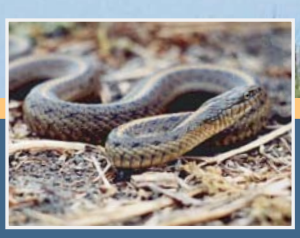

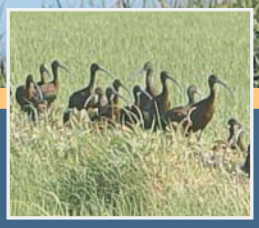

Biological Effectiveness Monitoring for the Natomas Basin Habitat Conservation Plan Area

2016 ANNUAL SURVEY RESULTS

April 2017

the NATOMAS BASIN conservancy

BIOLOGICAL EFFECTIVENESS MONITORING FOR THE NATOMAS BASIN HABITAT CONSERVATION PLAN AREA 2016 ANNUAL SURVEY RESULTS

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Acronyms and Abbreviations

Basin	Natomas Basin
BEMT	Biological Effectiveness Monitoring Team
BIC	Bayesian Information Criterion
BKS	Betts-Kismat-Silva
Cal-IPC	California Invasive Plant Council
CESA	California Endangered Species Act
CMR	capture-mark-recapture
CNDDB	California Natural Diversity Database
CPUE	catch per unit effort
DFG	California Department of Fish and Game
DFW	California Department of Fish and Wildlife
ESA	Endangered Species Act
g	gram
GIS	geographic information system
GPS	global positioning system
I-	Interstate
ICF	ICF International
MAP	Metro Air Park
MAP HCP	Metro Airpark Habitat Conservation Plan
MCMC	Markov Chain Monte Carlo
mm	millimeter
NBHCP	Natomas Basin Habitat Conservation Plan
NLIP	Natomas Levee Improvement Program
plan area	NBHCP Area
PIT	passive integrated transponder
Plan	Natomas Basin Habitat Conservation Plan
SAFCA	Sacramento Area Flood Control Agency
SCAS	Sacramento County Airport System
SMF	Sacramento International Airport

SR	State Route
SREL	Sacramento River east levee
SSMP	Site-Specific Management Plan
SVL	snout–vent length
TAC	Technical Advisory Committee
TNBC	The Natomas Basin Conservancy
TVL	tail–vent length
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator

Chapter 1
Introduction

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*) 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, which will support viable populations of Swainson's hawk (*Buteo swainsoni*), giant gartersnake (*Thamnophis gigas*), and other species covered under the Plan.

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

[1] The MAP HCP covers a 2,011-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.

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 the end of 2015, TNBC owned and operated 29 separate tracts totaling approximately 4,104 acres (1,661 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).

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 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 (formerly known as the Natomas Main Drainage Canal and the East Main Drainage Canal) 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 giant gartersnake—are currently listed under the California and/or federal ESAs and 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 and Avian Surveys,* with the exception of covered plant species, which are addressed in Chapter 2, *Land Cover Mapping, Floristic 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.

Land Cover Mapping, Floristic 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 habitat type and distribution that will continue through the permit term.

Floristic 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, Floristic Inventory, and Noxious Weed Monitoring*.

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. Chapter 3, *Giant Gartersnake*, describes the sampling protocol and methods and presents the results of the surveys.

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. The methods and results of the Swainson's hawk surveys are described in Chapter 4, *Swainson's Hawk*.

Other Covered Wildlife Species Monitoring

Monitoring of populations of Other Covered Species was initiated in 2004. The monitoring on reserve lands includes surveys to evaluate the Plan's effectiveness in meeting objectives for Other Covered Species. Surveys for Other Covered Species 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 and Avian Surveys*.

1.3 Summary of the 2015 Biological Effectiveness Monitoring Program Results

This section summarizes the 2016 results of the Biological Effectiveness Monitoring Program. It should be noted that 2016 was the fifth consecutive year of extreme drought in California, which would be expected to negatively affect populations of covered species in both predictable and unpredictable ways.

Construction is complete for most of the Natomas Levee Improvement Program (NLIP) setback levee along the rural portions of the Sacramento River, and disturbance associated with this construction has been minimal for the last 3 years. The large swaths of grassland, riparian habitat, and managed marsh habitat that were created as mitigation for NLIP have been fully functional for over 2 years and should contribute significantly to the conservation of Other Covered Species in the Basin.

There were only minor changes in land cover types from 2015 to 2016. There were slight increases in the acreages of rice, upland agricultural lands, and fallow lands and slight decreases in grasslands. The acreage of managed marsh lands remained stable.

Trends in giant gartersnake abundance estimated using open population models, which allow for emigration, immigration, birth, and death, showed an increase in giant gartersnake abundance for all monitored sites except Natomas Farms and BKS; however, the Natomas Farms and BKS sites are anomalous due to the small number of captures (Natomas Farms) and changes in the location of trap lines between years (BKS). Trends in other demographic parameters (recruitment and intrinsic rate of population growth) were variable. However, at all sites there was a higher probability of the population being stable or increasing than the probability of the population decreasing.

The dynamic occupancy monitoring models, which account for changes in occupancy of wetland units (defined as being contained within water control structures) between years due to extinction and colonization, showed a decrease in the probability of occurrence of giant gartersnake from 2015 to 2016. This reflects a potential change in the distribution of giant gartersnake within the wetlands, rather than a decline in populations.

Although the number of Swainson's hawk pairs in the Basin decreased slightly in 2016, there has been a statistically significant increase in the number of occupied territories in the Basin over the monitoring period (i.e., 2001–2016). All measures of reproductive success also decreased slightly in 2016, but remained higher than the average over the previous 16 years.

There has been a decline each year in the mean number of loggerhead shrike (*Lanius ludovicianus*) detections per survey on reserve lands over the last 5 years, with 2016 being the lowest number of detections recorded since monitoring began. The mean number of shrike detections per survey from Basin-wide surveys exhibited a similar decline, with 2016 being the lowest number of detections ever recorded.

White-faced ibis (*Plegadis chihi*) did not nest in the Basin in 2016, but the mean number of detections per survey increased slightly in 2016 for both reserve surveys and Basin-wide surveys. Tricolored blackbirds (*Agelaius tricolor*) did not nest in the Basin in 2016 and have not nested in the Basin for the last 5 years. The mean number of detections per survey on reserve lands has decreased over the last 5 years and 2016 was the lowest number of detections per survey recorded since monitoring began. Trends in both the mean number of detections per survey and the proportion of surveys with detections for Basin-wide surveys are more ambiguous. However, the species has declined significantly throughout its range and is being considered for listing under both the federal and state ESAs. The mean number of burrowing owls (*Athene cunicularia*) detected per survey on reserve lands in 2016 increased slightly, ending 6 years of continuous declines. However, Basin-wide surveys exhibited a continued decline in the nesting population of burrowing owls. The mean number of Pacific pond turtle (*Actinemys marmorata*) detections decreased slightly in 2016, but remained well above the average number of detections since monitoring began. This species is now established on most (if not all) tracts with managed marsh habitat.

1.4 References

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Table 1-1. Reserve Lands Acquired under the NBHCP as of December 2016

Reserve/Tract	Date Acquired	Acres
North Basin Reserve		
Atkinson	6/12/03	199.4
Bennett North	5/17/99	226.7
Bennett South	5/17/99	132.5
Bolen North	4/29/05	113.6
Bolen South	4/29/05	102.4
Bolen West	9/01/06	155.1
Frazer	7/31/00	92.6
Huffman East	9/30/03	135.8
Huffman West	9/30/03	157.9
Lucich North	5/18/99	268.0
Lucich South	5/18/99	351.9
Nestor	9/1/06	233.2
Ruby Ranch	6/23/03	91.1
Vestal	9/12/05	95.0
Central Basin Reserve		
Betts	4/5/99	139.0
Bianchi West	11/7/06	110.2
Elsie	11/7/06	158.0
Frazer South	11/7/06	110.4
Kismat	4/16/99	40.5
Sills	7/15/02	436.4
Silva	1/7/99	159.2
Silva South 1	9/28/12	29.1
Tufts	9/29/04	148.0
Fisherman's Lake Reserve		
Alleghany	11/7/02	50.3
Cummings	11/7/02	66.8
Natomas Farms	7/9/01	55.2
Rosa Central	3/23/05	100.0
Rosa East	3/23/05	106.3
Souza	7/2/01	40.0
Total		**4,104**[b]

Source: The Natomas Basin Conservancy 2017.

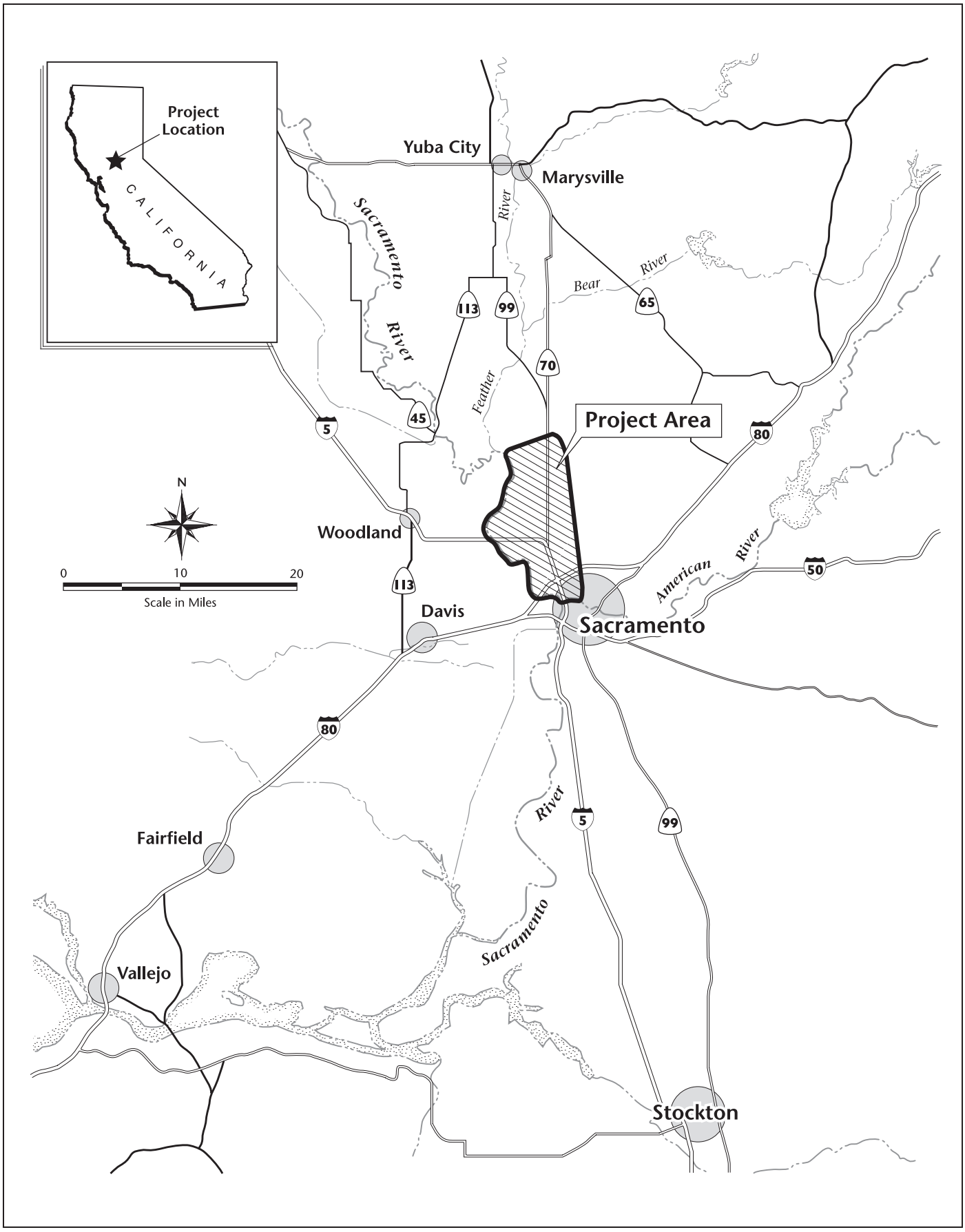
[a] Includes only properties owned by TNBC in fee title. Does not include 27.08 acres under easement.

[b] Acreages are rounded to the nearest tenth and reflect acreage totals at time of purchase. Acreage totals gathered through land cover mapping and GIS analysis may vary slightly.

Table 1-2. Species Covered under the NBHCP

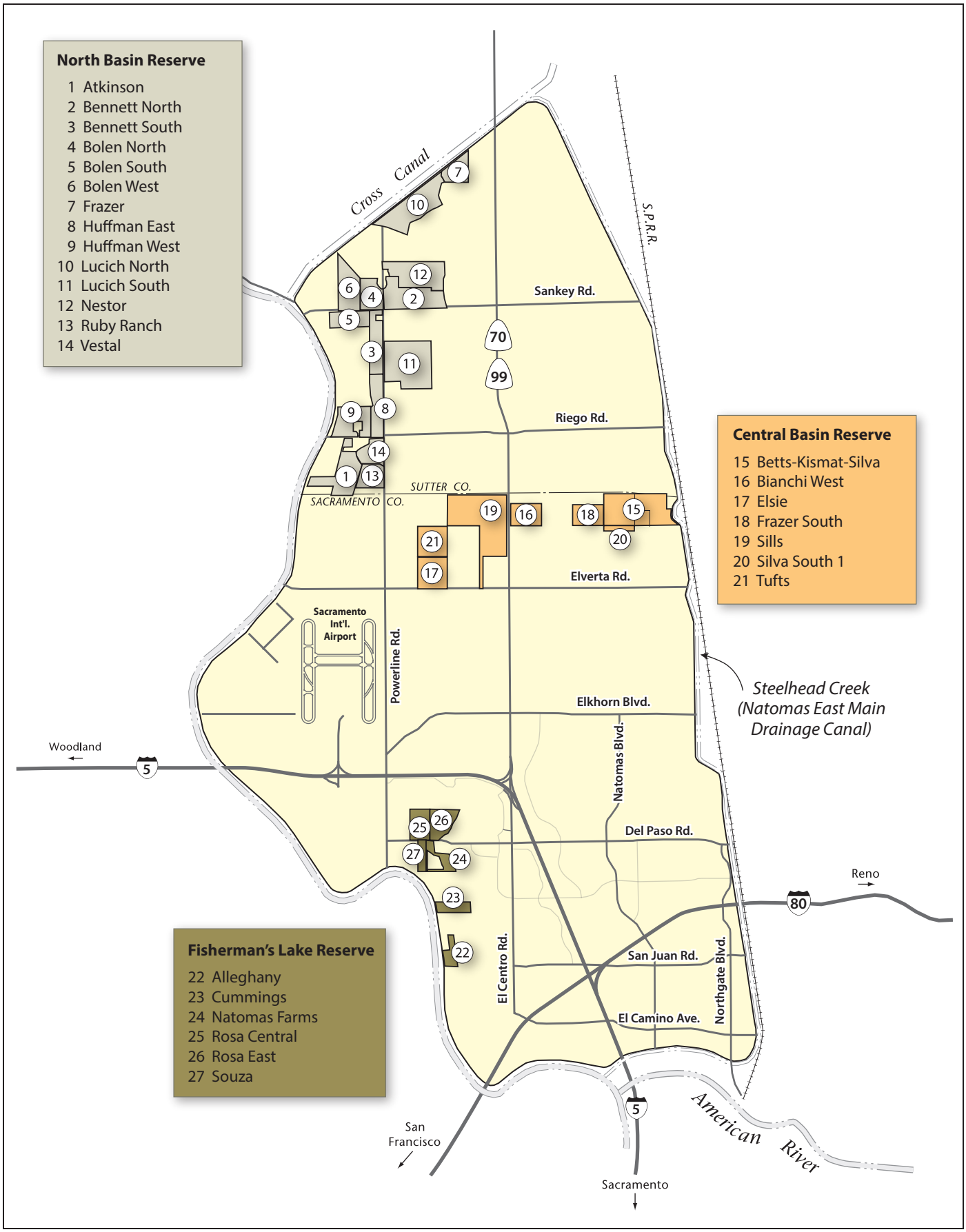
Common Name	Scientific Name
White-faced ibis	*Plegadis chihi*
Aleutian cackling goose[a]	*Branta hutchinsii leucopareia*[a]
Swainson's hawk	*Buteo swainsoni*
Burrowing owl	*Athene cunicularia*
Loggerhead shrike	*Lanius ludovicianus*
Bank swallow	*Riparia riparia*
Tricolored blackbird	*Agelaius tricolor*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

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



Graphics ... 890.110 NBC (01.05.17) TAG

Figure 1-1
Project Location



Graphics ... 890.110 NBC (01.05.17) TAG

Figure 1-2
Natomas Basin

Typical habitat of the central and northern Natomas Basin

Natomas Cross Canal

Graphics ... 890.10 (01.05.17) TAG

ICF

Figure 1-3
Central and Northern Basin Habitats

Fisherman's Lake

Mature riparian forest along the Sacramento River

Graphics ... 890.10 (01.05.17) TAG

Figure 1-4
Riparian Habitats in the Northern Basin

Typical habitat of the west and south Natomas Basin

Residential development in the south basin

Graphics ... 890.10 (01.05.17) TAG

Figure 1-5
Southern and Western Basin Habitats

Typical habitat of the east basin

Steelhead Creek (formerly the Natomas East Main Drain Canal)

Graphics ... 890.10 (01.05.17) TAG

ICF

Figure 1-6
Eastern Basin Habitats

Chapter 2

Land Cover Mapping, Floristic Inventory, and Noxious Weed Monitoring

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 monitoring on reserve lands and monitoring off reserves (i.e., 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). Floristic surveys are conducted to identify special-status 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.

Floristic surveys on reserves are conducted annually. The objectives of floristic surveys on reserve lands are listed below.

- Document changes in the distribution or condition of land cover and habitat types.
- Document the location, numbers, and/or cover of covered plant species or invasive or 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 determined using 2004 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 when available.

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 and on reserves is conducted annually, primarily while conducting surveys for other purposes. Any remaining polygons are checked later in the season before the fall harvest begins. Small portions of some polygons off reserves could not be checked because access to the private property on which they occur was not available. In these areas, the most current aerial imagery from Google Earth (Google 2016) was used to verify the 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 noxious weed populations.

2.2.2 Floristic Surveys

Floristic surveys were completed from March through October 2016 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 noxious weeds. 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). 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[1] 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 floristic surveys are those rated High or Moderate, or designated a Red Alert species by the California Invasive Plant Council[2]. These lists comprise 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, input from local land managers, and non-listed plants that are potentially invasive in wetlands and may be of management concern to TNBC.

Each noxious weed occurrence observed during the floristic surveys on reserves was hand-mapped on aerial imagery and added to the cumulative list of plant species. When highly invasive species requiring immediate management action are detected, a KMZ file is sent to TNBC that identifies the weed type and location. 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.

2.3 Results

2.3.1 Land Cover Types Basin-Wide

The acreages of each land cover type mapped in the Basin from 2004 to 2016 are listed in Table 2-1. The distribution of these types is shown in Figure 2-1 (several land cover types have been combined in the figure for clearer representation). The 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 compose the vast majority of foraging habitat for Swainson's hawk, one of the two Covered Species that are listed

[1] http://calflora.org/

[2] http://www.cal-ipc.org/ip/management/ipcw/categories.php

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 of the other Covered Species. The acreages of these land cover categories are shown in Table 2-2, along with the proportion of the Basin comprised by each type. Figure 2-2 shows changes in the acreage of major land cover types since 2004; these are summarized below.

- Active rice fields continue to dominate the landscape, decreasing by approximately 314 acres from 38.4% of the Basin in 2015 to 37.8% of the Basin in 2016.
- Managed marsh/wetlands acres have remained stable at 1,311 acres after the substantial increase in 2013 caused by the maturation of wetlands created by SAFCA as mitigation for the NLIP.
- Upland agricultural lands increased by 119 acres from 21.7% of the Basin in 2015 to 21.9% of the Basin in 2016.
- Fallow lands increased by 346 acres between 2015 (2.5% of Basin) and 2016 (3.2% of Basin).
- Grassland habitats decreased by 187 acres (0.3%) due to conversion to agricultural and developed land cover types.

The most significant changes in land and habitat values over the last 6 years have been driven by the 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, seasonal wetland, and fresh emergent marsh.

The acreage of developed lands remained relatively stable in 2016, primarily due to the moratorium on development implemented in December 2008 due to concerns about the level of flood protection in the Basin. The moratorium was recently lifted and development in the Basin is expected to resume in 2017.

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., 1.5% of the land area). As noted above, the Basin-wide acreage comprising these habitat types has generally been increasing due to mitigation from the NLIP and is now approximately 850 acres. The small area of terrace grassland on the eastern edge of the Basin was not differentiated from the nonnative annual grassland category, although this area includes some remnant valley floor grassland.

2.3.2 Land Cover Types on Reserves

The total acreage of each land cover type mapped on reserves from 2004 to 2016 are 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 mitigation lands comprised by each type.

The proportion of reserve lands in rice and upland agriculture decreased slightly in 2016 because of regular crop rotations, while the total acreage of wetlands on reserves has remained stable since 2007. The acreages of each mapped land cover type for 2004–2016 are listed by reserve and tract in Appendix A.

