard				X	X																			
<b>Callitrichaceae</b>	<b>Water-Starwort Family</b>																								
<i>Callitriche marginata</i>	Water-starwort			X																					
<b>Caryophyllaceae</b>	<b>Pink Family</b>																								
<i>Cerastium glomeratum</i> *	Mouse-ear chickweed			X																					
<i>Spergularia rubra</i> *	Red sandspurry			X							X				X										
<i>Stellaria media</i> *	Common chickweed							X					X		X			X			X	X			
<b>Ceratophyllaceae</b>	<b>Hornwort Family</b>																								
<i>Ceratophyllum demersum</i>	Hornwort								X		X	X										X			
<b>Chenopodiaceae</b>	<b>Goosefoot Family</b>																								
<i>Chenopodium album</i> *	White goosefoot										X														
<i>Chenopodium</i> sp.	Goosefoot				X	X									X			X			X				X
<i>Salsola tragus</i> * (previous family – Asteraceae)	Russian thistle, tumbleweed										X	X			X								X		
<b>Convolvulaceae</b>	<b>Morning Glory Family</b>																								
<i>Convolvulus arvensis</i> *	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
<i>Cressa truxillensis</i>	Alkali weed												X		X						X		X		

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<b>Crassulaceae</b>	<b>Stonecrop Family</b>																									
<i>Crassula aquatica/solieri</i>	Water pygmy-weed									X	X															
<i>Crassula tillaea*</i>	Moss pygmy-stonecrop								X																	
<b>Elatinaceae</b>	<b>Waterwort Family</b>																									
<i>Elatine ambigua*</i>	Asian waterweed							X		X					X							X				
<i>Elatine brachysperma/rubella</i>	Waterweed							X		X																
<b>Euphorbiaceae</b>	<b>Spurge Family</b>																									
<i>Chamaesyce maculata*</i>	Spotted spurge														X									X		
<i>Chamaesyce serpyllifolia</i> ssp. <i>serpyllifolia</i>	Thyme-leaved spurge							X		X																
<i>Eremocarpus setiger (setigerus)</i>	Doveweed														X						X		X			
<b>Fabaceae</b>	<b>Legume Family</b>																									
<i>Acmispon americanus (Lotus purshianus)</i>	Spanish lotus			X																						
<i>Glycyrrhiza lepidota</i>	Wild licorice																				X		X	X		
<i>Lotus corniculatus*</i>	Bird's-foot trefoil	X	X	X											X						X		X			
<i>Lupinus bicolor</i>	Miniature lupine			X				X		X	X				X						X					
<i>Medicago polymorpha*</i>	Bur-clover	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
<i>Medicago sativa*</i>	Alfalfa					X		X	X					X							X					X
<i>Melilotus alba*</i>	White sweetclover	X	X	X				X		X	X												X			
<i>Melilotus indica*</i>	Indian sweetclover		X					X		X													X			
<i>Robinia pseudoacacia*</i>	Black locust																									
<i>Trifolium campestre*</i>	Hop clover			X											X							X				



**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<i>Trifolium dubium*</i>	Suckling clover			X					X						X								X		
<i>Trifolium fragiferum*</i>	Strawberry clover														X										
<i>Trifolium glomeratum*</i>	Clustered clover														X										
<i>Trifolium gracilentum</i>	Pinpoint clover														X										
<i>Trifolium hirtum*</i>	Rose clover							X														X			
<i>Trifolium pratense*</i>	Red clover														X										
<i>Trifolium repens*</i>	White clover														X						X				
<i>Trifolium subterraneum*</i>	Subterranean clover														X										
<i>Vicia sativa*</i>	Common vetch			X				X				X			X			X							
<i>Vicia villosa*</i>	Hairy vetch		X				X	X	X						X						X	X			
<b>Fagaceae</b>	<b>Oak Family</b>																								
<i>Quercus lobata</i>	Valley oak	X		X	X				X	X		X	X		X						X	X	X	X	X
<b>Gentianaceae</b>	<b>Gentian Family</b>																								
<i>Zeltnera muehlenbergii (Centaurium muehlenbergii)</i>	Monterey centaury			X			X	X	X												X				
<b>Geraniaceae</b>	<b>Geranium Family</b>																								
<i>Erodium botrys*</i>	Big stork's-bill		X	X	X	X		X		X	X				X	X	X	X							
<i>Erodium cicutarium*</i>	Red-stemmed filaree		X		X	X	X	X	X	X	X		X		X	X	X	X				X			
<i>Erodium moschatum*</i>	White-stemmed filaree	X	X				X	X	X	X		X			X				X		X				
<i>Geranium dissectum*</i>	Cut-leaf geranium	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X		X	X	X		
<i>Geranium molle*</i>	Dove's-foot geranium								X						X										
<b>Haloragaceae</b>	<b>Water-Milfoil Family</b>																								
<i>Myriophyllum sp.</i>	Water milfoil						X	X																	