Table 2-5 summarizes the major habitat types on reserves as a proportion of those habitats in the entire Natomas Basin. In 2016, reserve lands accounted for 48.1% of the managed marsh/wetlands in the Basin, but only 11.4% of the rice lands and 4.7% of upland agricultural habitats. Reserve lands accounted for a smaller proportion of wetlands in the Basin beginning in 2014 because of the fresh emergent marsh habitats created as mitigation for the NLIP. These lands are now being managed by TNBC to maximize habitat values for covered species.

Riparian and woodland habitats created on reserve lands, including the two elderberry mitigation sites in the Fisherman's Lake Reserve, have continued to mature and thrive. A small area of plantings was added on the Souza Tract in the Fisherman's Lake Reserve. These plants were just becoming established in 2016.

2.3.3 Noxious Weed Surveys

Noxious weed occurrences recorded from 2004 to 2016 are summarized in Table 2-6. A total of 26 new weed populations were documented in 2016: 13 yellow star-thistle (*Centaurea solstitialis*), 9 bull thistle (*Cirsium vulgare*), 2 Himalayan blackberry (*Rubus armeniacus*), and 2 Italian thistle (*Carduus pycnocephalus*). The Atkinson, Huffman West, Lucich North, Lucich South, Ruby Ranch, Vestal, Bianchi West, and Sills tracts all had new occurrences of yellow star-thistle. These occurrences were found along edges of regularly disturbed areas such as agricultural fields and dirt roads. The Bolen North, Huffman East, Lucich South, Nestor, Vestal, BKS, and Souza tracts all had new occurrences of bull thistle, which were also found along the edges of disturbed areas.

No new occurrences of perennial pepperweed (*Lepidium latifolium*) were found in 2016. Efforts to control the spread of perennial pepperweed in managed marsh habitats on reserve lands since it was first documented in 2004 have been very successful. Because this species is highly invasive and seedbanks or root segments can lay dormant for several years, careful monitoring should continue.

Eighteen noxious weed occurrences documented in 2015 that were not found in 2016 are listed below.

- 8 occurrences of bull thistle on the Bennett North, Bennett South, Bolen West, Lucich North, Cummings, and Rosa tracts.
- 2 occurrences of Himalayan blackberry on the Alleghany and Natomas Farms tracts.
- 6 occurrences of yellow star-thistle on the Bennett South, Frazer, BKS, Elsie, Tufts, and Alleghany tracts.
- 1 occurrence of perennial pepperweed on the Rosa tract.

- 1 occurrence of Italian thistle on the Ruby Ranch tract.

These populations have been controlled by active management practices. Due to regeneration from seedbanks or root segments, it will not be known if the populations have been eradicated for a few more growing seasons. However, data from the past several years appear to show an overall decrease in noxious weed populations within the reserves, and the current control programs appear to be highly successful.

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 BKS and Cummings tracts, and Himalayan blackberry on several tracts. Given the extent of construction activities in the Basin over the last 6 years and the propensity for construction activities to result in the spread of noxious weeds, careful monitoring and active management should continue.

2.3.4 Floristic Surveys

No covered plant species were recorded on TNBC reserves in 2016. Freshwater marsh and banks adjacent to open water canals provide suitable habitat for Delta tule pea and Sanford's arrowhead. However, suitable vernal pool habitat for the remaining covered plants is extremely rare in the Basin. This finding was anticipated on the basis of thorough surveys in potentially suitable habitat and historical survey records. The cumulative list of plant species recorded on each tract through the 2016 field season is presented by reserve in Appendix B.

2.3.5 Managed Marsh Vegetation Management

Potential declines in the functionality and habitat values of the created managed marsh holdings due primarily to invasive aquatic vegetation were noted in 2006 by both TNBC and the BEMT. Threats to marsh functionality and habitat values included channel clogging by water primrose (*Ludwigia* sp.), azolla (*Azolla* sp.), and water fern (*A. filiculoides*) and channel invasion by cattails (*Typha* sp.). TNBC, in consultation with the BEMT, responded to the potential loss of habitat values for Covered Species by initiating several maintenance and enhancement projects in managed marsh habitats in 2007. These projects were implemented on all tracts with managed marsh components in the North Basin Reserve: Frazer, Lucich North, Lucich South, Bennett North, and Bennett South.

Similar activities were initiated in spring 2008 on the Natomas Farms and Cummings tracts in the Fisherman's Lake Reserve. Marsh maintenance and enhancement activities were completed in late summer 2008. Marsh maintenance and enhancement activities at BKS began in 2009 and have been conducted in stages. The south course channel of the BKS tract underwent channel clearing with some design enhancements in spring 2009. Phase 1 of the north course channel clearing project of the BKS tract was initiated in August and completed in September 2011. Phase 2 of the project—conducted in 2012—was completed in 17 days. The third phase of the BKS north course channel clearing project was completed in 2013, and phase 4 was completed in 2014.

Vegetation management to prevent the spread of water primrose and perennial pepperweed has been very effective and although infestations of azolla and water fern still occur in some places, the severity of such infestations appears to have been reduced in most areas.

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 the fallowing of rice lands in 2006 and subsequent return to rice over the last decade and to the implementation of the NLIP, which resulted in an increase in grasslands and managed marsh/wetland habitats.

The continuing 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 project have resulted in a significant increase in habitats available for use by giant gartersnake.

The resumption of rice agriculture that began in 2011 resulted in a concomitant decrease in fallow lands that are considered suitable Swainson's hawk foraging habitat. However, some of the lands fallowed initially in 2006 were converted to upland agricultural crops, which are considered a higher value habitat type for Swainson's hawk than fallow lands, offsetting to a degree the losses associated with the resumption of rice agriculture. Although the total amount of suitable Swainson's hawk foraging habitat decreased modestly in 2016, the row and field crop category — one of the higher value crop types for Swainson's hawk —increased slightly.

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 2016, active rice lands on reserves constituted 11.4% of the Basin-wide total, down slightly from 11.7% in 2015. Upland agriculture on reserve lands accounted for approximately 4.7% of the upland agriculture in the Basin in 2016, a slight decrease of 0.3% from 2015.

2.4.3 Floristic Surveys

A cumulative total (2004–2016) of 383 plant species from 71 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 51 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 were species that are common and widespread in agricultural habitats in the Central Valley. Occurrences typically comprised small patches with low to moderate levels of infestation.

Described below are four noxious weed species that could pose a significant threat to habitat values on reserve lands—perennial pepperweed, water primrose, red sesbania (*Sesbania punicea*), and small smutgrass. Perennial pepperweed is considered an aggressive invader of wetlands in California. Once established—typically in moist habitats such as wetland perimeters and riparian areas—it forms dense monospecific stands that exclude other plants (Bossard et al. 2000). Complete eradication is very time consuming, expensive, and difficult. Intensive control efforts implemented immediately after detection on the BKS tract while the infestation was still relatively small have been highly successful in containing and perhaps eliminating this species from the BKS tract.

Water primrose is a perennial aquatic plant that roots along the shoreline and in shallow water and grows out across the water surface where it can form dense mats several inches deep. In some cases, it can cover 100% of the water surface. Water primrose is of growing concern in central and northern California, and research is focusing on developing effective control methods. The taxonomy and identification of water primrose in California is unresolved at this time; further research is focusing on clarifying which species or subspecies are invasive, because specific identity may be a factor in applying appropriate control methods, as different taxa may respond differently to treatments (Grewell 2007). Aggressive control of water primrose using a variety of methods has been highly effective on reserve lands in preventing the re-establishment of this species at any significant levels of infestation.

Red sesbania is a highly aggressive invader of wetlands and has a California Invasive Plant Inventory Rating of High; it forms dense clusters that preclude access to rivers and creeks in the Sacramento region (California Invasive Plant Council 2016a). Red sesbania was not found within any TNBC reserves in 2016, despite the presence of a large population in Steelhead Creek that extends along most of the eastern border of the Basin. Monitoring efforts for red sesbania within reserves and closely monitoring populations within the Basin should continue.

Small smutgrass was detected on the BKS tracts by TNBC staff in 2010. This grass is not listed in the California Invasive Plant Inventory Database but is on the Cal-IPC's watchlist (California Invasive Plant Council 2016b). According to the Cal-IPC weed alert, small smutgrass has been found invading irrigated pastures of the Sacramento Valley. The plant reproduces by seed, and fruit production is frequently prolific; seeds become sticky and gelatinous when moistened, facilitating distribution (DiTomaso and Healy 2007:1308). Monitoring for small smutgrass within the Basin where suitable habitat is present should continue.

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 habitats for Covered Species.

Improved communication and coordination among TNBC, the BEMT, and other land management and weed control contractors hired by TNBC have been effective in improving management actions that are implemented in a more 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. Management actions are now routinely initiated to control noxious weeds and invasive aquatic plants. Control of perennial pepperweed and invasive aquatic plants such as water primrose will likely continue to be required annually; actions taken to date have been successful in reducing the level of infestation of perennial pepperweed to an almost undetectable level and in some cases, eliminating this species. 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 the years since marsh maintenance and enhancement activities resulted in their complete removal.

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, hornwort [*Ceratophyllum demersum*], perennial pepperweed, small smutgrass, and red sesbania) 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.
- 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.
- 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.

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Table 2-1. Basin-Wide Extent (acres) of Mapped Land Cover Types, 2005–2016

Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Rice	22,321	14,792	14,590	14,224	15,014	15,023	15,287[a]	16,956	19,001	20,104	20,796	20,482
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
Alfalfa	931	1,401	1,189	1,519	2,194	1,302	2,417	2,023	1,303	1,179	1,200	1,386
Irrigated grassland	452	374	451	373	378	345	746	750	757	757	352	326
Grass hay	178	153	2,212	2,367	2,769	6,724	5,423	6,504	6,250	6,850	7,582	7,043
Wheat	1,824	2,375	1,104	804	3,919	695	585	413	440	978	650	1,192
Milo	0	328	211	161	0	0	0	0	155	94	0	0
Tomatoes	50	145	112	113	8	10	0	0	0	108	63	40
Sunflower	709	572	0	251	166	804	714	362	821	903	388	519
Safflower	886	532	244	426	162	214	278	322	0	29	448	426
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
Orchard	184	184	184	99	99	94	53	50[b]	50	307[d]	406[d]	406
Fresh emergent marsh (created)	575	575	676	897	897	897	897	897	897	1,042	1,042	1,042
Fresh emergent marsh	138	154	154	155	155	155	154	154	154	154	154	154
Seasonal wetland	105	105	108	105	105	110	103	103	115	115	115	115
Grassland (created)	49	71	68	74	74	80	74	75	469[c]	511	511	511
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
Ruderal	329	406	409	399	704	747	864	766	754	856	946	924
Valley oak woodland	191	195	192	192	194	209	240	242	257	248	261	322[e]
Riparian woodland	348	346	357	357	354	359	357	398	398	393	389	390
Riparian scrub	117	117	114	133	133	133	133	133	133	134	134	138
Nonriparian woodland	52	50	51	51	51	29	28	43	43	43	28	28
Open water	352	340	340	337	337	360	381	387	490	459	459	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
Developed—high density	9,859	10,764	11,533	11,304	11,260	10,910	10,770[a]	10,604	10,529	10,533	10,505	10,539
Disturbed/bare	1,440	1,127	578	573	291	2,321	1,659	1,243	744	58	63	62
Total	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**	**54,206**

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

[b] Decrease in orchard acreage due to availability of new aerial imagery that allowed visibility of private property. This 3-acre crop is now irrigated grassland.

[c] Increase in grassland (created) due to conversion of disturbed/bare by the Sacramento Area Flood Control Agency (SAFCA).

[d] Increase in orchard due to conversion of land west of the airport from row crops to orchard in 2014 and 2015.

[e] Increase in valley oak woodland due to establishment of woodland planted during the SAFCA revegetation of the setback levee.

Table 2-2. Basin-Wide Summary of Major Habitat Types, 2005–2016

	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
Habitat Type[a]	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[b]	28.2[b]	16,956	31.3	19,001	35.1	20,104	37.0	20,796	38.4%	20,482	37.8
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
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
Grassland	7,767	14.3	7,263	13.4	5,669	10.5	5,461	10.1	5,794	10.7	4,853	9.0	4,608	8.5	4,493	8.3	4,832	8.9[c]	4,961	9.2	4,344	8.0%	4,157	7.7
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
Developed	12,864	23.7	13,531	25.0	13,817	25.5	13,826	25.5	13,512	24.9	15,208	28.1	14,543[b]	26.8[b]	14,049	25.9	13,581	25.1	12,887	23.8	12,878	23.8%	12,907	23.8
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
Total	**54,206**	**100.0**	**54,206**	**100.0**	**54,206**	**100.0**	**54,206**	**100.0**	**54,206**	**100.0**	**54,206**	**100.0**	**54,206**	**100.0**	**54,206**	**100.0**	**54,206**	**100.0**	**54,206**	**100.0**	**54,206**	**100.0 %**	**54,206**	**100.0**

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

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

[c] Increase in grassland (created) due to conversion of disturbed/bare by the Sacramento Area Flood Control Agency.

Table 2-3. On-Reserve Extent (acres) of Mapped Land Cover Types, 2005–2016

Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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
Fallow	820	593	727	373	375	450	668	348	177	206	64	214
Alfalfa	106	106	150	150	204	127	126	259	204	348	348	348
Irrigated grassland	0	96	0	0	4	5	0	0	0	0	0	0
Grass hay	19	19	81	160	157	144	57	84	147	135	158	57
Wheat	207	497	77	79	132	187	58	58	58	58	47	74
Milo	0	0	49	0	0	0	0	0	155	94	0	0
Tomatoes	0	0	55	55	0	0	0	0	0	0	0	0
Sunflower	0	0	0	0	0	104	116	84	56	50	0	0
Safflower	0	0	0	0	104	0	68	11	0	0	0	23
Other row crops	10	157	279	472	26	32	27	6	27	0	37	59
Fresh emergent marsh (created)[a]	561	561	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
Seasonal wetland	6	6	4	4	4	4	3	3	4	4	4	4
Grassland (created)	47	76	76	72	72	72	71	72	72	73	73	73
Nonnative annual grassland	318	225	254	254	254	254	254	228	226	226	226	203
Ruderal	38	33	29	29	29	28	25	25	25	36	36	36
Valley oak woodland	6	7	7	7	7	7	7	7	7	7	7	7
Riparian woodland	13	13	12	12	12	12	12	12	12	12	12	12
Riparian scrub	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
Open water	0	0	0	0	0	0	0	0	20[c]	20	20	20
Developed—low density	5	5	5	5	5	5	5	5	5	5	5	5
Developed—high density	0	0	0	0	0	0	0	0	0	0	0	0
Disturbed/bare	0	0	0	0	0	0	63[b]	47	11	0	0	0
Total[d]	**3,835**	**3,931**	**4,154**	**4,154**	**4,154**	**4,124[b]**	**4,124**	**4,082[b]**	**4,112[e]**	**4,112**	**4,112**	**4,112**

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

[b] Acreage change from previous years is due to the Sacramento Area Flood Control Agency Natomas Levee Improvement Project.

[c] Completion of improvements to linear water conveyance features in the North Basin Reserve resulted in the change of 20 acres of disturbed/bare to open water habitat in 2013.

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

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

Table 2-4. On-Reserve Summary of Major Habitat Types, 2005–2016

	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
Habitat Type	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
Managed marsh/ wetlands[a]	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
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
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
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
Developed	5	0.1	5	0.1	5	0.1	5	0.1	5	0.1	5	0.1	68[b]	1.6	51	1.2	16	0.4	5	0.1	5	0.1%	5	0.1
Other	25	0.7	26	0.7	25	0.6	25	0.6	25	0.6	54	0.8	26	0.6	25	0.6	45	1.1	140	3.4	46	1.1%	46	1.1
Total[c]	**3,835**	**100.0**	**3,931**	**100.0**	**4,154**	**100.0**	**4,154**	**100.0**	**4,154**	**100.0**	**4,124[b]**	**100.0**	**4,124**	**100.0**	**4,082[b]**	**100.0**	**4,112[d]**	**100**	**4,112**	**100**	**4,112**	**100%**	**4,112**	**100**

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

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

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

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

Table 2-5. On-Reserve Extent of Major Habitat Types as a Proportion of Each Habitat Type in the Basin, 2005–2016

	2005			2006			2007			2008			2009			2010			2011			2012			2013			2014			2015			2016		
Habitat Type	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves	Reserve Acres	Basin Acres	% of Habitat on Reserves
Rice	1,671	22,321	7.5	1,529	14,782	10.3	1,715	14,745	11.6	1,849	14,224	12.9	2,136	15,014	14.2	2,059	15,023	14.0	1,930	15,287[c]	13.1	2,200	16,956	13.0	2,273	19,001	12.0	2,205	20,104	11.0	2,442	20,796	11.7%	2,344.4	20,482	11.4
Managed marsh/ wetlands[a]	569	818	69.6	569	834	68.2	631	936	67.3	631	1,157	54.5	631	1,156	54.5	631	1,162	54.0	631	1,153	54.6	631	1,153	54.7	631	1,165	54.2	631	1,311	48.0	630	1,311	48.1%	630.1	1,311	48.1
Upland agriculture	342	7,566	4.5	875	6,462	13.5	691	7,919	8.7	916	8,293	11.0	627	11,692	5.4	594	13,863	4.3	452	15,100	3.0	502	14,019	3.6	647	12,096	5.3	591	11,601	5.1	591	11,771	5.0%	560	11,850	4.7
Grassland	403	7,766	5.2	334	7,263	4.6	359	5,669	6.3	355	5,461	6.5	355	5,794	6.1	331	4,853	6.8	350	4,608	7.6	325	4,493	7.2	323	4,832	6.7	334	4,961	6.7	334	4,344	7.7%	312	4,157	7.5
Fallow	820	1,625	50.5	593	10,101	5.9	727	10,035	7.2	373	10,076	3.7	375	5,869	6.4	450	2,912	15.5	668	2,323	28.8	348	2,282	15.2	177	2,160	8.2	206	1,555	13.2	64	1,366	4.7%	214	1,712	12.5
Developed	5	12,864	0	5	13,531	0	5	13,817	0	5	13,826	0	5	13,512	0	5	15,208	0	67[d]	14,543[c]	0.4	51	14,049	0.4	16	13,581	0.1	5	12,887	0	5	12,878	0.0%	5	12,907	0.0
Other	25	1,245	2	26	1,233	2.1	25	1,239	2	25	1,169	2.1	25	1,168	2.1	54	1,184	4.6	26	1,192	2.2	25	1,254	2.0	45	1,371	3.3	140	1,787	7.8	46	1,740	2.6%	46	1,787	2.6
Total[f]	**3,835**	**54,206**	**7.1**	**3,931**	**54,206**	**7.3**	**4,154**	**54,206**	**7.6**	**4,154**	**54,206**	**7.7**	**4,154**	**54,206**	**7.7**	**4,124[b]**	**54,206**	**7.6**	**4,124**	**54,206**	**7.6**	**4,082[b]**	**54,206**	**7.5**	**4,112[e]**	**54,206**	**7.6**	**4,112**	**54,206**	**7.6**	**4,112**	**54,206**	**7.6%**	**4,112**	**54,206**	**7.6**

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

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

[c] In 2011, 586 acres of rice were erroneously mapped as developed—low density; these acreages have been corrected in this report.

[d] Changes due to construction of water delivery features along the Natomas Cross Canal.

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

[f] 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.

Table 2-6. Noxious Weed Occurrences on TNBC Reserve Lands, 2005–2016

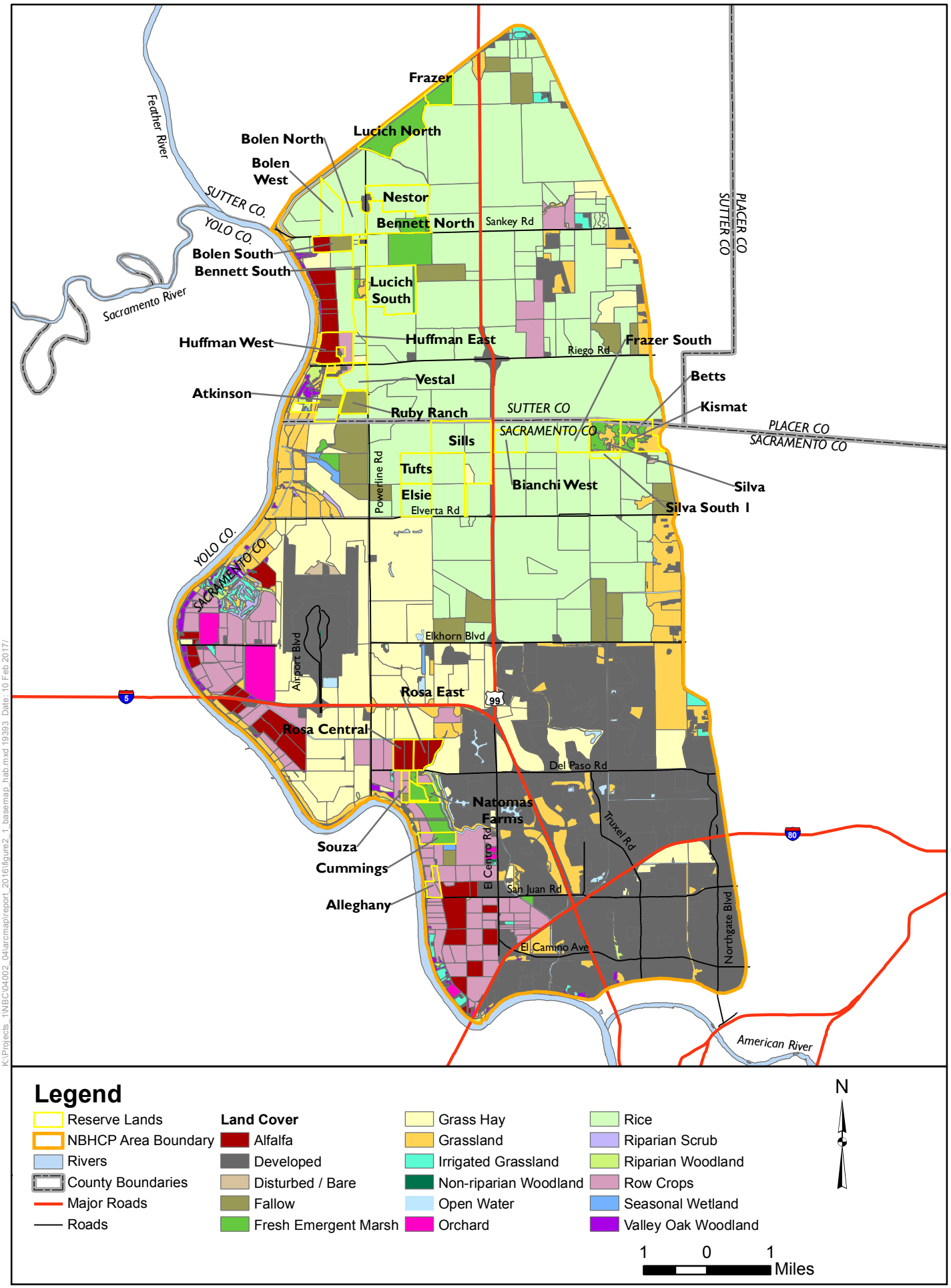
Reserve	Noxious Weed Species	Number and Degree of Occurrences[a]											
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
North Basin Reserve													
Atkinson	Edible fig	1, T	1, T	1, T	1, T	1, T	1, T	1, T	1,T	1, T	1, T	1, T	1, T
	Perennial pepperweed	3, M-H	3, M-H	1, M	1, M	1, M	–	–	–	–	–	–	–
	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
	Yellow star-thistle	–	–	–	–	2, L-M	2, L	1, L	2, L	3, L	1, L	3, L	4, L
Bennett North	Yellow star-thistle	1, L	1, L	1, L	–	–	1, L	2, M	1, L	1, T	–	1, T	1, L
	Bull thistle	–	–	–	–	–	1, L	–	1, L	2, T	3, T	2, T	1, T
Bennett South	Bull thistle	–	–	–	–	–	–	–	2, L	–	–	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
Bolen North	Perennial pepperweed	1, M	1,L	–	–	–	–	–	–	–	–	–	–
	Himalayan blackberry	1, T	1,T	–	–	–	–	–	–	–	–	–	–
	Bull thistle	–	–	–	–	–	3, L	2, L	2, L	1, T	2, T	1, T	3, T
Bolen South	Himalayan blackberry	5, L-H	5, L	–	–	–	2, M	2, M	–	–	–	–	–
	Bull thistle	–	–	2, L	2,L	2, L	–	–	1, L	2, L	–	1, L	1, L
Bolen West	Bull thistle	–	–	–	–	–	1, M	–	1, L	–	1, T	2, T	–
Frazer	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
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
	Himalayan blackberry	1, M	1, M	–	–	–	1, M	1, M	–	–	–	–	–
	Bull thistle	–	–	2, T	3, T	3,T	–	–	1,L	–	2, T	–	1, L
Huffman West	Yellow star-thistle	–	–	–	–	–	1, L	1, L	2, L	3, T	–	2, L	4, T
	Sweet fennel	2, T	2, T	–	–	1, T	–	–	–	–	–	–	–
	Himalayan blackberry	–	–	1, H	1, H	1, M	2, M	–	–	–	–	–	–
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
	Perennial pepperweed	3, H	3, H	1, T	1, T	1, T	1, T	–	–	–	–	–	–
	Bull thistle	–	–	4, T-H	4, T-H	3, T-H	2, T	–	1, T	1, T	4, T	3, L-M	2, T
	Pennyroyal	–	–	–	–	–	–	1,M	1, M	1, M	1, M	1, M	1, M
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
	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
	Italian thistle	–	–	1, L	1, L	1, L	1, L	1, L	–	–	–	1, L	2, L

Table 2-6. Continued

Reserve	Noxious Weed Species	Number and Degree of Occurrences[a]											
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Nestor	Bull thistle	–	–	–	–	–	–	1, L	–	–	–	–	1, T
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	–
Vestal	Yellow star-thistle	–	3,T	–	–	–	3, L-M	2, L-M	2, L	3, T	2, T	1, L	3, T
	Himalayan blackberry	–	–	1, M	1, M	1, M	–	–	–	–	–	–	–
	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
Betts-Kismat-Silva	Bull thistle	–	–	–	–	2, T	1, T	–	–	1, T	2, T	1, T	2, T
	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	–	–	–	–
	Giant reed	L	L	L	–	–	–	–	–	–	–	–	–
	Italian thistle	1, T	–	–	–	–	–	–	–	–	–	–	–
	Pennyroyal	L-M	L-M	–	–	–	2, M	2, M	1, M	1, M	2, M	1, M	1, 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
	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	–	–	–	–	–	–
Bianchi West	Harding grass	–	–	–	–	–	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
Elsie	Yellow star-thistle	–	–	–	–	–	–	2, T	1, M	2, T	–	2, T	1, T
Frazer South	–	–	–	–	–	–	–	–	–	–	–	–	–
Sills	Yellow star-thistle	–	–	1, M	1, M	2, L	1, L	2, L	1, M	2, T	–	1, T	2, T
Tufts	Yellow star-thistle	1, M	1,M	–	–	–	–	–	–	–	–	1, M	–

Table 2-6. Continued

Reserve	Noxious Weed Species	Number and Degree of Occurrences[a]											
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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
	Harding grass	–	–	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
	Yellow star-thistle	–	–	–	–	–	1, L	1, L	2, L	2, T	–	3, L	2, T
Cummings	Himalayan blackberry	1, M	1, M	1, M	1, M	1, M	1, M	1, M	–	–	1, T	1, M	1, L
	Sweet fennel	1, T	1, T	–	–	1, T	–	–	–	–	–	–	–
	Perennial pepperweed	1, L-M	1, L	–	–	–	–	–	1, M	–	–	–	–
	Pampas grass	–	–	1,L	1, L	1, L	–	–	1, M	1, M	–	–	–
	Bull thistle	–	–	–	–	–	1, L	–	–	1, T	2, M	3, L	1, T
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
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
	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
	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
Souza	English ivy	1, D	1, M	–	–	–	–	–	–	–	–	–	–
	Himalayan blackberry	–	–	1, L	1, L	1, L	–	–	–	–	–	–	–
	Bull thistle	–	–	1, L	1, L	1, L	1, L	–	1, L	2, L	3, T	–	2, T



K:\Projects_1\NBC\04002_04\arcmap\report_2016\figure2_1_basemap_hab.mxd 19393 Date: 10 Feb 2017/

Figure 2-1
Distribution of Land Cover Types in the Natomas Basin, 2016

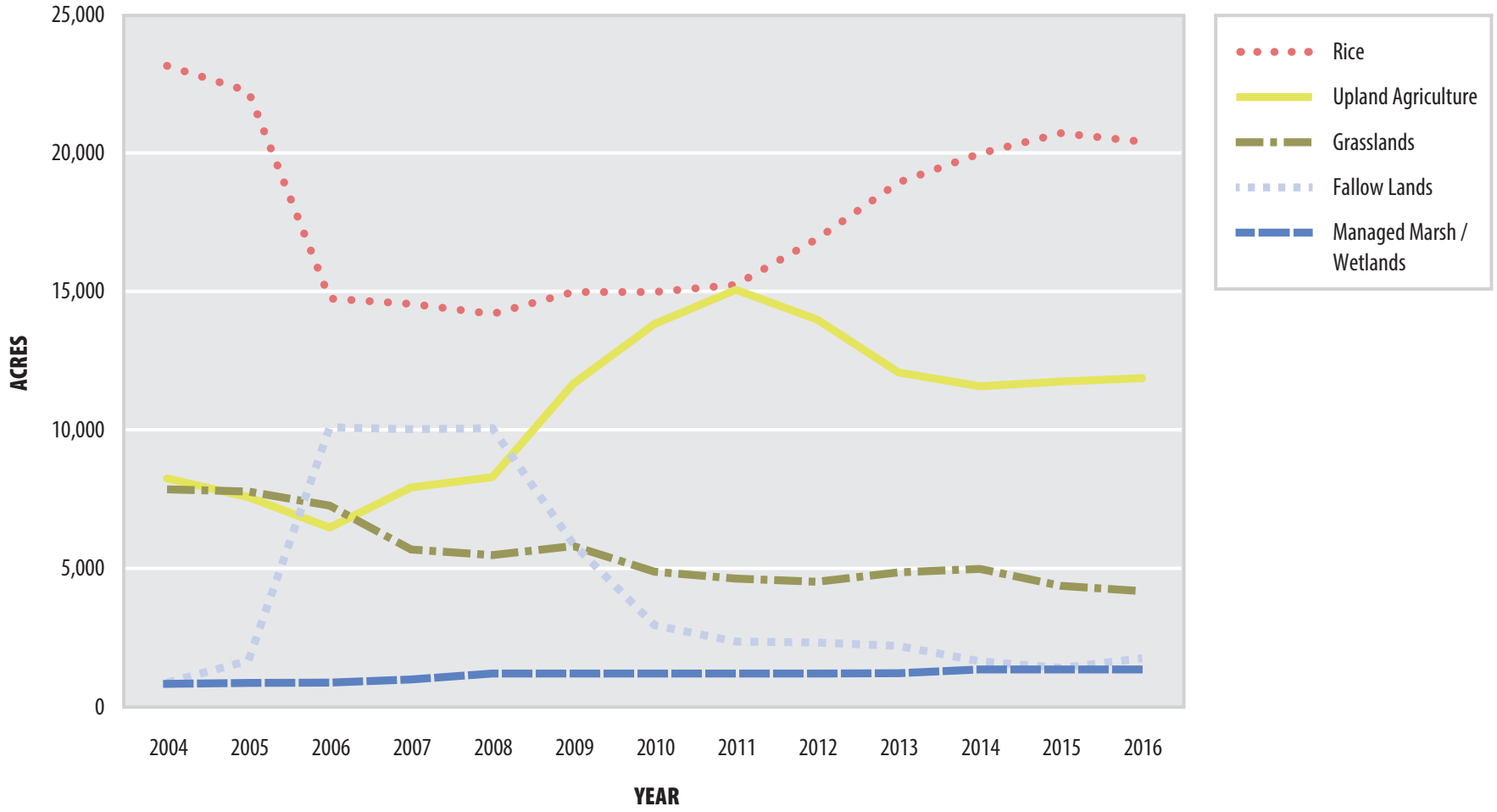


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Figure 2-2

Changes in Acreage of the Major Habitat Types in the Natomas Basin from 2004 to 2016

Chapter 3
Giant Gartersnake

3.1 Introduction

3.1.1 Background

The NBHCP (City of Sacramento et al. 2003) and its Implementing Agreement require an annual assessment of giant gartersnake populations within the 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.

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 key locations within the Natomas Basin, with an emphasis on measuring abundance, survival, recruitment, and population growth rate, and quantify the effects of management practices 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 purpose of monitoring giant gartersnake demography on selected reserves is to determine the abundance, apparent survival (the probability of surviving and remaining in the sampled area from one year to the next), recruitment (the rate at which individuals are born in [and survive their first year] or immigrate to the sampled area), and population growth rate of giant gartersnake at selected locations. This type of monitoring also provides information on habitat, environmental, and individual variables that affect demographic rates such as survival and recruitment. 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 (*Schoenoplectus* [*Scirpus*] *acutus*). Although conversion of wetlands to agriculture has nearly extirpated giant gartersnake from the San Joaquin Valley, this species persists in rice fields 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 agricultural habitats relative to natural or restored marshes is an area of active research.

Giant gartersnake feeds primarily on small fish, frogs, and tadpoles (Rossman et al. 1996). Specific prey items may include tadpoles and small adults of American bullfrog (*Lithobates catesbeianus*) and tadpoles and adults of Sierran treefrog (*Pseudacris sierra*). Fish prey items include but are not limited to mosquitofish (*Gambusia affinis)* and small cyprinid and centrarchid fishes. Little is known about the diet of juvenile giant gartersnakes.

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). Males and females exhibit differing patterns of seasonal growth, with males forgoing foraging (and growth) for reproductive opportunities in the early spring (Coates et al. 2009). Similarly, male body condition is much lower than female body condition during the spring mating season, but males and females enter hibernation in similar condition (Coates et al. 2009). Body condition might be related to the thermal ecology of giant gartersnake. Female giant gartersnakes exhibit elevated body temperatures during June, July, and August (Wylie et al. 2009), which is the period during which they are gravid. In contrast, males elevate body temperature in the winter and early spring (Wylie et al. 2009), likely to prepare for the spring mating season. The elevated body temperature of male snakes might be metabolically costly, causing decreased body condition for them in spring.

Although some aspects of giant gartersnake demography remain elusive, detailed study of populations in the Sacramento Valley has yielded some insight into the population ecology of giant gartersnake. Giant gartersnakes in the Sacramento Valley tend to produce smaller litters than those historically observed in the San Joaquin Valley. In the San Joaquin Valley, mean litter size was 23 (Hansen and Hansen 1990). In the Sacramento Valley, mean litter size was 17 (95% credible interval[1] = 13–21) (Halstead et al. 2011a). 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).

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 less in canals than away from canals, but in systems with natural or restored marshes, risk of mortality was less 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).

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, less in a natural wetland modified for agricultural uses, less still in rice agriculture, and least 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 snowmelt has been limited, and the waters have been diverted by a network of dams and levees. As a result, giant gartersnake populations have become fragmented with only small isolated populations remaining in the San Joaquin Valley. These factors precipitated the listing of giant gartersnake by the State of California (California Department of Fish and Game Commission 1971) and later by the U.S. Fish and Wildlife Service as a threatened species with a recovery priority designation of 2C: full species, high degree of threat, and high recovery potential (U.S. Fish and Wildlife Service 1993, 1999). The recovery of giant gartersnake will require the restoration and protection of marsh habitats, a reliable supply of water to these habitats throughout the year, and further research into the most effective conservation practices for this species.

3.1.4 History of the Natomas Basin

The lands of the Natomas Basin were historically subject to frequent flooding events because of the Basin's proximity to the American and Sacramento Rivers. Situated just north of the confluence of these major river systems, the 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 of giant gartersnakes.

3.2 Methods

3.2.1 Trapping Giant Gartersnakes

All aspects of the giant gartersnake monitoring effort involve using trap transects composed of floating galvanized minnow traps (Casazza et al. 2000) to capture giant gartersnakes. 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.

Trap transects were positioned along the banks, at the edges of emergent vegetation in wetlands, or along the edges of canals because giant gartersnakes forage 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 the opening of traps temporarily or relocation of 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. Both cartridge-style pre-sterilized needles with pre-loaded PIT tags and syringe injector needles swabbed with alcohol before each use with manually loaded PIT tags were used, 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.

3.2.2 Analytical Methods

All analyses were conducted in a Bayesian analytical framework. In Bayesian analyses, the probabilities are interpreted slightly differently than in 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. *Credible intervals* are the Bayesian equivalent of confidence intervals in traditional frequentist statistics. Unless otherwise noted, for all parameter estimates posterior medians with symmetric 95% credible intervals are reported in parentheses.

3.2.3 Demography

Field Methods

Demography of giant gartersnake was monitored at the following five TNBC reserves selected for their dispersed locations in the Basin and high historical abundance of giant gartersnake: Lucich North and Lucich South in the North Basin Reserve, BKS and Sills in the Central Basin Reserve, and Natomas Farms in the Fisherman's Lake Reserve. At each site, 3 transects of 50 traps each were deployed, with traps spaced approximately 10 meters apart. Trap transects were deployed from as early as possible in the active season (beginning April 11, 2016) until approximately July 15, 2016.

Transects were generally placed in the same location as in previous years; this approach maintains the same extent of sampling to provide unbiased estimates of apparent survival, recruitment, and population growth rate. However, in 2013 and 2014, transects at BKS were placed in different areas from previous years due to habitat maintenance and enhancement activities. By the beginning of the 2015 trapping season, these habitat maintenance and enhancement activities had been completed and transects were returned to their locations prior to 2013. In addition, one transect at Lucich North was moved in 2014 from the north canal adjacent to Lucich North to the wetlands within Lucich North to better sample snakes occurring within the wetlands at this site. Sampling at trap transects at Sills was delayed until May 9, 2016, because of later water delivery associated with planting of rice. The final trap transect at Sills was further delayed until May 23, 2016.

Analytical Methods

Abundance of giant gartersnake at each of the demographic monitoring sites was estimated using Bayesian analysis of capture-mark-recapture (CMR) data using data augmentation (Royle and Dorazio 2008).[2]

Two distinct modeling approaches were used to estimate abundance of giant gartersnake at each demographic monitoring site: closed population models and open population models. Closed population models are models that assume no emigration out of or immigration into the population of interest over the sampling period (in this case, approximately mid-April through mid-July). These models are used to estimate abundance using simplifying assumptions. For 2016, a single model that shared information on capture probability among sites was used, which resulted in more precise estimates of abundance at each site.[3] The effects of water temperature, snake SVL, snake sex, and a behavioral response on capture probabilities were tested. Investigators also tested for temporal variation in capture probability (i.e. variation in capture probability among days of sampling). In addition to the closed population models, Jolly-Seber models (Williams et al. 2002) for open populations[4] were also fit to data from 2004–2016 for each demographic monitoring site. Each demographic monitoring site was sampled every year from 2004–2016, with the exception of BKS in 2009 (although trapping was conducted at Natomas Farms in 2004, the effort was not sufficient to produce reliable parameter estimates; therefore, results for Natomas Farms from 2004 are not presented). To make data from 2004 through 2010 as comparable as possible to those obtained since 2011, data were limited to those from individuals captured at locations similar to the demographic monitoring trap transects and only individuals captured prior to July 15 each year. Open population models are more complex than closed population models because in addition to abundance, these models also estimate demographic rates, including recruitment, apparent survival, and rate of population growth. *Recruitment* is defined as the proportion of a population that is new from the previous year and includes both birth and immigration into the population of interest. *Apparent survival* is defined as the combination of survival and emigration. For the rate of population growth, the instantaneous per capita, or exponential, growth rate (r) was reported rather than the geometric growth rate (λ) usually used for populations that reproduce in discrete time because of its interpretability (i.e., it is symmetric about 0, rather than asymmetric about 1). Probabilities are provided for benchmarks of population change (10% increase, 10% decrease, and stability [less than 10% change in either direction]). Because of sparse data (few recaptures) at all demographic monitoring sites, only a relatively simple model was fit with recruitment and annual survival rates that varied annually.[5]

Effects of habitat and vegetation on annual giant gartersnake apparent survival probabilities was assessed using Cormack-Jolly-Seber (CJS) models for all demographic monitoring sites from 2011 through 2016. CJS models differ from Jolly-Seber models by conditioning on an individual's first capture and ignoring the recruitment process; therefore, they estimate apparent survival probabilities more precisely by using fewer parameters in the model. For the CJS models, annual apparent survival was assumed constant except for the effects of changing habitat or vegetation conditions. Five habitat variables (percent cover of emergent vegetation, terrestrial vegetation, floating vegetation, submerged vegetation, and whether the site was associated with rice) and four vegetation variables (percent cover of tules, cattails [*Typha* spp.], water-primrose [*Ludwidgia* spp.], and mosquito fern [*Azolla* spp.]) were examined for their effect on annual apparent survival probabilities of giant gartersnakes at the site level. Because sampling is conducted in the spring, vegetation characteristics from sampling in year t were used to characterize habitat and vegetation in the interval between year t and year $t + 1$. It was assumed that sites had different baseline apparent survival probabilities, but that the effects of habitat and vegetation on annual apparent survival probabilities were the same across sites. For the CJS models, daily capture probabilities were assumed constant, but allowed to vary among years and sites.

Sex ratios and size distributions were calculated using data from all captured individuals, regardless of method of capture, date of capture, or whether captured as part of the demographic monitoring or occupancy monitoring (see Section 3.2.4, *Distribution of Giant Gartersnake on Reserve Lands*). Bayesian analytical methods were used to estimate sex ratios with binomial tests of proportions for all sampling locations within the Basin and individually at each demographic monitoring site.[6] Bayesian methods were also used to describe the mean SVL and mass of giant gartersnakes from all sampling locations within the Basin and at each demographic monitoring site.[7] Sexual size dimorphism in SVL and mass was examined throughout the Basin using the best-supported model for mean size, but with separate means and variances for males and females. These tests are equivalent to t-tests with unequal variances (Kéry 2010).[8] Sexual size dimorphism was not examined at individual sites because of the great uncertainty in estimating means with small sample sizes.

3.2.4 Distribution of Giant Gartersnake on Reserve Lands

Field Methods

The occurrence of giant gartersnake was monitored on TNBC reserve sites randomly selected in 2011. Sites consisted of individual wetland units (defined as being contained within water control structures) and canals adjacent to rice, and selection of sampled units was stratified by habitat type (wetland or rice) and reserve area (North Basin, Central Basin, and Fisherman's Lake). Random selection of reserve sites allows inference to TNBC reserves as a whole. At each selected site, trap transects composed of 50 traps spaced 10 meters apart were deployed for a target duration of 21 days between July 23 and September 27, 2016. Within selected sites transects were placed in the same locations as in previous years based on field observations of habitat quality and on giant gartersnake locations documented prior to 2011 to maximize the likelihood of detection. The traps remained deployed and were checked daily until two giant gartersnakes were captured or until the target 21-day deployment duration was reached, whichever came first.