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<b>Juglandaceae</b>	<b>Walnut family</b>																									
<i>Juglans hindsii</i> ( <i>Juglans californica</i> var. <i>hindsii</i> )	California black walnut														X						X	X	X		X	
<b>Lamiaceae</b>	<b>Mint Family</b>																									
<i>Lamium amplexicaule</i> *	Henbit deadnettle								X		X							X								
<i>Lycopus americanus</i>	American bugleweed						X																			
<i>Mentha pulegium</i> *	Pennyroyal									X					X											
<i>Stachys ajugoides/albens</i>	Hedge nettle	X																								
<i>Trichostema lanceolatum</i>	Vinegarweed			X											X											
<b>Lythraceae</b>	<b>Loosestrife Family</b>																									
<i>Ammannia coccinea/robusta</i>	Redstem	X		X	X		X	X		X	X				X							X	X	X		
<i>Lythrum hyssopifolia</i> *	Hyssop loosestrife	X	X	X	X	X	X	X	X	X	X				X			X				X	X			
<b>Malvaceae</b>	<b>Mallow Family</b>																									
<i>Abutilon theophrasti</i> *	Velvet-leaf	X			X	X	X	X		X	X	X									X	X	X	X	X	
<i>Malva neglecta</i> *	Common mallow		X		X		X	X				X				X	X	X			X					
<i>Malva nicaeensis</i> *	Bull mallow	X	X	X		X		X	X		X	X	X		X			X			X	X	X			
<i>Malvella leprosa</i>	Alkali mallow	X	X	X	X	X	X	X	X	X			X	X	X	X		X	X	X	X		X	X		
<i>Modiola caroliniana</i> *	Carolina bristle-mallow														X											
<b>Montiaceae (Split from Portulacaceae)</b>	<b>Miner's Lettuce Family</b>																									
<i>Calandrinia ciliata</i>	Red maids		X	X			X	X	X	X	X		X					X				X	X			
<i>Claytonia perfoliata</i>	Miner's lettuce			X									X		X								X			

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<b>Moraceae</b>	<b>Mulberry Family</b>																									
<i>Ficus carica</i> *	Edible fig	X		X						X				X	X						X		X			
<i>Morus alba</i> *	White mulberry	X													X									X		
<b>Myrtaceae</b>	<b>Myrtle Family</b>																									
<i>Eucalyptus camulduensis</i> *	River red gum														X							X				
<i>Eucalyptus globulus</i> *	Blue gum														X											
<i>Eucalyptus polyanthemus</i> *	Silver dollar gum														X											
<b>Oleaceae</b>	<b>Olive Family</b>																									
<i>Fraxinus latifolia</i>	Oregon ash																				X	X		X	X	
<b>Onagraceae</b>	<b>Evening-Primrose Family</b>																									
<i>Epilobium brachycarpum</i>	Panicled willow-herb				X	X	X						X			X	X	X						X		
<i>Epilobium campestre</i> ( <i>Epilobium pygmaeum</i> )	Smooth spike-primrose														X											
<i>Epilobium ciliatum</i>	Fringed willowherb	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Ludwigia peploides</i>	Floating water-primrose				X			X	X	X									X	X						
<i>Ludwigia peploides</i> ssp. <i>montevideensis</i> *	Floating water-primrose		X	X				X		X	X				X			X								
<i>Ludwigia peploides</i> ssp. <i>peploides</i>	Floating water-primrose									X					X								X	X		
<i>Oenothera elata</i>	Evening primrose	X						X																		
<b>Orobanchaceae (split from Scrophulariaceae)</b>	<b>Broomrape Family</b>																									
<i>Castilleja attenuata</i>	Valley tassels										X															
<i>Triphysaria eriantha</i>	Johnny-tuck														X											