Analytical Methods

The probability of occurrence of giant gartersnake on TNBC reserves was estimated using Bayesian analysis of single season occupancy models (Royle and Dorazio 2008; Kéry 2010). Two separate analyses of the data were conducted, including probability of occurrence as a linear function of selected habitat variables (the habitat model) and probability of occurrence varying among reserve areas (North Basin, Central Bain, and Fisherman's Lake; the reserve model). The effects of wetland or rice habitat and the percent cover of emergent vegetation, floating vegetation, open water, and terrestrial vegetation on the probability of occurrence of giant gartersnake were examined in the habitat models. Priors for the occupancy component of each model were chosen to be uninformative (Table 3-1). Investigators fit two versions of the occurrence model 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 3-1).[9]

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. 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. Thus 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.[10] 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.

3.2.5 Habitat Assessment

Habitat Distribution and Abundance

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, Floristic 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.

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.

3.3 Results

Overall, 215 individual giant gartersnakes were captured 338 times by hand or trap on TNBC reserves over the course of nearly 92,000 trap days in 2016 (Table 3-2). Catch per unit effort across the Basin was 0.0037 in 2016, much higher than in 2015 (0.0017), but similar to capture rates in 2014 (0.0033), 2013 (0.0035), 2012 (0.0028) and 2011 (0.0031).

3.3.1 Demography

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 0.010 (0.006 – 0.016), and the standard deviation of capture probability among sites (0.002; 0.0001 – 0.012) was slightly lower than the standard deviation of capture probability among days (0.0045; 0.002 – 0.008). There was strong evidence for a positive effect of water temperature on capture probability, a positive ephemeral behavioral response to capture, and temporal variation in capture probability (Figure 3-2; Table 3-3).

At Natomas Farms one female was captured 3 times in 2016 (Table 3-4). In 2015, one female was captured once. In 2014, four individuals (three females, one male) were captured five times. In 2013, one individual male was captured once, and in 2011 and 2012, a single female was captured. Abundance at Natomas Farms in 2016 was estimated to be 2 (1–7) individuals, with a mode (most likely value) of 2 individuals (Figure 3-3).

At BKS, 71 individuals were captured 130 times in 2016 (Table 3-4). This is greater than in 2015, when 35 individuals were captured 41 times in traps. The estimated model-averaged abundance at BKS was 103 (88–125) individuals, with a mode of 102 individuals (Figure 3-4).

At Sills, 14 individuals were captured 19 times in traps in 2016 (Table 3-4). In 2015, 9 individuals were captured 15 times in traps. The estimated model-averaged abundance at Sills in 2016 was 22 (16–37) individuals, with a mode of 21 individuals (Figure 3-5).

At Lucich North, 49 individuals were captured 89 times in traps in 2016 (Table 3-4). In 2015, 11 individuals were captured 21 times in traps. The estimated model-averaged abundance at Lucich North in 2016 was 72 (59–91) individuals, with a mode of 71 individuals (Figure 3-6).

At Lucich South, 37 individuals were captured 53 times in traps in 2016 (Table 3-4). In 2015, 20 individuals were captured 26 times in traps. The estimated model-averaged abundance at Lucich South in 2016 was 62 (47–93) individuals, with a mode of 58 individuals (Figure 3-7).

Annual estimates of abundance at each of the five demographic monitoring sites over the last 5 years based on annual closed population models are summarized in Table 3-5. It should be noted that an improved statistical model was used to estimate abundance for 2015 and 2016, resulting in improved and more precise estimates of abundance. Values for those years are therefore not comparable to the values shown for previous years. Trends in abundance should be evaluated using the open population model estimates.

Estimates of Abundance and Demographic Rates Using Open Population Models

The open population model for Natomas Farms produced point estimates of annual abundance that were always less than 20 individuals, and less than 10 individuals in 9 of 12 years for which abundance could be estimated (Figure 3-8). The point estimates of annual apparent survival probability over the 12-year period varied from a low of 0.39 (0.16–0.68) for 2014–2015 to a high of 0.46 for 2008–2009 (0.23–0.72). Estimates of annual per-capita recruitment were generally low and imprecise (Figure 3-9). Recruitment was particularly low from 2009 through 2013 and in 2016. The intrinsic population growth rate was variable, but credible intervals in all years overlapped 0 (Figure 3-10). The mean annual population growth rate at Natomas Farms from 2005 through 2016 was -0.092 (-0.268–0.063; Figure 3-10). The probability that the population was stable (less than 10% change) from 2005 to 2016 was 0.53, which was higher than the probability that abundance increased by more than 10% annually (0.01) and the probability that the population decreased by more than 10% annually (0.46) since 2005.

The open population model for BKS produced annual abundance estimates in the tens to hundreds of individuals, ranging from a low of 14 (5–128) in 2004 to a high of 156 (108–238) in 2012 (Figure 3-11). The estimates of annual apparent survival probability over the 12-year period varied from a low of 0.10 (0.05–0.21) for 2014–2015 to a high of 0.53 (0.37–0.68) for 2008–2009 and 2009–2010. Estimates of annual per-capita recruitment probability varied considerably in the earlier years of monitoring. Per-capita recruitment was more stable in recent years, with annual modes in the range

0.6 to 0.9 (Figure 3-12). The mean annual intrinsic population growth rate at BKS from 2004 through 2016 was 0.16 (-0.02–0.26; Figure 3-15). The population growth rate was highest in 2011, and lowest in 2007 (Figure 3-13). The probability that the population increased by more than 10% annually (0.73) was greater than the probability that the population was stable (less than 10% annual change; 0.27) or the probability that the population decreased by more than 10% annually (< 0.01) since 2004.

The open population model for Sills produced estimates of annual abundance in the tens of individuals, with a low of 4 (2–31) in 2004 and a high of 33 (24–48) in 2011 (Figure 3-14). The estimates of annual apparent survival probability over the 12-year period were usually slightly lower than 0.2, and ranged from a low of 0.15 (0.05–0.30) from 2013–2014 to a high of 0.21 (0.08–0.41) from 2008–2009. At Sills, the per-capita recruitment probability varied from year to year, with annual modes between 0.3 and 1.1, and 95% credible intervals ranging from 0.0 to 15.0, with greater uncertainty in earlier years (Figure 3-15). Credible intervals for the intrinsic population growth rate in all years overlapped 0 (Figure 3-16). The mean annual population growth rate at Sills was 0.07 (-0.12–0.19; Figure 3-16). The probability that the population increased by more than 10% annually was 0.65, which was higher than the probability that abundance was stable (less than 10% annual change) (0.35) and the probability that abundance decreased by more than 10% annually (< 0.01) since 2004.

The open population model for Lucich North produced estimates of annual abundance ranging from 15 (7–44) individuals in 2006 to 81 (63–104) individuals in 2016 (Figure 3-17). The estimates of annual apparent survival probability ranged from 0.18 (0.09–0.33) for 2012–2013 to 0.31 (0.16–0.50) for 2008–2009. The average per capita recruitment probability was slightly greater in 2007, 2011, and 2016 than in other years (Figure 3-18). The estimates of the instantaneous per capita population growth rate fluctuated between positive and negative growth (Figure 3-19). The mean annual population growth rate at Lucich North from 2004 through 2016 was 0.06 (0.02–0.10; Figure 3-19). The probability that the population was stable (less than 10% annual change) was 0.99, which was much higher than the probability that abundance increased by more than 10% annually (0.01) and the probability that abundance decreased by more than 10% annually (< 0.01).

The open population model for Lucich South produced estimates of annual abundance in the dozens of individuals, ranging from 33 (18–76) in 2008 to 110 (53–231) in 2011 (Figure 3-20). The estimate of annual apparent survival probability ranged from a low of 0.32 (0.15–0.54) for 2014–2015 to a high of 0.45 (0.26–0.68) for 2005–2006. Average per capita recruitment was generally low, except in 2009, 2011, and 2016 (Figure 3-21). The mean annual population growth rate at Lucich South from 2004 through 2016 was 0.06 (-0.02–0.16; Figure 3-22). The probability that abundance was stable (less than 10% annual change) was 0.77, which was higher than the probability that abundance increased by more than 10% annually (0.23) and the probability that the population decreased by more than 10% annually (< 0.01).

There was a notable amount of uncertainty in the effects of habitat and vegetation variables on giant gartersnake apparent survival probabilities. The null model, with no effect of any habitat variable on annual apparent survival, had the greatest posterior probability (Table 3-6). Based on the habitat model, average annual apparent survival probabilities in the Basin were 0.11(0.06–0.22) with considerable variation among sites (standard deviation of random site effect = 0.48 [0.01–2.1]). None of the vegetation variables examined had an effect on giant gartersnake apparent survival probabilities within the ranges of habitat variation observed at demographic monitoring sites in the Basin (Table 3-7).

Size Distribution and Sex Ratio

The overall sex ratio in the Basin was 1.017 (0.817 – 1.248) males per female. Sex ratios were not statistically biased towards either sex at any demographic monitoring sites (Table 3-8). Basin-wide SVL was best approximated by a normal distribution (ΔBIC = 47; posterior probability > 0.999; Table 3-9), but Basin-wide mass was best approximated by a lognormal distribution (ΔBIC = 70; posterior probability > 0.999; Table 3-10). Distributions of SVL and mass at individual monitoring sites followed patterns similar to Basin-wide distributions (Tables 3-9 and 3-10). Basin-wide mean SVL was 545 mm (526–565 mm), and Basin-wide mean mass was 81.2 g (72.7–90.7 g; Table 3-11). Mean female SVL (587 mm [555–618 mm]) was 77 mm (39–114 mm) greater than mean male SVL (510 mm [489–531 mm]), and mean female mass (106.5 g [89.9–126.0 g]) was 42.0 g (17.3–68.9 g) greater than mean male mass (64. g [57.1–72.7 g]; Figure 3-23).

3.3.2 Distribution of Giant Gartersnake on Reserve Lands

Giant gartersnakes were detected at 12 of 37 occupancy sites sampled in 2016. Using uninformative priors it was estimated that approximately 52% (25–88%) of reserve sites with average habitat profiles were occupied by giant gartersnake. Inference using informative priors was lower, indicating that approximately 48% (25–77%) of reserve sites were occupied (Figure 3-24). Of the sites monitored, 17 (12–28) were estimated to be occupied based on uninformative priors; 16 (13–22) were estimated to be occupied based on informative priors (Figure 3-24).

Regardless of the prior probabilities used for the detection component of the occupancy model, there were positive effects of floating vegetation and emergent vegetation on the probability of occurrence (Table 3-12). The probability that floating vegetation had an effect on the probability of occurrence was 0.60 with uninformative priors and 0.62 with informative priors. Based on uninformative priors, the odds of a positive effect of floating vegetation on the probability of occurrence was 41.7 times higher than the odds of a negative effect (Table 3-13; Figure 3-25). The probability that emergent vegetation had an effect on the probability of occurrence was 0.61 with uninformative priors and 0.60 with informative priors. Based on uninformative priors, the odds of a positive effect of emergent vegetation on the probability of occurrence was 50 times higher than the odds of a negative effect (Table 3-13; Figure 3-26). The effects of other variables on the probability of occurrence were not as pronounced. Regardless of the analysis, detection probabilities were low and were affected by water temperature and date, though effects of these variables on detection probabilities were estimated with greater precision when prior information on the detection process was accounted for (Figure 3-27). Water temperature positively affected detection probability using both informative and uninformative priors, whereas date negatively affected detection probability using informative priors but had no effect on detection probability using uninformative priors (Figure 3-27).

In the analysis of an effect of reserve area (i.e., North Basin, Central Basin, and Fisherman's Lake) on the probability of occurrence of giant gartersnake, the effect of reserve area was well-supported (probability of effect of reserve area = 0.966 with uninformative priors; 0.975 with informative priors). Based on uninformative priors, the probability of occurrence in the North Basin Reserve was 0.474 (0.217–0.812), the probability of occurrence in the Central Basin Reserve was 0.827 (0.418–0.985), and the probability of occurrence in the Fisherman's Lake Reserve was 0.145 (0.025–0.505). Informative priors had little effect on these estimates, which were 0.481 (0.228–0.776) in the North

Basin Reserve, 0.842 (0.437–0.985) in the Central Basin Reserve, and 0.141 (0.026–0.448) in the Fisherman's Lake Reserve.

The dynamic occupancy model indicated evidence for a decrease in the probability that sites on TNBC reserves were occupied by giant gartersnakes since 2011 (Figure 3-28). The number of occupied sampled sites followed a similar pattern (Figure 3-29). The annual probability that occupied sites became unoccupied was generally low, particularly between 2013 and 2014, but the probability of occupied sites becoming unoccupied increased between 2015 and 2016 (Figure 3-28). The annual probability that unoccupied sites were colonized exhibited no trend from 2011–2016 (Figure 3-28). The mean intrinsic growth rate of occupancy from 2011 through 2016 was -0.12 (-0.19–-0.05; Figure 3-30). Occupancy growth was negative between 2015 and 2016 (Figure 3-30). The probability that the number of occupied sites decreased by more than 10% from 2011 through 2016 was 0.66, which was higher than the probability that the number of occupied sites was stable (less than 10% change; 0.34) or that occupancy increased by more than 10% annually (< 0.01). It should be noted that the inclusion of the eight SAFCA wetland units into the occupancy analysis in 2015 could potentially result in a decrease in the estimate of occupancy from 2014 to 2015 due to the inclusion of habitats that did not previously exist. However, because a giant gartersnake was captured in 2016 (but not in 2015), the decrease in occupancy from 2015 to 2016 cannot be explained by this inclusion of additional wetland units into the sample. There was no strong evidence of an effect of habitat on initial occupancy, colonization, or extirpation probabilities (Table 3-17).

3.3.3 Habitat Assessment

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 16.8%[11] (718 acres) of the area of reserve properties, but just 1% (478 acres) of non-reserve lands. TNBC reserves provided 60% 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 55% (2,344 acres) of the area of reserve properties compared to 36.3% (18,137 acres) of the non-reserve lands. Overall, 3,062 acres (71.9%) of the total acres of TNBC reserve lands was potential giant gartersnake habitat, while only 37.2% (18,615 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 through 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 419 acres. A total of 72.3 of these acres (17.2%) were created marsh in 2016. No rice existed in the Fisherman's Lake Reserve area tracts in 2016. Recently constructed wetlands comprised 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.

Tracts in the Central Basin Reserve cover approximately 1,343 acres. A total of 140 of these acres (10.4%) were created marsh in 2016. A total of 978 acres (72.8%) of rice existed in the Central Basin Reserve in 2016. Overall, 1,118.4 acres (83.3%) of the total acreage of the Central Basin Reserve was potential giant gartersnake habitat in 2016, although—as noted above—only created marsh and some canals associated with rice agriculture provide suitable habitat in all seasons. Of the eight tracts in the Central Basin reserve area, all contained habitat suitable for giant gartersnake.

Tracts in the North Basin Reserve cover approximately 2,351 acres. A total of 414 of these acres (17.6%) were created marsh in 2016, and 1,366 acres (58.1%) of rice existed in the North Basin Reserve in 2016. Overall, 1,780 acres (75.7%) of the total acreage of the North Basin Reserve was potential giant gartersnake habitat in 2016. Of the 14 tracts in the North Basin Reserve, 3 (Bolen South, Huffman West, and Ruby Ranch) did not contain habitat suitable for giant gartersnake. Five tracts (Bennett North, Bennett South, Frazer North, Lucich North, and Lucich South) contained created marsh.

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 (U.S. Geological Survey unpublished data). 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 the TNBC reserve system are well connected, some notable exceptions exist (Figure 3-31). In particular, although surface water connects the Fisherman's Lake Reserve with other reserve areas, the northern end of the northernmost suitable Fisherman's Lake Reserve tract (Natomas Farms), is 7.6 kilometers (by canal) south of the nearest suitable Central Basin Reserve tract (Elsie). Giant gartersnakes have small home ranges and typically move relatively small distances (Valcarcel 2011) but nonetheless can exhibit movements up to 5 kilometers over multiple days (U.S. Geological Society unpublished data). The marginal nature of long stretches of the canals that connect these reserve areas, surrounding land uses inhospitable to giant gartersnake, and potential fragmentation caused by Interstate (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 demographically connected to other reserves. Connectivity between the Fisherman's Lake Reserve and other habitats north of I-5 have may have improved with the completion of a 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. However, the distance between suitable non-canal habitats remains high, the crossing under I-5 is long, and

habitats in the West Drainage Canal south of I-5 are unsuitable (Figure 3-31). Within the Fisherman's Lake Reserve, the two suitable tracts, Natomas Farms and Cummings, are connected by approximately 0.9 kilometer of canal habitats that compose Fisherman's Lake. The recently-constructed SAFCA wetlands provide much greater continuity of habitat within the Fisherman's Lake area than was previously present.

In contrast to the tracts of the Fisherman's Lake Reserve, the tracts of the Central Basin Reserve are in proximity to those of the North Basin Reserve. The eastern edge of Ruby Ranch tract in the North Basin Reserve is only 2.6 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 suitable canal, so demographic connectivity among these tracts is likely and genetic connectivity nearly certain. Perhaps a greater barrier to connectivity among Central Basin tracts is State Route (SR) 99, which lies between the Bianchi West and Sills tracts. Although this highway is a formidable barrier, 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).

The Elverta Road and Riego Road Interchange Projects, conducted by Caltrans, began in 2012 (California Department of Transportation 2012). Canals that bordered SR 99 and each road near the intersection were diverted to accommodate highway exit and entrance ramps. The Elverta Road Interchange Project was completed in late summer 2013, and the Riego Road Interchange Project was completed in mid-2014 (California Department of Transportation 2012). With the diverted canals and long-term construction, the potential for disturbance and population fragmentation is high. The extent to which this might affect connectivity or snake movement across the SR 99 corridor is unknown.

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 2 kilometers between the Lucich North and Bennett North tracts. This gap occurs along the North Drain, which is suitable giant gartersnake habitat. 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 gartersnakes from neighboring 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 giant gartersnake populations leaves them at risk for founder effects, inbreeding depression, and fixation of deleterious alleles through genetic drift, and 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.

3.4 Discussion

3.4.1 Demography

Abundance

Abundance varied substantially among sites but was generally in the range of tens to approximately 100 individuals. Estimates for the 2015 and 2016 monitoring years were much improved over previous years for two reasons. Overall, in 2016 the number of individuals captured and the total number of captures increased at all five demographic monitoring sites compared to 2015. Indeed, the total number of individuals (172) and the number of captures (294) summed over all sites was the greatest of any year of monitoring since the study design was changed in 2011. In addition, a new and innovative statistical model that allowed information on capture probability to be shared among demographic monitoring sites was used to estimate abundance in 2015 and 2016. The combination of these two factors resulted in a substantial increase in precision of the closed population model estimates for 2015 and 2016 over previous years.

Capture probabilities varied somewhat among sites, but a greater amount of variability in capture probability can be attributed to differences among days of sampling. 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.

It should be noted that comparing abundance across sites is problematic because of the potential for the area sampled to differ among sites. Thus, two sites with the same density could have different abundance estimates if the area sampled by traps at the two sites differs. Differences in area sampled can arise from different spatial configurations of trap transects, variability in movement behavior of individuals at different sites, or a combination of these factors.

Although the 2015 and 2016 monitoring year abundance estimates are likely to be more accurate and precise, changes in abundance over time are more accurately reflected in abundance estimates from the open population models, which show an increase in abundance from 2015 to 2016 for all sites except Natomas Farms and BKS. The decrease in abundance from 2015 to 2016 at BKS could be attributable to the movement of trap locations between years to accommodate marsh maintenance and enhancement activities.

Similar to 2015, there was strong support for an effect of water temperature on capture probabilities in 2016. 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 addition to water temperature, there was also strong evidence of a positive ephemeral behavioral response to capture ("trap-happiness"). The behavioral response was likely 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 pattern could also be observed simply because the individuals were in the vicinity of the traps immediately after release and happened to enter another trap, or because individual snakes might forage for several consecutive days, then shelter in burrows to digest their meals or shed. This effect of behavioral response is a common theme across all years of monitoring. There was also support for random variation in capture probability among days that likely reflects day to day changes in the weather which influence the behavior of the 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.

Demographic Rates

The completion of 6 years of monitoring under the revised sampling protocol at demographic monitoring sites, plus the inclusion of data collected at these locations in 2004–2010, allowed the estimation of several demographic parameters. In particular, apparent survival, per capita recruitment, and population growth rates of giant gartersnakes were estimated at all of the demographic monitoring sites. All models assumed constant within-year daily capture probability. This assumption is likely not true, but because capture probabilities are very low, it is difficult to detect effects of covariates on detection probability.

In contrast to previous years, year-specific survival rates could be estimated instead of assuming constant annual survival at a site from 2004–2016. Apparent survival from 2015–2016 was highest for Natomas Farms and Lucich South, while survival estimates for BKS, Lucich North, and Sills were much lower. The annual survival rates estimated for 2015–2016 were very similar to the constant annual survival estimates reported for all five sites in 2015. It is important to note that capture-mark-recapture models estimate apparent survival probabilities, rather than true survival probabilities. Several factors can contribute to a lack of recaptures of individuals captured in previous years. Low annual survival rate is one obvious explanation. However, because many large snakes were captured—and the expected annual survival rate of adult females in the Sacramento Valley has been estimated at 0.6 (0.4–0.8; Halstead et al. 2012)—this is likely not the case. It seems more likely that emigration out of the effective trap area is responsible for a large proportion of the estimate of apparent survival.

Sills, the only demographic monitoring site composed entirely of rice, had the second lowest apparent survival estimates. This might be caused by a larger number of transient individuals (i.e., individuals that pass through the site and are not resident within it) in canals associated with rice fields than in restored wetlands. BKS had the lowest apparent survival estimates. In this case, it appears that apparent survival was biased low because of changing the locations of trap transects in 2013 and again in 2015. In effect, some snakes may have "emigrated" from the BKS site because the area sampled changed in the past. As future trapping occurs in the same areas, this confounding effect of emigration should be ameliorated somewhat. Natomas Farms likely has the highest apparent survival probability because until the recent establishment of the SAFCA wetlands, individuals were confined to a smaller habitat area and had less opportunity to emigrate from the site.

Emigration can be either permanent or temporary. If permanent emigration is the problem, it means either that giant gartersnakes in the Natomas Basin do not establish stable home ranges, or that the size of the trapped area on demographic monitoring sites is small relative to home range size. The latter is suspected, as most snake species (including giant gartersnakes) tend to limit their

movements to a well-defined, familiar area. Temporary emigration occurs when an individual that is part of the population is temporarily (i.e., over the course of a season of sampling) unavailable for capture. This can result from physical movement outside the area of the traps or from behaviors that render an individual untrappable during the sampling period. Temporary emigration can be analytically separated from the capture process, improving estimates of both capture probabilities and apparent survival, but only after several years of sampling. The low apparent survival rates at the demographic monitoring sites may be primarily caused by temporary emigration, and if allowed to continue under the current sampling scheme, this issue will be addressed analytically as more data are collected to adequately fit these more complex models. Regardless of the mechanism leading to low apparent survival rates, it is important to note that drawing conclusions about survival (or other demographic parameters) from a short-term study is fraught with uncertainty (Lebreton et al. 1992), especially when capture probabilities are low.

Per capita recruitment rates of giant gartersnakes varied substantially across years at most demographic monitoring sites, with BKS, Lucich North, and Lucich South in particular showing patterns of several years of low recruitment punctuated by a few years of higher recruitment. Like survival, recruitment comes in two forms: births of individuals to resident females, and immigration of individuals from outside the sampled area. Both sources may contribute to recruitment at the demographic monitoring sites in the Natomas Basin, although the contribution of reproduction and immigration likely varies from one site to another. Differences in per-capita recruitment rates among sites and years prior to 2012 (and at BKS in 2013 and 2015) might be partially attributable to differences in the locations of trap transects from one year to the next. Thus it cannot be concluded that a high estimate of recruitment in a given year is directly caused by a pulse of newborn snakes entering the population.

At BKS and Sills, the probability that the populations increased more than 10% annually was greater than the probability that they decreased by more than 10% annually or remained stable between 2004 and 2016. At Natomas Farms, Lucich South, and Lucich North, the probability that these populations changed less than 10% annually was the greatest. At Natomas Farms, the population appears stable, but extremely small. In 2016, populations at Sills, Lucich North, and Lucich South appeared to increase in abundance compared to 2015, reversing a declining trend from 2012–2015.

It is premature to relate these trends in population growth to habitat characteristics or management practices. Many factors other than management practices can affect giant gartersnake, and such widespread declines (if they indeed occurred prior to 2016) may have been likely caused by regional (e.g., drought), rather than site-specific, variables. Similarly, caution must be taken against presuming that the population at Natomas Farms is healthy because it exhibited stable growth rates. Because the sampled population is very small, the recruitment or exit of a single individual has a very large influence on the estimated population growth rates, as do simple random sampling events (i.e., whether a particular individual was captured in a given year). This strong influence of random chance, combined with low capture probabilities, complicates inferences about the health of the population. The longer the current sampling protocol is implemented, the greater the likelihood that changes in survival and recruitment (and ultimately, abundance) can to be related to climatic, habitat, and management variables.

Size Distribution and Sex Ratio

The sex ratio of giant gartersnakes on in the Natomas Basin was not distinguishable from one male per female, and should not limit the reproductive potential of the species. Continued monitoring of

giant gartersnake sex ratios is warranted. 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]).

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. 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).

3.4.2 Distribution of Giant Gartersnake on Reserve Lands

The occupancy analysis for 2016 indicated that giant gartersnake is expected to occur in about half of wetland and rice units on reserve lands, with occupancy especially high in the Central Basin Reserve. Interestingly, evidence existed for positive effects of floating vegetation and emergent vegetation on the probability of occurrence of giant gartersnake in 2016. The effect of floating vegetation on giant gartersnake occurrence was also found in 2015, but it is surprising because it runs counter to other studies indicating the opposite relationships. It is important to note that floating vegetation comprised less than 50% of the total habitat for the vast majority of the trapping locations in this study. It is possible that the probability of occurrence may decrease drastically if floating vegetation were greater than half of the vegetation present because floating vegetation—which in the Natomas Basin is predominantly mosquito fern, duckweed (*Lemna* spp.), and algae—likely changes many aspects of the physical and biological environment negatively for giant gartersnakes. The effect of emergent vegetation on occurrence was not seen in 2015, but was observed in years prior to 2014. It is suspected that emergent vegetation still provides the best habitat for cover from predators and higher prey concentrations. Because tule marsh is giant gartersnake's historic habitat, management for emergent vegetation, particularly tule, is important. Additional research with greater sample sizes will be required to determine the strength of the effects of emergent vegetation, floating vegetation, and rice on the probability of occurrence of giant gartersnake and the mechanisms by which these components of the habitat affect giant gartersnake occupancy.

Based upon the dynamic occupancy model, the proportion of wetland units on reserve lands occupied was decreasing by more than 10% annually from 2011 through 2016 with 66% probability, and it was very unlikely (probability < 0.001) that occupancy increased by more than 10% during that period. This continues a trend of decreasing giant gartersnake occupancy seen in 2015. Relative to previous years, the probability that occupied sites became unoccupied was greater in 2016. The probability that unoccupied sites became occupied was very similar to previous intervals. As such, it is unclear whether one of these processes had a stronger effect on changes in the proportion of sites occupied. One potential mechanism leading to a decrease in the proportion of sites occupied is a lingering effect of extreme drought conditions from 2012–2015. Although water remained on TNBC reserves, it is unknown to what extent the source of water (surface water vs. groundwater) affects giant gartersnake occupancy or demography. It will be interesting to see if increased precipitation since 2015 leads to changes in giant gartersnake occupancy in the coming years. Habitat and vegetation variables appeared to be unrelated to occupancy dynamics on TNBC reserves.

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 gartersnakes in the Natomas Basin.

The primary issue affecting giant gartersnake throughout its range is habitat, and the Natomas Basin is no different in this regard. Marshes that most nearly approximate natural tule marshes provide the best habitat for giant gartersnake, promoting both higher densities and greater body condition than other habitats (Wylie et al. 2010). With the exception of Natomas Farms, which might suffer the compounding effects of a small founding population and poor connectivity relative to other demographic monitoring sites, all created marsh habitats had greater abundance than the Sills tract, which was the only demographic monitoring site at which rice was the predominant habitat. Abundance likely increased on Sills over the past year (> 10% increase from 2015–2016 with 65% probability), a reversal of the population trend from 2014–2015 (> 10% decrease with 93% probability). 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), restriction of giant gartersnake to structurally simple linear canals during the other 5 months of the active season, as well as the rice idling in response to drought in recent years likely reduces 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 that provide connectivity between other patches of suitable habitat. 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 year is important for giant gartersnake. 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. TNBC has been highly effective in creating managed marsh habitats that—with the exception of years where marsh maintenance and enhancement activities are required—provide persistent aquatic habitat throughout the year. Habitat management activities that require drying of marshes should be limited to circumstances in which it is absolutely necessary.

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 gartersnake 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 gartersnake 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.

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, and other conservation goals. Minimizing unnecessary ground disturbance 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).
- 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 gartersnakes.
- 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 control mosquito fern and other floating vegetation where possible. Giant gartersnakes tend 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). 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).
- 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, and 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.
- 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 historic drying of natural wetlands in the Central Valley. Doing so might provide giant gartersnakes 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 gartersnakes 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 climb. If slopes must be steep, provide periodic (every 50 meters) shallower slopes that allow entrapped snakes to exit the channel.

3.7 References

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

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

[3] To estimate abundance accurately, the probability of capturing a giant gartersnake must also be estimated. Investigators fit a single "multinomial N-mixture model" (Kéry & Royle 2016) using capture data from all five sites, with a random effect of site 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. Posterior probability was calculated for each subset of the full model using indicator variables on model parameters (Kuo and Mallick 1998; Royle and Dorazio 2008). The capture histories of trapped individuals were augmented with 628 all-zero capture histories to give a total pool of 800 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, half-Cauchy(0,1) for standard deviations, and Bin(1,0.5) for indicator variables. For all sites, posterior inference regarding abundance was based upon averaging across all models in the model set (Burnham and Anderson 2002; Anderson 2008).

The closed population model was run on 7 independent chains of 35,000 iterations after a burn-in of 5,000; each chain was thinned by a factor of 10. The model was analyzed by calling JAGS 4.2.0 (Plummer 2003) from R 3.3.1 (R Core Team 2016) using the package R2jags (Su & Yajima 2015). Posterior distributions were summarized with the posterior median and 95% credible interval (2.5% and 97.5% quantiles of the posterior distribution).

[4] Jolly-Seber models for open populations are statistical models that allow for the population to change over the course of the study because they are "open" to emigration, immigration, birth, and death.

[5] Each dataset was augmented with 300–600 all-zero capture histories. The number of pseudo-individuals was deemed adequate by the posterior density for superpopulation abundance falling far below the number of augmented individuals. Uninformative Uniform(0,1) priors were used for all simple probabilities, and an uninformative Dir(α=1) prior was used on the multinomial entrance probability.

Each Jolly-Seber open population model was run on 10 independent chains of 50,000 iterations after a burn-in of 49,000 iterations; each chain was thinned by a factor of 5. Each model was analyzed by calling JAGS 4.2.0 (Plummer 2003) from R 3.3.1 (R Core Team 2016) using the package jagsUI (Kellner 2016). Posterior distributions were summarized with the posterior median and 95% symmetrical credible interval (2.5% and 97.5% quantiles of the posterior distribution).

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

[7] Both normal and log-normal models were evaluated for size, and the goodness of fit of each model was examined with a Bayesian p-value. If both models fit, evidence for each model was evaluated using the Bayesian Information Criterion (BIC) based upon the minimum deviance (Ntzoufras 2011), and posterior model probabilities were calculated using a uniform prior on the model set (Link and Barker 2006).

[8] Each model was run on 5 independent chains of 100,000 iterations after a burn-in of 10,000; each chain was thinned by a factor of 5. Each model was analyzed by calling OpenBUGS 3.2.3 (Lunn et al. 2009) from R 3.1.2 (R Core Team 2014) using the R package R2OpenBUGS (Sturtz et al. 2005). Posterior distributions were summarized with the posterior median and 95% credible interval.

[9] 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 20,000 iterations each after a burn-in of 2,000; each chain was thinned by a factor of 5. Each model was analyzed by calling OpenBUGS 3.2.3 (Lunn et al. 2009) from R 3.1.2 (R Core Team 2014) using the package R2OpenBUGS (Sturtz et al. 2005). Posterior distributions were summarized with the posterior median and 95% symmetrical credible interval.

[10] All probabilities were given U(0,1) priors. The dynamic occupancy model was run on 7 independent chains of 30,000 iterations each after a burn-in of 10,000; each chain was thinned by a factor of 7. Each model was analyzed by calling JAGS 4.2.0 (Plummer 2003) from R 3.3.1 (R Core Team 2016) using the package R2jags (Su & 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).

[11] 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.

Table 3-1. Prior Probabilities for Parameters of Single-Season Occupancy Models for Giant Gartersnake on Natomas Basin Conservancy Reserve Properties, 2016

			Prior Distribution	
Component	Model	Parameter	Uninformative	Informative
Detection	All	β_0	*N(0,1.648)*	*N(-2.018,0.133)*
	All	β_{temp}	*N(0,1.648)*	*N(0.277,0.052)*
	All	β_{date}	*N(0,1.648)*	*N(-0.307,0.059)*
	All	σ_{site}	*U(0,10)*	*Gamma(100.359,98.536)*
Occupancy	$\psi_{habitat}$ and ψ_{basin}	β_0	*N(0,1.648)*	NA
	$\psi_{habitat}$	β_{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
	ψ_{basin}	$\beta_{central}$	*N(0,1.648)*	NA
		$\beta_{central}$	*N(0,1.648)*	NA
		β_{south}	*N(0,1.648)*	NA

Table 3-2. Summary of Giant Gartersnake Captures and Sampling Effort at Natomas Basin Conservancy Reserves, 2016

Reserve Area and Reserve	Number of Giant Gartersnake		Dates Trapped (2016)	Total Trap-Days
	Individuals	Captures		
North Basin				
Atkinson	0	0	3 Sept – 26 Sept	1,041
Bennett North (rice)	0	0	1 Sept – 24 Sept	1,028
Bennett North Central (wetland)	0	0	21 Aug – 13 Sept	1,050
Bennett South (wetland)	2	2	1 Sept – 24 Sept	350
Bolen North	0	0	4 Sept – 27 Sept	1,050
Bolen West	0	0	11 Aug – 1 Sept	1,050
Frazer North Central	1	1	2 Sept – 25 Sept	1,049
Frazer North Southeast	0	0	23 Aug – 15 Sept	1,050
Frazer North West	1	1	21 Aug – 13 Sept	1,050
Huffman East	0	0	3 Sept – 26 Sept	1,050
Huffman West	0	0	25 Jul – 29 Jul	193
Lucich North Demography	49	89	12 Apr – 15 Jul	12,496
Lucich North Northeast	0	0	25 Jul – 15 Aug	1,050
Lucich North Southwest 2	3	3	23 Jul – 27 Jul	200
Lucich North Southwest 4	2	2	20 Aug – 22 Aug	100
Lucich South Demography	37	53	13 Apr – 15 Jul	12,531
Ruby Ranch	0	0	23 Aug – 15 Sept	1,046
Central Basin				
Bianchi West	2	2	27 Jul – 17 Aug	1,035
BKS Demography	71	130	11 April – 15 Jul	13,329
BKS Northeast	6	7	13 Sept – 23 Sept	500
BKS Northwest Central	4	4	23 Jul – 24 Jul	50
BKS Southeast Central	5	5	23 Jul – 24 Jul	50
BKS Southwest Central	14	14	25 Jul – 27 Jul	50
Elsie	2	2	23 Aug – 15 Sept	1,049
Frazer South	0	0	2 Sept – 25 Sept	1,067
Sills Demography	14	19	9 May – 15 Jul	8,503
Tufts	0	0	4 Sept – 25 Sept	948
Fisherman's Lake				
Cummings East	0	0	21 Aug – 13 Sept	1,049
Cummings East Central	0	0	17 Aug – 9 Sept	1,049
Cummings West	0	0	16 Aug – 8 Sept	1,048
Natomas Farms Demography	1	3	14 Apr – 15 Jul	13,140
Natomas Farms North	0	0	29 Jul – 19 Aug	1,050
Rosa East	0	0	23 Jul – 13 Aug	1,043
Rosa Central	0	0	24 Aug – 16 Sept	1,050

Reserve Area and Reserve	Number of Giant Gartersnake		Dates Trapped (2016)	Total Trap-Days
	Individuals	Captures		
SAFCA1	0	0	24 Aug – 16 Sept	1,049
SAFCA2	0	0	26 Jul – 16 Aug	1,049
SAFCA3	0	0	18 Aug – 10 Sept	1,050
SAFCA4	0	0	13 Aug – 3 Sept	1,050
SAFCA5	0	0	1 Sept – 24 Sept	1,050
SAFCA6	0	0	28 Jul – 18 Aug	1,050
SAFCA7	1	1	4 Sept – 27 Sept	1,048
SAFCA8	0	0	15 Aug – 7 Sept	1,049
Total	**215**	**338**	**11 Apr – Sept 27**	**91,789**

Table 3-3. Posterior Model Probabilities for Abundance of Giant Gartersnake at Five Sites in the Natomas Basin, April–July 2016

Explanatory Variable					
Water Temperature	SVL	Sex	Behavioral Response	Temporal Heterogeneity	Posterior Probability
1	0	0	1	1	0.902
1	0	1	1	1	0.062
0	0	0	0	0	0

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 3-4. Summary of Giant Gartersnake Captures at the Five Demographic Monitoring Sites, 2011–2016

	2011		2012		2013		2014		2015		2016	
Site	Indiv	Cap	Indiv	Cap	Indiv	Cap	Indiv	Cap	Indiv	Cap	Indiv	Cap
Natomas Farms	1	2	1	1	1	1	4	5	1	1	1	3
BKS	62	66	71	84	68	101	86	131	35	41	71	130
Lucich North	30	33	39	53	32	44	26	33	11	21	49	89
Lucich South	24	26	15	15	17	17	16	18	20	26	37	53
Sills	25	38	17	28	15	23	13	18	9	15	14	19
Total	**142**	**165**	**143**	**181**	**133**	**186**	**145**	**205**	**76**	**104**	**172**	**294**

Indiv = individuals; cap = captures

Table 3-5. Estimated Abundance (Symmetric Posterior 95% Credible Intervals) of Giant Gartersnake at the Five Demographic Monitoring Sites, 2011–2016, Based upon Annual Closed Population Models

Site	2011	2012	2013	2014	2015	2016
Natomas Farms	3 (1–24)	48 (1–388)	6 (1–87)	13 (4–125)	5 (1–52)	2 (1–7)
BKS	175 (101–318)	205 (125–348)	138 (106–191)	155 (122–214)	111 (65–255)	103 (88–125)
Lucich North	216 (71–506)	100 (58–183)	70 (47–123)	201 (59–500)	32 (19–70)	72 (59–91)
Lucich South	264 (70–508)	261 (85–498)	120 (40–444)	116 (35–449)	47 (28–96)	62 (47–93)
Sills	44 (28–75)	27 (18–42)	41 (21–97)	38 (16–244)	15 (8–36)	22 (16–37)

Table 3-6. Posterior Model Probabilities for Effects of Habitat on Apparent Survival of Giant Gartersnake in the Natomas Basin, 2011–2016

Explanatory Variable					
Emergent Vegetation	Terrestrial Vegetation	Floating Vegetation	Submerged Vegetation	Rice	Posterior Probability
0	0	0	0	0	0.23
0	0	0	1	0	0.1
0	0	0	0	1	0.1
0	0	0	1	1	0.08

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

Table 3-7. Posterior Model Probabilities for Effects of Selected Vegetation Types on Apparent Survival of Giant Gartersnake in the Natomas Basin, 2011–2016

Explanatory Variable				
Tule	Cattail	Water-primrose	Mosquito Fern	Posterior Probability
0	0	0	0	0.43
0	1	0	0	0.11
0	0	1	0	0.09
1	0	0	0	0.06

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

Table 3-8. Sex Ratios (Symmetric Posterior 95% Credible Intervals) of the Giant Gartersnake at Demographic Monitoring Sites in the Natomas Basin, 2016

Site	Male : Female Sex Ratio
Natomas Basin	1.017 (0.817–1.248)
BKS	1.219 (0.847–1.698)
Lucich North	1.091 (0.708–1.612)
Lucich South	0.773 (0.439–1.256)
Sills	2.329 (0.837–5.501)
Natomas Farms	0.332 (0.006–1.502)

Note:
Sex ratios based upon a binomial model that assumes sampling with replacement.

Table 3-9. Model Selection Table for Mean Snout-Vent Length of the Giant Gartersnake in the Natomas Basin, 2016

Site	Model	Bayesian p-value	BIC	ΔBIC	Prior Probability	Posterior Probability
Natomas Basin	Normal	0.514	2730	0	0.5	> 0.999
	Log-normal	0.732	2777	47	0.5	< 0.001
BKS	Normal	0.521	866	0	0.5	0.832
	Log-normal	0.558	870	3	0.5	0.168
Lucich North	Normal	0.525	642	0	0.5	> 0.999
	Log-normal	0.757	669	27	0.5	< 0.001
Lucich South	Log-normal	0.502	487	0	0.5	0.955
	Normal	0.534	493	6	0.5	0.045
Sills	Normal	0.555	179	0	0.5	0.562
	Log-normal	0.541	180	1	0.5	0.438

Note:
Within each site, the best-supported model is listed first.

Table 3-10. Model Selection Table for Mean Mass of the Giant Gartersnake in the Natomas Basin, 2016

Site	Model	Bayesian p-value	BIC	ΔBIC	Prior Probability	Posterior Probability
Natomas Basin	Log-normal	0.757	2406	0	0.5	> 0.999
	Normal	0.517	2542	136	0.5	< 0.001
BKS	Log-normal	0.679	754	0	0.5	> 0.999
	Normal	0.523	783	28	0.5	< 0.001
Lucich North	Log-normal	0.502	553	0	0.5	> 0.999
	Normal	0.529	593	39	0.5	< 0.001
Lucich South	Log-normal	0.401	427	0	0.5	> 0.999
	Normal	0.539	472	45	0.5	< 0.001
Sills	Log-normal	0.635	155	0	0.5	0.650
	Normal	0.556	156	1	0.5	0.350

Note:
Within each site, the best-supported model is listed first.