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<i>Triphysaria pusilla</i>	Dwarf owl's clover														X											
<b>Oxalidaceae</b>	<b>Oxalis Family</b>																									
<i>Oxalis corniculata</i> *	Yellow sorrel														X											
<i>Oxalis</i> sp.*	Sorrel																				X					
<b>Phrymaceae (split from Scrophulariaceae)</b>	<b>Lopseed Family</b>																									
<i>Mimulus guttatus</i>	Seep-spring monkeyflower	X													X											
<b>Plantaginaceae</b>	<b>Plantain Family</b>																									
<i>Bacopa eisenii</i> ( <i>Bacopa eisenmanii</i> )	Eisen water-hyssop	X	X	X				X	X		X	X													X	
<i>Dopatrium junceum</i> *	Horsefly's eye			X																						
<i>Gratiola ebracteata</i>	Bractless hedge-hyssop									X																
<i>Kickxia elatine</i> *	Sharp-leaved fluellin							X																		
<i>Lindernia dubia</i>	Yellowseed false pimpernel			X																						
<i>Plantago coronopus</i> *	Buckhorn plantain														X											
<i>Plantago lanceolata</i> *	English plantain							X			X				X	X		X	X							
<i>Plantago major</i> *	Common plantain														X											
<i>Veronica anagallis-aquatica</i> *	Water speedwell								X		X								X			X				
<i>Veronica arvensis</i> *	Corn speedwell														X											
<i>Veronica peregrina</i> ssp. <i>xalapensis</i>	Purslane speedwell	X	X	X				X	X	X	X	X	X		X				X		X		X			
<i>Veronica persica</i> *	Persian speedwell														X											
<b>Platanaceae</b>	<b>Plane Family</b>																									
<i>Platanus racemosa</i>	Western sycamore		X									X			X							X				

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<b>Polygonaceae</b>	<b>Buckwheat Family</b>																									
<i>Persicaria amphibian</i> ( <i>Polygonum amphibium</i> )	Water smartweed				X	X	X																			
<i>Persicaria hydropiper</i> ( <i>Polygonum hydropiper</i> )*	Common smartweed, marsh pepper		X	X				X	X	X	X		X											X		
<i>Persicaria lapathifolia</i> ( <i>Polygonum lapathifolium</i> )	Willow smartweed	X	X		X	X			X	X	X	X			X										X	
<i>Polygonum aviculare</i> subsp. <i>depressum</i> ( <i>Polygonum arenastrum</i> )*	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
<i>Rumex conglomeratus</i> *	Clustered dock															X										
<i>Rumex crispus</i> *	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	X
<i>Rumex dentatus</i> *	Toothed dock							X			X															
<i>Rumex pulcher</i> *	Fiddle dock	X						X			X				X									X		
<b>Portulacaceae</b>	<b>Purslane Family</b>																									
<i>Portulaca oleracea</i> *	Common purslane											X			X											
<b>Primulaceae</b>	<b>Primrose Family</b>																									
<i>Anagallis arvensis</i> *	Scarlet pimpernel	X		X	X	X	X	X	X	X	X	X			X	X	X	X					X	X		X
<b>Ranunculaceae</b>	<b>Buttercup Family</b>																									
<i>Myosurus minimus</i>	Common mousetail		X									X							X							
<i>Ranunculus bonariensis</i> var. <i>trisepalus</i>	Carter's buttercup			X								X		X		X										
<i>Ranunculus muricatus</i> *	Prickle-fruited buttercup	X						X			X				X								X	X		
<i>Ranunculus</i> sp.	Buttercup							X																		

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<b>Rhamnaceae</b>	<b>Buckthorn Family</b>																									
<i>Frangula californica</i> ( <i>Rhamnus californica</i> )	California coffeeberry																							X		
<b>Rosaceae</b>	<b>Rose Family</b>																									
<i>Pyracantha angustifolia</i> *	Firethorn														X											
<i>Rosa californica</i>	California wild rose	X	X	X											X						X					
<i>Rubus armeniacus</i> *	Himalayan blackberry	X		X	X	X		X	X					X	X						X	X	X	X	X	X
<i>Rubus ursinus</i>	California blackberry	X	X			X									X						X	X	X		X	X
<b>Rubiaceae</b>	<b>Madder Family</b>																									
<i>Cephalanthus occidentalis</i> var. <i>californicus</i> (formally in <i>Rosaceae</i> family)	Buttonwillow		X	X				X			X	X									X	X			X	
<i>Galium aparine</i>	Bedstraw	X		X				X													X	X				X
<b>Salicaceae</b>	<b>Willow Family</b>																									
<i>Populus fremontii</i>	Fremont cottonwood	X		X		X		X	X	X	X	X	X	X	X						X	X	X	X	X	X
<i>Salix exigua</i>	Narrow-leaved willow	X	X	X																						
<i>Salix gooddingii</i>	Black willow	X		X				X	X		X	X			X							X	X	X		
<i>Salix lasiolepis</i>	Arroyo willow	X		X				X				X										X		X		
<b>Scrophulariaceae</b>	<b>Figwort Family</b>																									
<i>Limosella acaulis</i>	Broad-leaved mudwort							X			X															
<b>Simaroubaceae</b>	<b>Quassia Family</b>																									
<i>Ailanthus altissima</i> *	Tree-of-heaven														X											