Table 3-11. Mean Snout-Vent Length and Mean Mass of the Giant Gartersnake (Symmetric Posterior 95% Credible Intervals) throughout the Natomas Basin and at Demographic Monitoring Sites, 2016

Site	SVL (mm)	Mass (g)
Natomas Basin	545 (526–565)	81.2 (72.7–90.7)
BKS	524 (494–554)	71.4 (59.4–85.8)
Lucich North	545 (500–591)	82.4 (65.6–103.3)
Lucich South	505 (462–552)	72.0 (54.3–95.9)
Sills	557 (482–633)	83.3 (52.3–132.0)

Note:
Measurements are based upon best-supported models for snout-vent length and mass for each site.

Table 3-12. Posterior Model Probabilities for Probability of Occurrence of the Giant Gartersnake Based on Habitat on Natomas Basin Conservancy Reserves, 2016

Explanatory Variable					Posterior Probability	
Rice	Emergent Vegetation	Floating Vegetation	Open Water	Terrestrial Vegetation	Uninformative	Informative
0	1	1	0	0	0.060	0.062
0	1	0	0	0	0.060	0.057
0	0	1	0	0	0.055	0.056
1	1	0	0	0	0.060	0.056
1	1	1	0	0	0.056	0.054
1	0	1	0	0	0.054	0.053
1	1	1	1	1	0.046	0.051
0	0	0	0	0	0.035	0.035

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 3-13. Model-Averaged Posterior Distributions for Parameters of Single-Season Occupancy Habitat Models for the Giant Gartersnake on Natomas Basin Conservancy Reserve Properties, 2016

		Form of Priors on Detection Component of Model	
Model component	Parameter	Uninformative	Informative
Detection	α_0	-2.061 (-4.104 – -0.082)	-1.986 (-2.242 – -1.731)
	α_{temp}	0.606 (-0.082 – -1.36)	0.288 (0.186 – 0.390)
	α_{date}	-0.010 (-1.155 – 1.20)	-0.305 (-0.420 – -0.190)
	σ_{site}	2.771 (1.25 – 4.76)	1.073 (0.885 – 1.287)
Occurrence	β_0	0.075 (-1.116 – 1.954)	-0.070 (-1.124 – 1.223)
	β_{rice}	0 (-2.939 – 0.964)	0 (-2.910 – 0.746)
	$\beta_{em.veg}$	0.435 (-0.015 – 2.642)	0.441 (0 – 2.496)
	$\beta_{fl.veg}$	0.400 (-0.055 – 2.813)	0.514 (0 – 2.823)
	$\beta_{open.water}$	0 (-0.845 – 1.814)	0 (-0.743 – 1.866)
	$\beta_{terr.veg}$	0 (-0.507 – 1.846)	0 (-0.3869 – 1.938)
	ψ_{ag}	0.519 (0.247 – 0.876)	0.481 (0.246 – 0.773)
	N_{occ}	17 (12 – 28)	16 (13 – 22)

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

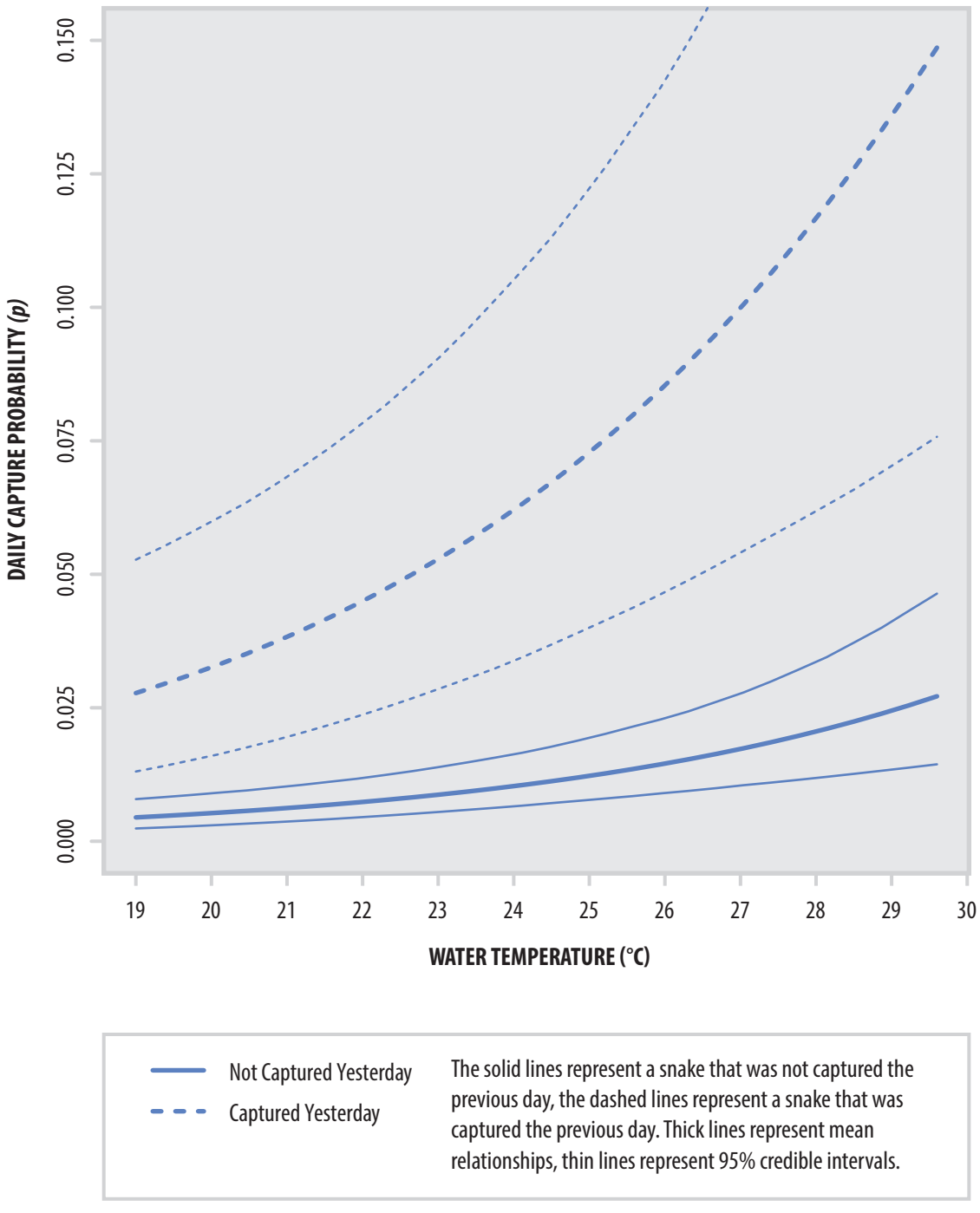
Table 3-14. Posterior Model Probabilities for Probability of Occurrence of the Giant Gartersnake Based on Habitat on Natomas Basin Conservancy Reserves, 2016

Explanatory Variable					
Emergent Vegetation	Terrestrial Vegetation	Floating Vegetation	Submerged Vegetation	Rice	Posterior Probability
0	0	0	0	0	0.31
1	0	0	0	0	0.11
0	0	0	0	1	0.10
0	0	1	0	0	0.06

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.

00890.10 NBC (3-31-2017)

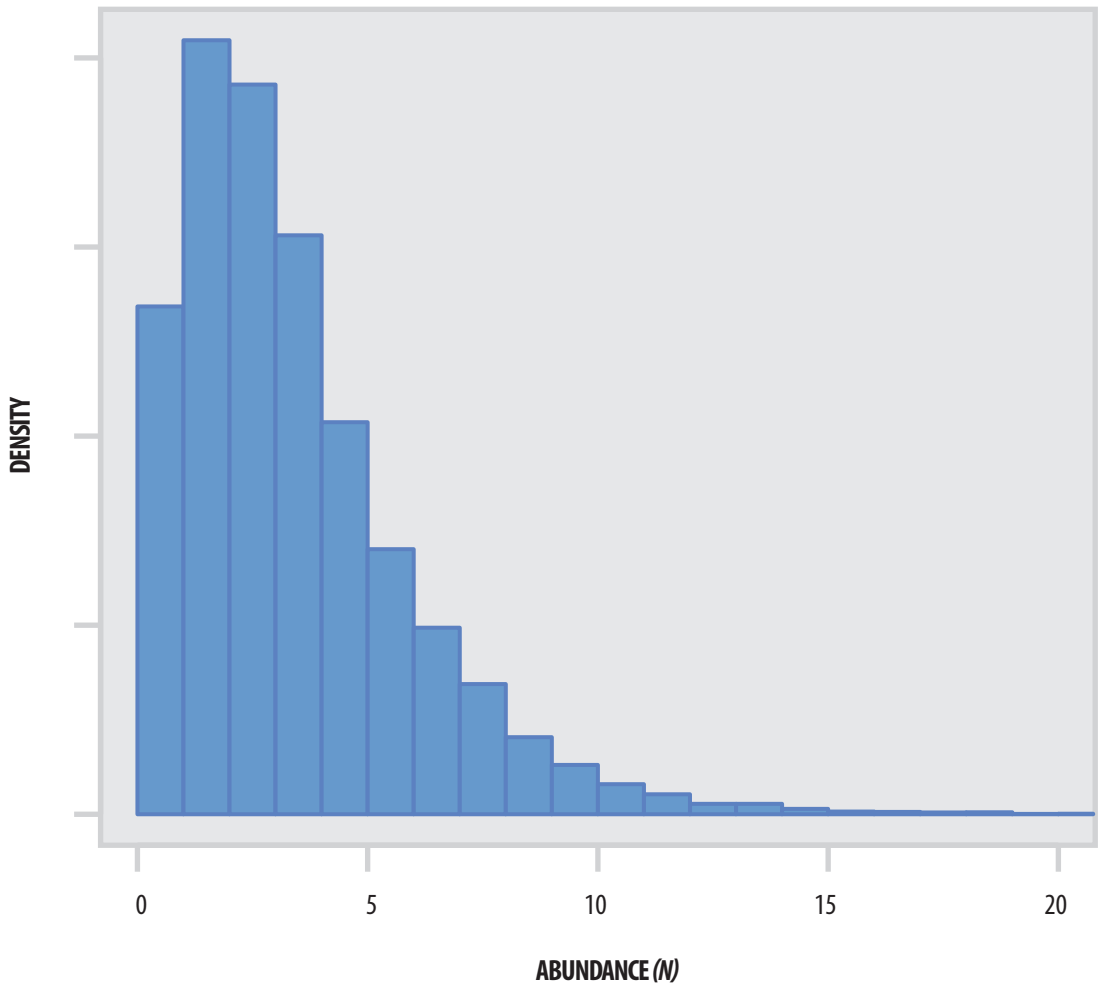
Figure 3-1
Giant Gartersnake



Graphics ... 890.10 NBC (3-21-17) TG

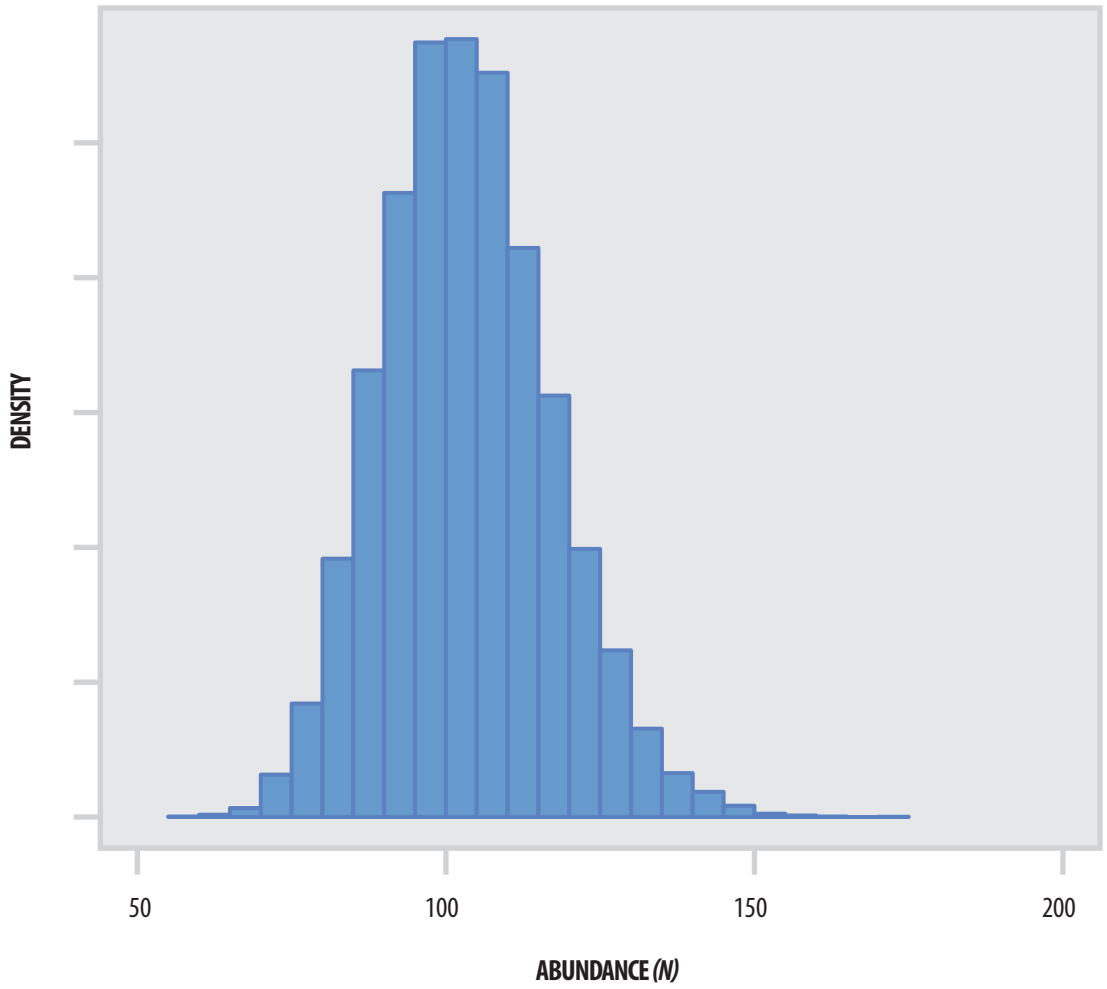
Figure 3-2

Model Averaged Effect of Water Temperature and an Ephemeral Behavioral Response on Giant Gartersnake Capture Probability in the Natomas Basin, 2016



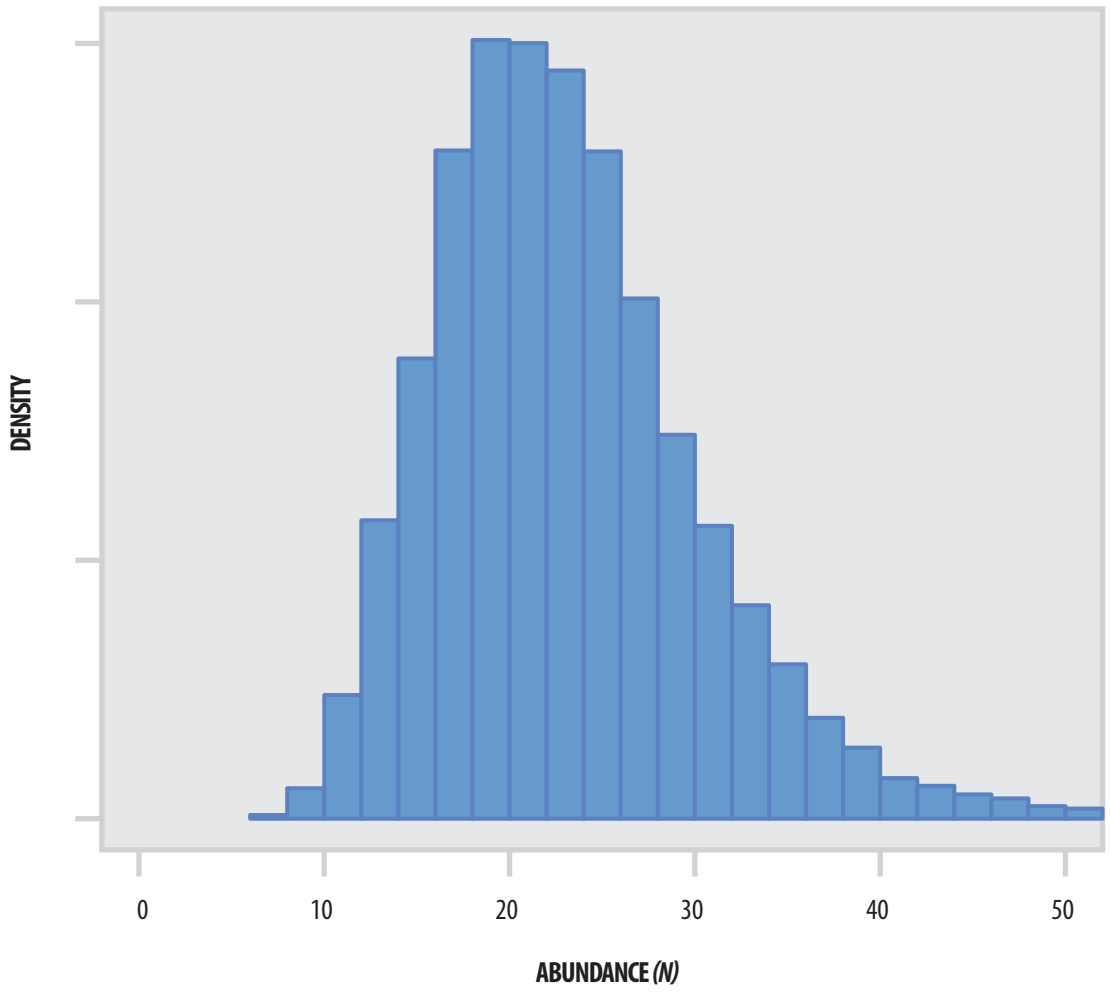
Graphics ... 890.10 NBC (3-21-17) TG

Figure 3-3
Estimated Giant Gartersnake Abundance in the Sampled Area at Natomas Farms Based on Closed Population Models, 2016



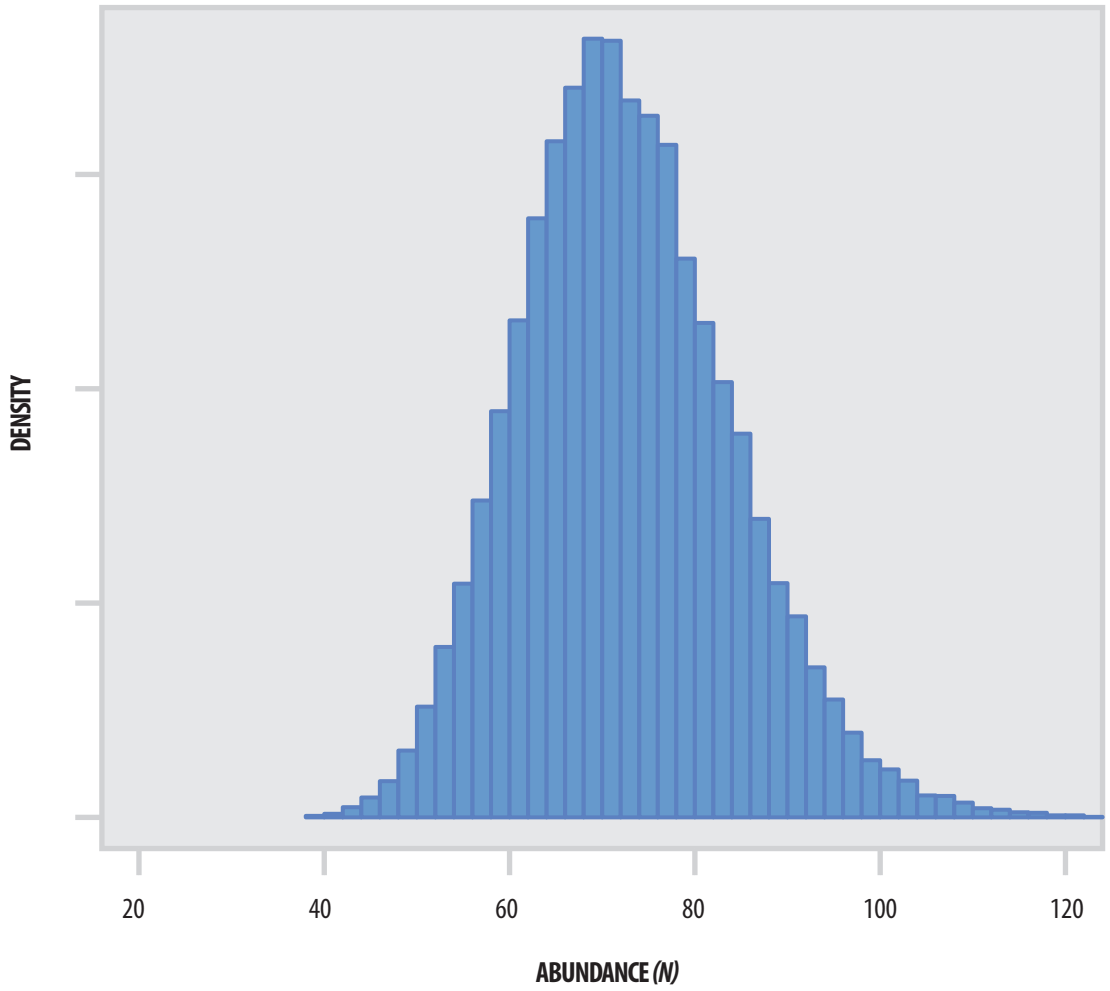
Graphics ... 890.10 NBC (3-21-17) TG

Figure 3-4
Estimated Giant Gartersnake Abundance in the Sampled Area at BKS Based on Closed Population Models, 2016