**Table B-1. Continued**

Scientific Name (previous scientific name) <sup>a</sup>	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
<b>Solanaceae</b>	<b>Nightshade Family</b>																									
<i>Datura stramonium</i> *	Jimson weed	X																							X	
<i>Lycopersicon esculentum</i> *	Tomato							X																		
<i>Physalis lancifolia</i> *	Narrowleaf tomatillo	X	X									X			X										X	
<i>Physalis philadelphica</i> *	Tomatillo						X			X					X											
<i>Solanum americanum</i>	Common nightshade			X	X	X				X	X	X			X										X	
<b>Urticaceae</b>	<b>Nettle Family</b>																									
<i>Urtica urens</i> *	Dwarf nettle																							X		
<b>Verbenaceae</b>	<b>Vervain Family</b>																									
<i>Phyla nodiflora</i> var. <i>nodiflora</i>	Turkey tangle fogfruit									X					X											
<i>Verbena bonariensis</i> *	Purpletop vervain		X		X	X	X	X		X	X	X				X	X	X								
<b>Viscaceae</b>	<b>Mistletoe Family</b>																									
<i>Phoradendron serotinum</i> ( <i>Phoradendron villosum</i> )	Oak mistletoe	X																								
<b>Vitaceae</b>	<b>Grape Family</b>																									
<i>Vitis californica</i>	California wild grape	X																					X	X	X	X
<b>Zygophyllaceae</b>	<b>Caltrop Family</b>																									
<i>Tribulus terrestris</i> *	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.

<sup>a</sup> 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.

*This Page Intentionally Left Blank*



Appendix C

## **Avian and Other Covered Species Survey Results**

---



**Table C-1. Common and Scientific Names of Wildlife Species Observed on NBHCP Reserves, 2004–2021**

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

**Table C-1. Continued**

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

**Table C-1. Continued**

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

**Table C-1. Continued**

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

**Table C-1. Continued**

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

*This page intentionally left blank*



**Table C-2. Total Numbers of Birds Detected on NBHCP Mitigation Lands during 2021 Avian Surveys**

Common Name	North Basin Reserve															Verona	Willey	Central Basin Reserve								Fisherman's Lake Reserve					SAFCA			Total
	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lauppe South	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal			Betts Kismat Silva	Bianchi West	Elsie	Frazer South	Paulson South	Richter	Sills	Tufts	Alleghany 50	Cummings	Natomas Farms	Rosa Central	Souza	AKT	Natomas Farms West	Sharma	
Greater White-fronted Goose	1632	600	409		300	630	160				1430	1200		20		200	500	3730	68	102	290													11271
Snow Goose		1000		2060		2000					1	3201	1			2300		650															11213	
Canada Goose		145					113				320	18						515			7	2			33	198	8	5	18	53	133	1568		
Domestic Goose											1																					1		
Tundra Swan	25					272																										297		
Wood Duck							2				12		2	2				10					1		4	2	2		38	40	142	257		
American Wigeon		20				40					50	20						132										4	20	38	374			
Mallard	33	117	18	14		13	107	11		2	192	47	27	8	18	7	36	411	8	2	18	41	2	45	9		122	114	13	209	56	163	1863	
Blue-winged Teal											1							1			2			1	10						2	17		
Cinnamon Teal						1	2					1						42		4	4	3		2				5				64		
Northern Shoveler		4				50					4	255					150	33	300		110	50									4	960		
Northern Pintail	120	1				400					3	766					60		100		42	50										1542		
Green-winged Teal											3	40					10	110	200		40											403		
Redhead											2																					2		
Ring-necked Duck		1																														1		
Greater Scaup																		8														8		
Lesser Scaup																												7	1			8		
Bufflehead																		79							2							81		
Common Goldeneye												10						4								3		12	11	9		49		
Ruddy Duck											8							3														11		
Ring-necked Pheasant			2																													2		
Wild Turkey	142				1																									1		144		
California Quail	10																										2					12		
Pied-billed Grebe		35	8				49				36	2						85					5			6		13	17	40		296		
American White Pelican											91							86														177		
Double-crested Cormorant	1	20	1				10				77	2						110								1			1		223			
American Bittern			1				1		1	2	1											1	1									8		
Great Blue Heron	1	23	17	8		8	23	16		3	55	30	18	12	6	5	3	41	11	4	15	5	1	40	2		14	11	6	2	15	22	23	440
Great Egret	1	28	32	13	3	19	30	75	8	26	84	69	36	55	17	7	11	51	18	7	37	14	6	87	18		12	12	6	10	11	11	814	
Snowy Egret		3	2				8				12		1					24	1		19	2		7	2		5	3		2		92		
Green Heron																		3											3	2	2	13		
Black-crowned Night-Heron		105	26				15			2	4	8		9				46	3		1				3		1	2	1	5	3	4	238	
White-faced Ibis	11	7	80	86		419	157	1573	27	122	13	721	325	396	29	134	86	50	145	133	41	62	80	384	223				9			11094		
Turkey Vulture	19	7				5	1		12		5	1	3		1						3			1					1		2	62		
Osprey	1								1																					1		3		
White-tailed Kite	6	19	2								1						1	9		2		1	2				7	2		1	1	3	57	