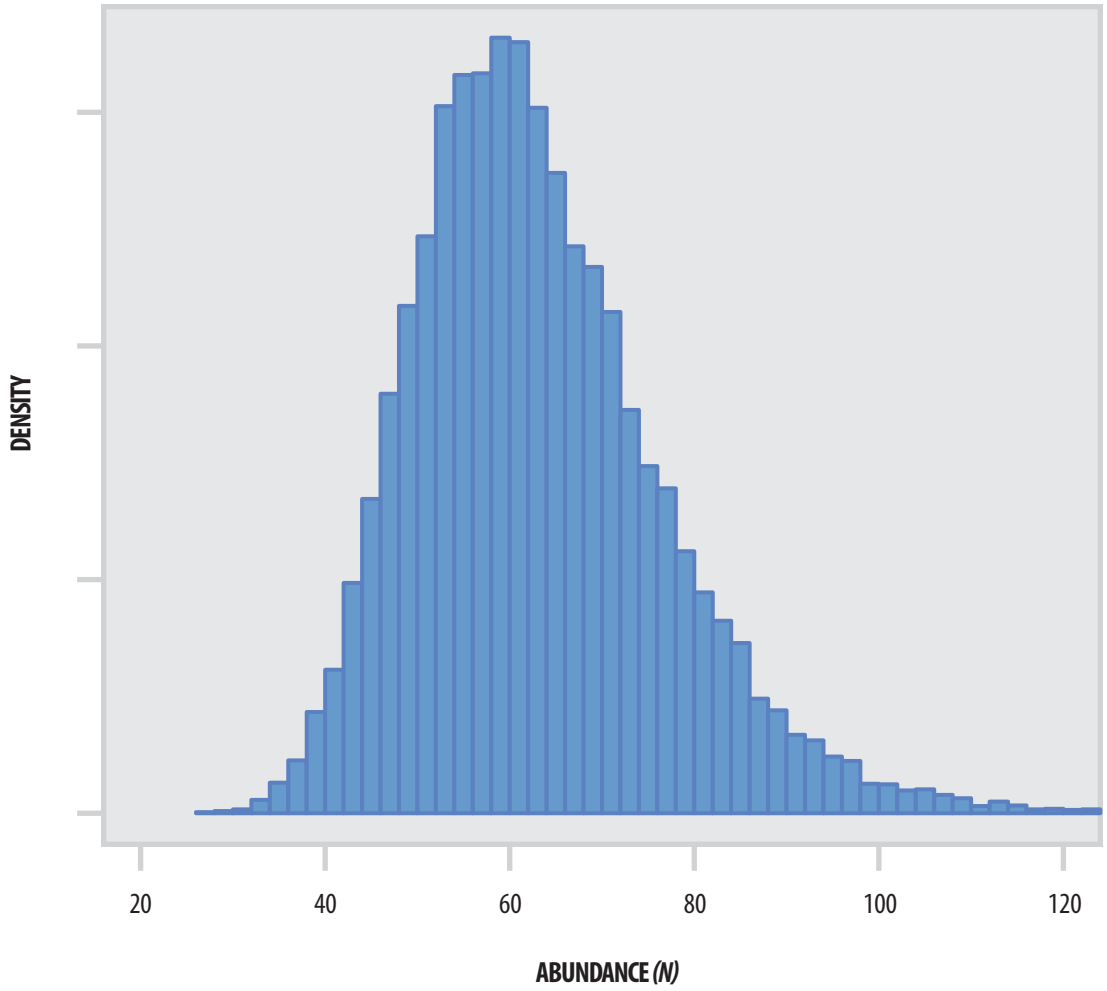
Graphics ... 890.10 NBC (3-21-17) TG

Figure 3-5
Estimated Giant Gartersnake Abundance in the Sampled Area at Sills Based on Closed Population Models, 2016



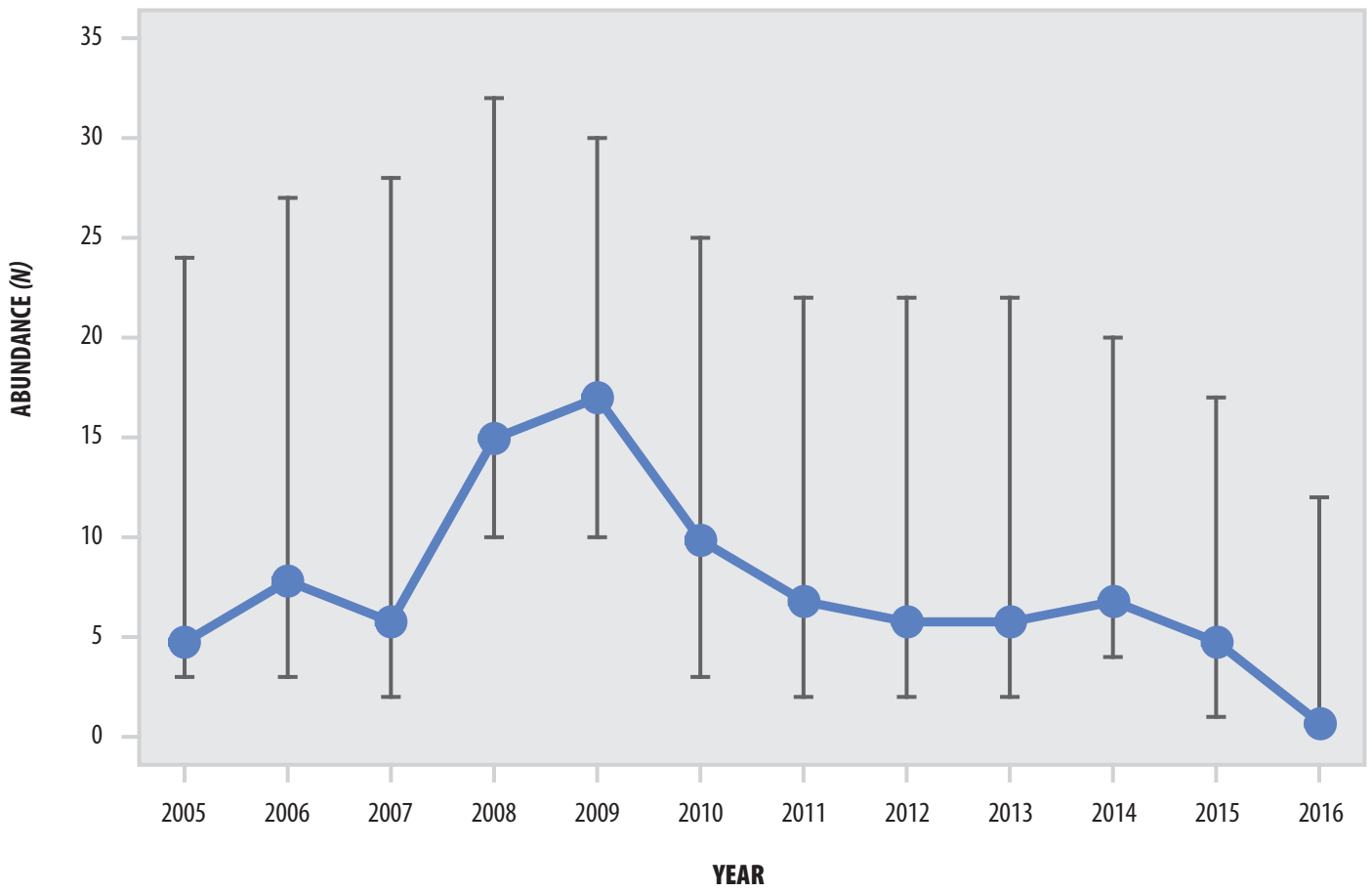
Graphics ... 890.10 NBC (3-21-17) TG

Figure 3-6
Estimated Giant Gartersnake Abundance in the Sampled Area at Lucich North Based on Closed Population Models, 2016



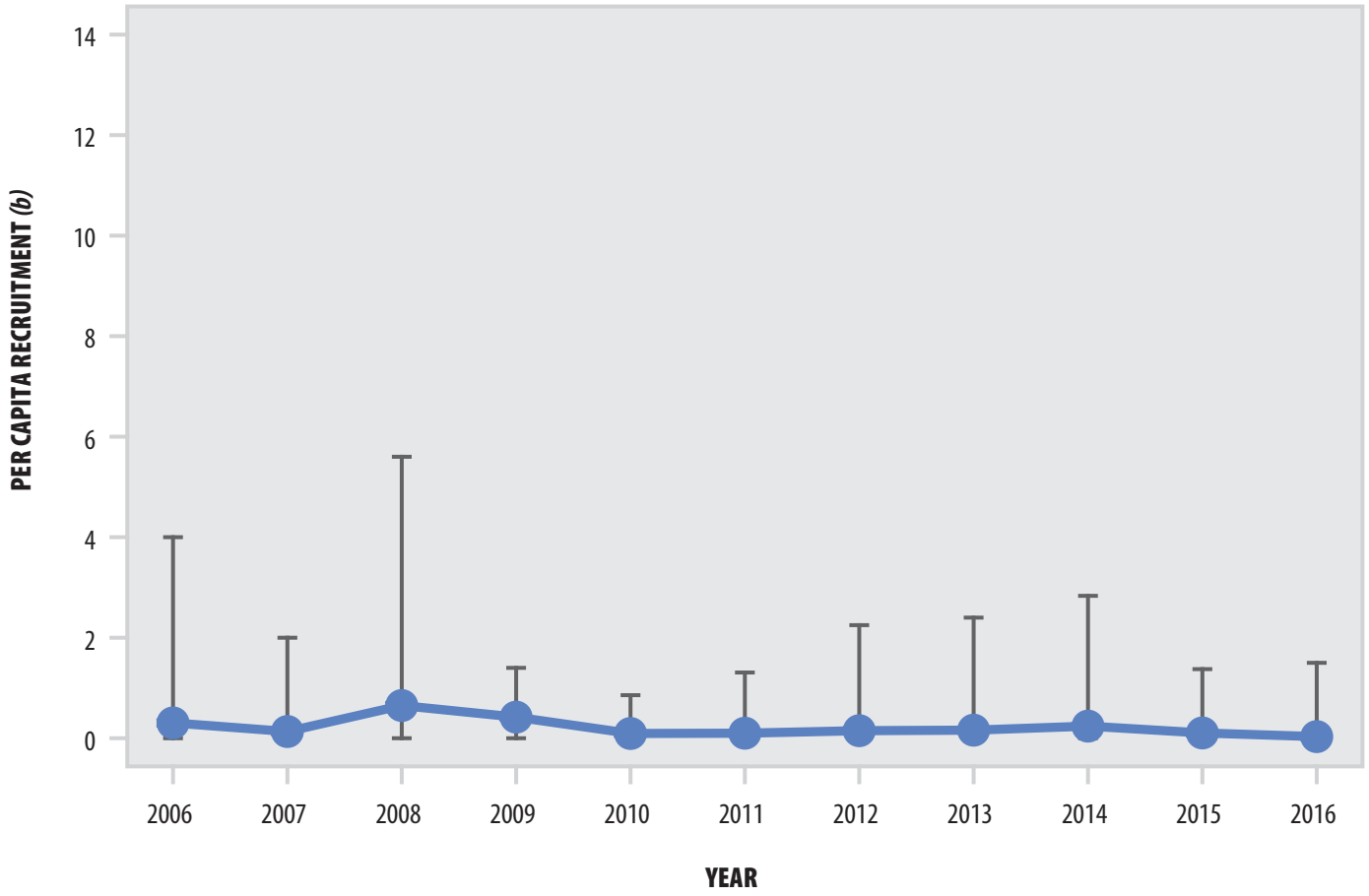
Graphics ... 890.10 NBC (3-21-17) TG

Figure 3-7
Estimated Giant Gartersnake Abundance in the Sampled Area at Lucich South Based on Closed Population Models, 2016



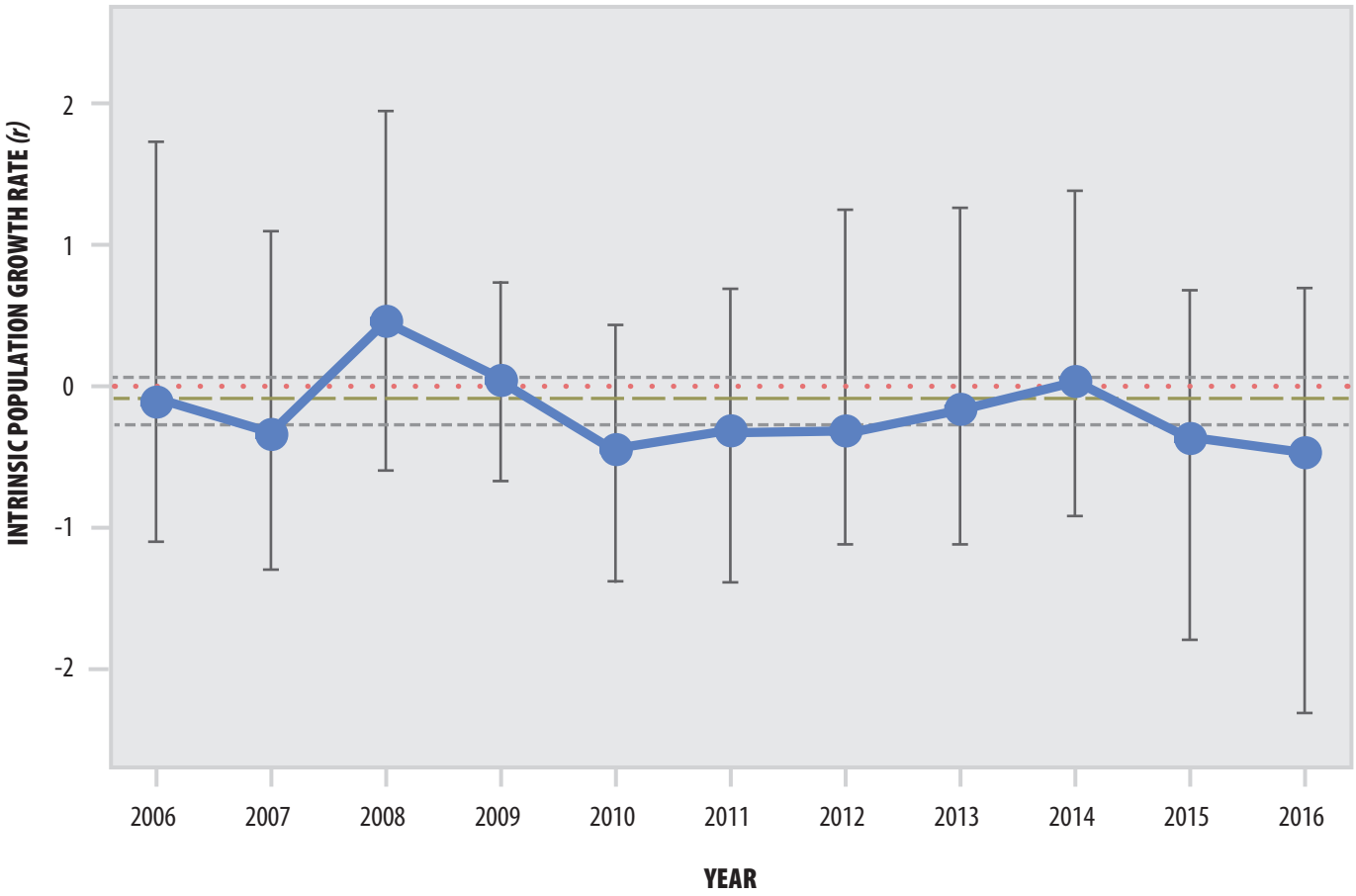
Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-8
Annual Giant Gartersnake Abundance at Natomas Farms Based on the Jolly-Seber Open Population Model, 2005–2016



Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-9
Annual per Capita Recruitment of Giant Gartersnake at Natomas Farms



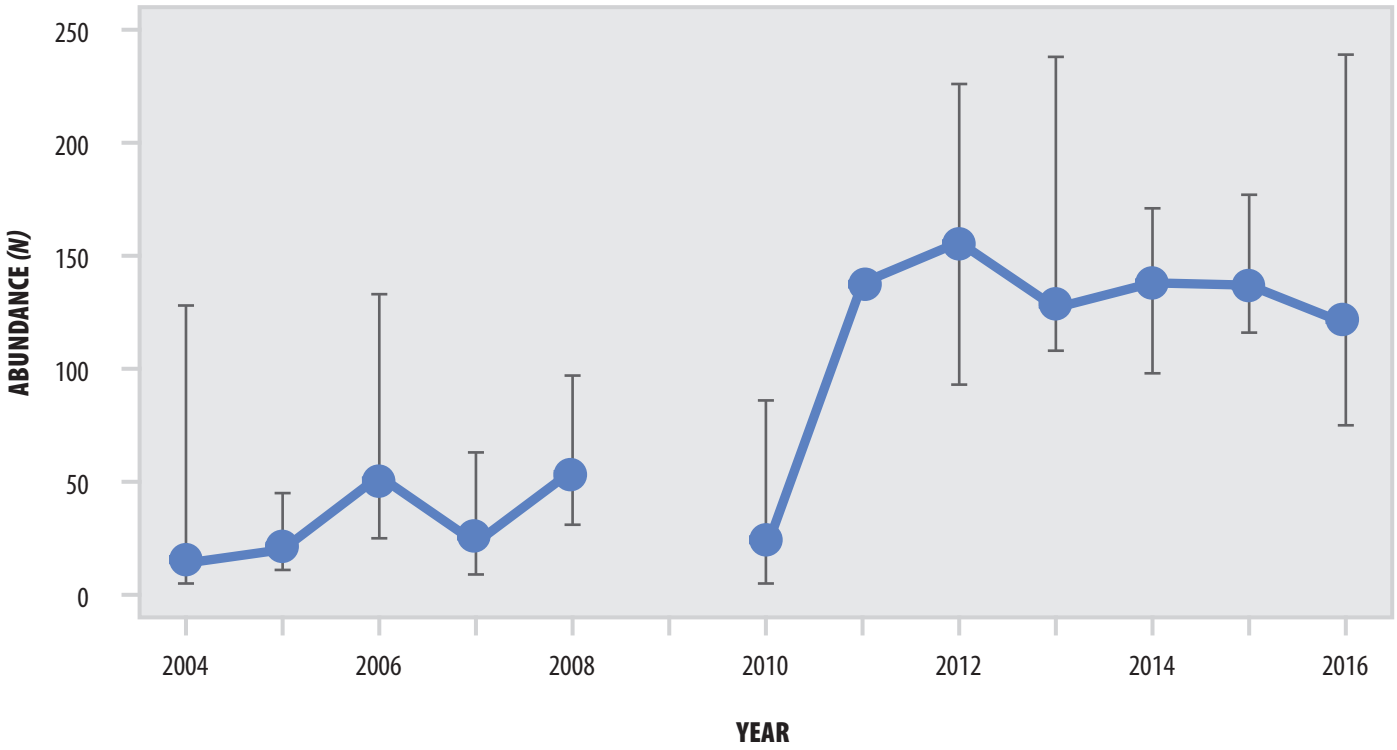
The dotted red horizontal line at 0 indicates no population change. The mean population growth rate from 2005 through 2016 is indicated by the long-dashed line (mode) and short-dashed dashed lines (95% credible interval).