Table C-2. Continued

Common Name	North Basin Reserve															Verona	Willey	Central Basin Reserve								Fisherman's Lake Reserve					SAFCA			Total	
	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lauppe South	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal			Betts Kismat Silva	Bianchi West	Elsie	Frazer South	Paulson South	Richter	Sills	Tufts	Alleghany 50	Cummings	Natomas Farms	Rosa Central	Souza	AKT	Natomas Farms West	Sharma		
Northern Harrier	2	2	5	3		3	2	4			6	8	5	2	1	1	2	4	1	1			2	5	4			1	2		2	3	2	1	74
Cooper's Hawk	2	1	3			2					2				1			2								1		1						15	
Red-shouldered Hawk	1	1							1	1		2						5		1						2	1		1					16	
Swainson's Hawk	1		1			1			3						1							1			1									17	
Red-tailed Hawk	19	5	10	2	4	1	5	6	7		13	15	4	4	1	2	32		20	6	1	4	21	10		1	7	3		3	1	2	209		
Ferruginous Hawk												1																						1	
American Kestrel	9	1	2		1		1	2	13		4	4		1	2		2									2	1	8	3	1	1	2		60	
Peregrine Falcon																			1															2	
Sora																	9														3	1		13	
Common Gallinule		6					2				11						44			2										30	7	14		116	
American Coot		433				45	163	2			367	68					2289			88			1			1			115	57	73		3702		
Killdeer	5	7	6	6		4	15	6	6	1	18	13	33	10	15	5	53	11	6	11	3	5	60	7		5	7	2	1	5	6	2	334		
Black-necked Stilt											7	1		8			14						4											34	
American Avocet																							3											3	
Greater Yellowlegs	1		10	1		3		2	7		227	41	1	2			16	4	12	2	6	5	1	7									348		
Long-billed Curlew				41		32					60								18		9													169	
Western Sandpiper													4																					4	
Least Sandpiper			4									20					21	24		80														149	
Baird's Sandpiper													4																					4	
Dunlin												5																						5	
Long-billed Dowitcher			14			374					177																							565	
Wilson's Snipe		1										10	1				1																	13	
Wilson's Phalarope																							8											8	
Ring-billed Gull										17		161							32														2	212	
California Gull						18					1						1		1															21	
Forster's Tern																	2																	2	
Rock Pigeon																					3											6	9		
Eurasian Collared-Dove	4																15											1					20		
Mourning Dove	68		2	2	3	2	3	4	3	5	4	2	2	19	11	2	113		2	5					3	5	6	12	25	3	33	27	366		
Great Horned Owl			5				1	1			1	1					3																	12	
Burrowing Owl																			2				4											11	
Short-eared Owl																			3															3	
Anna's Hummingbird	1			1																						2	1		2	2	2		11		
Belted Kingfisher							3				2				1		1									2			1	1			11		
Acorn Woodpecker	1																																	1	
Red-breasted sapsucker	1																																	1	
Nuttall's Woodpecker	24			1																						1	1							27	
Northern Flicker	3																2																	5	
Western Wood-Pewee	5																																	5	