Graphics ... 00890.10 NBC (4-3-17) TG

ICF

Figure 3-10

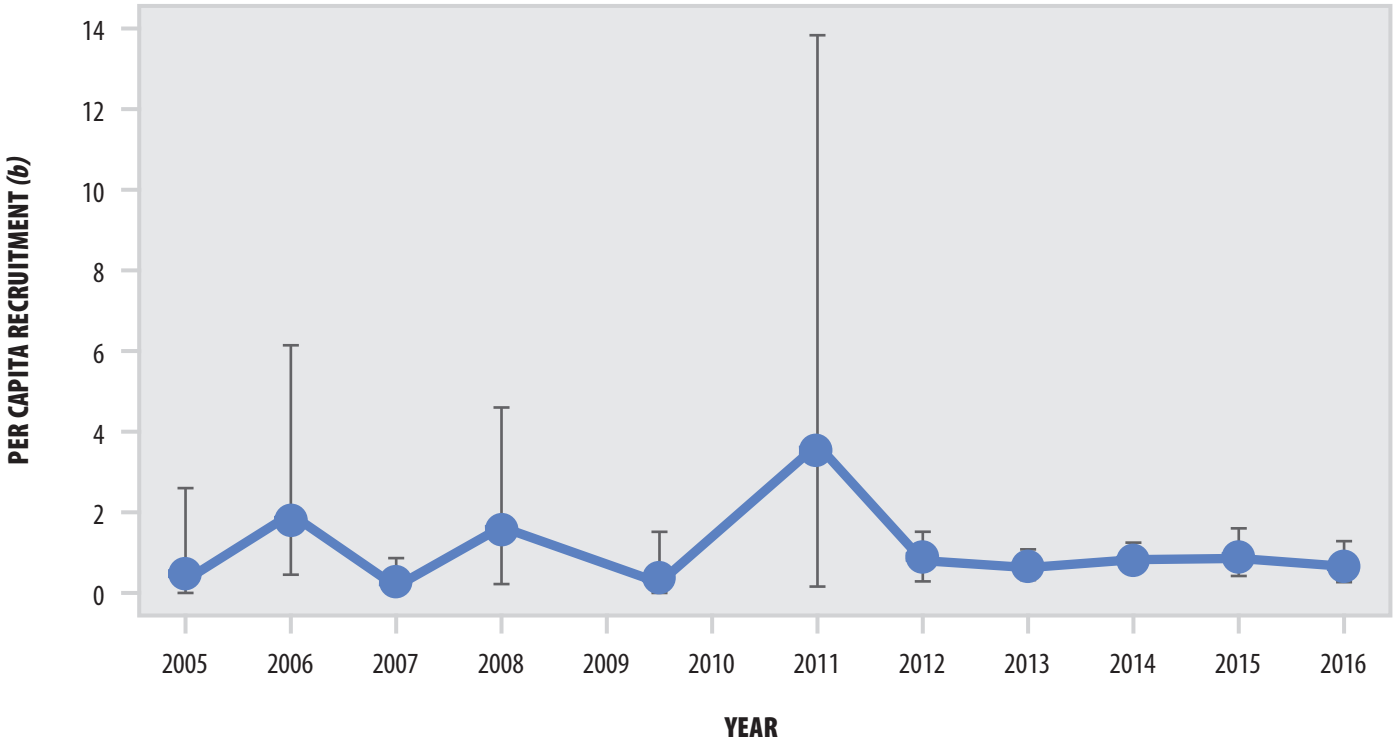
Annual Intrinsic Rate of Population Growth for Giant Gartersnake at Natomas Farms



Graphics ... 00890.10 NBC (4-3-17) TG

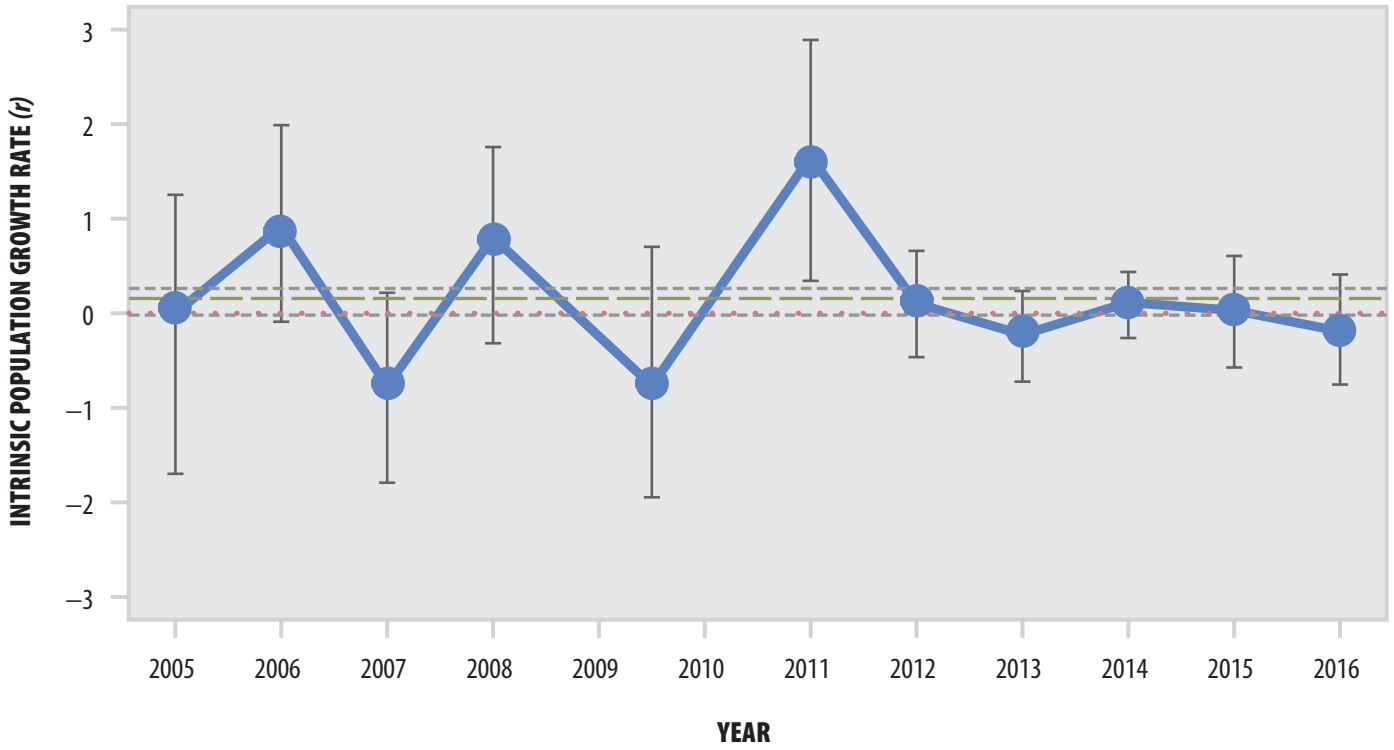
Figure 3-11

Annual Giant Gartersnake Abundance at BKS Based on the Jolly-Seber Open Population Model



Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-12
Annual per Capita Recruitment of Giant Gartersnake at BKS



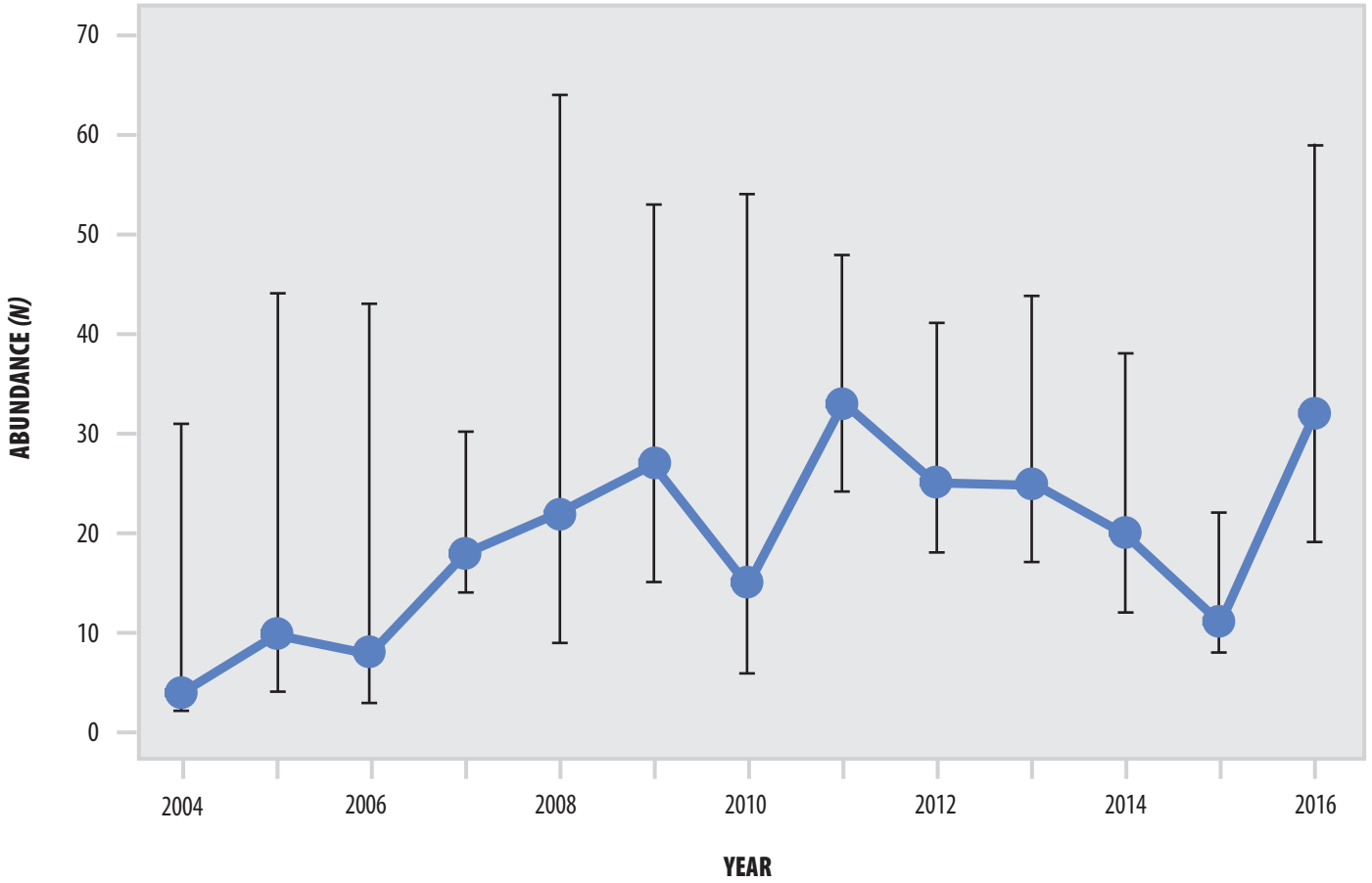
The dotted red horizontal line at 0 indicates no population change. The mean population growth rate from 2004 through 2016 is indicated by the long-dashed line (mode) and short-dashed dashed lines (95% credible interval).

Graphics ... 00890.10 NBC (4-3-17) TG

ICF

Figure 3-13

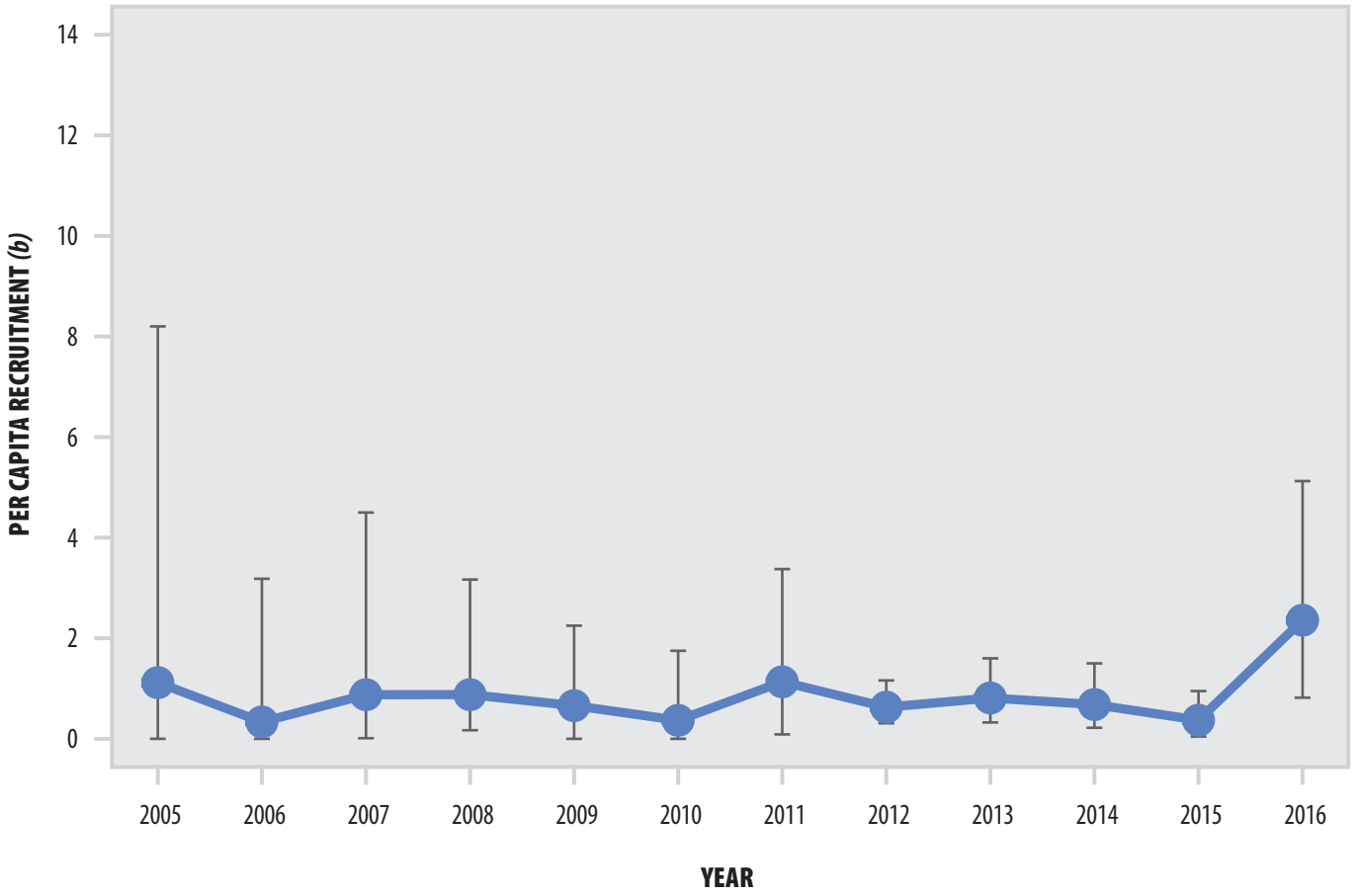
Annual Intrinsic Rate of Population Growth for Giant Gartersnake at BKS



Graphics ... 00890.10 NBC (4-3-17) TG

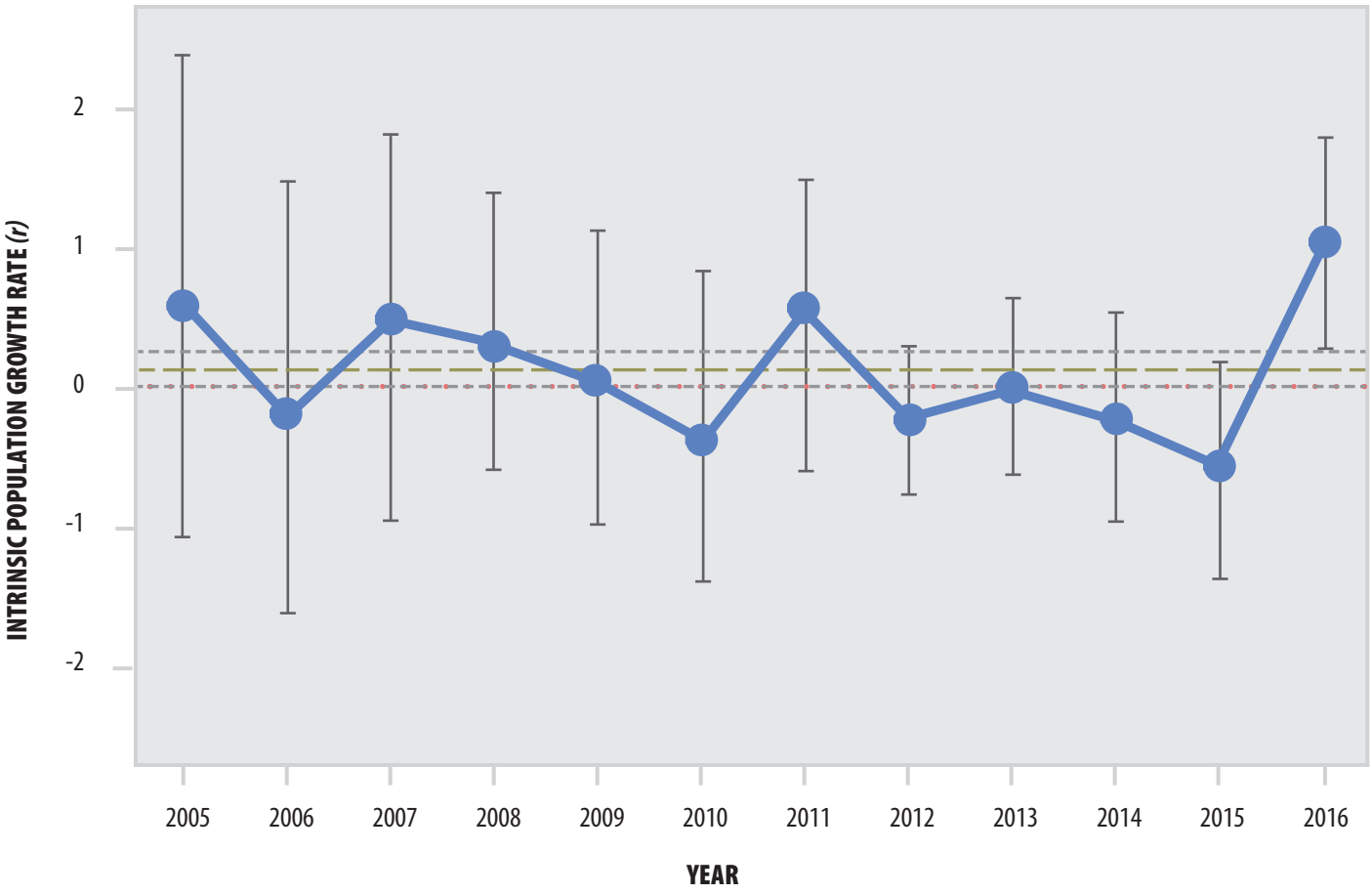
Figure 3-14

Annual Giant Gartersnake Abundance at Sills Based on the Jolly-Seber Open Population Model



Graphics ... 00890.10 NBC (3-24-17) TG

Figure 3-15
Annual per Capita Recruitment of Giant Gartersnake at Sills



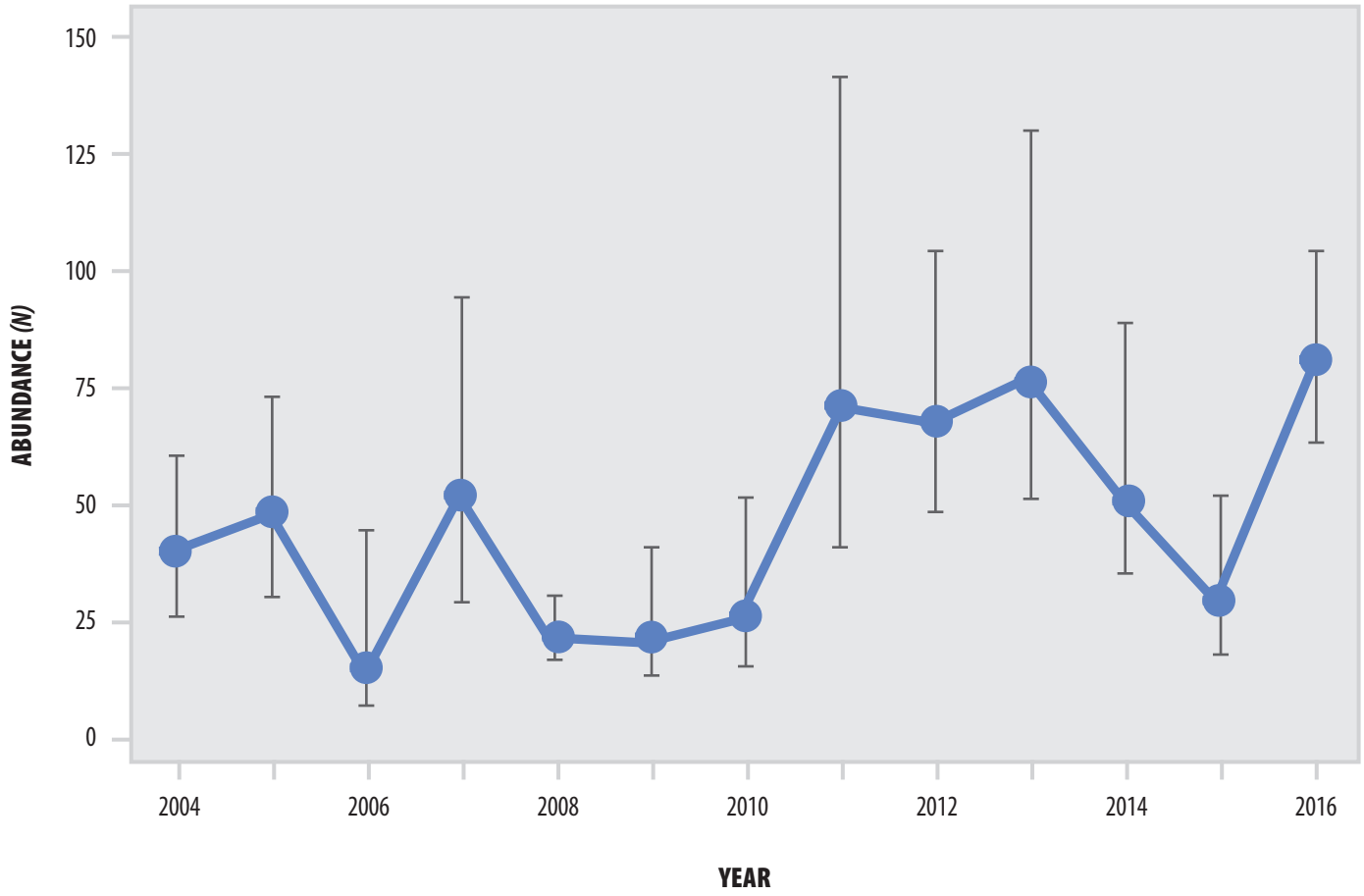
The dotted red horizontal line at 0 indicates no population change. The mean population growth rate from 2004 through 2016 is indicated by the long-dashed line (mode) and short-dashed dashed lines (95% credible interval).

Graphics ... 00890.10 NBC (4-3-17) TG

ICF

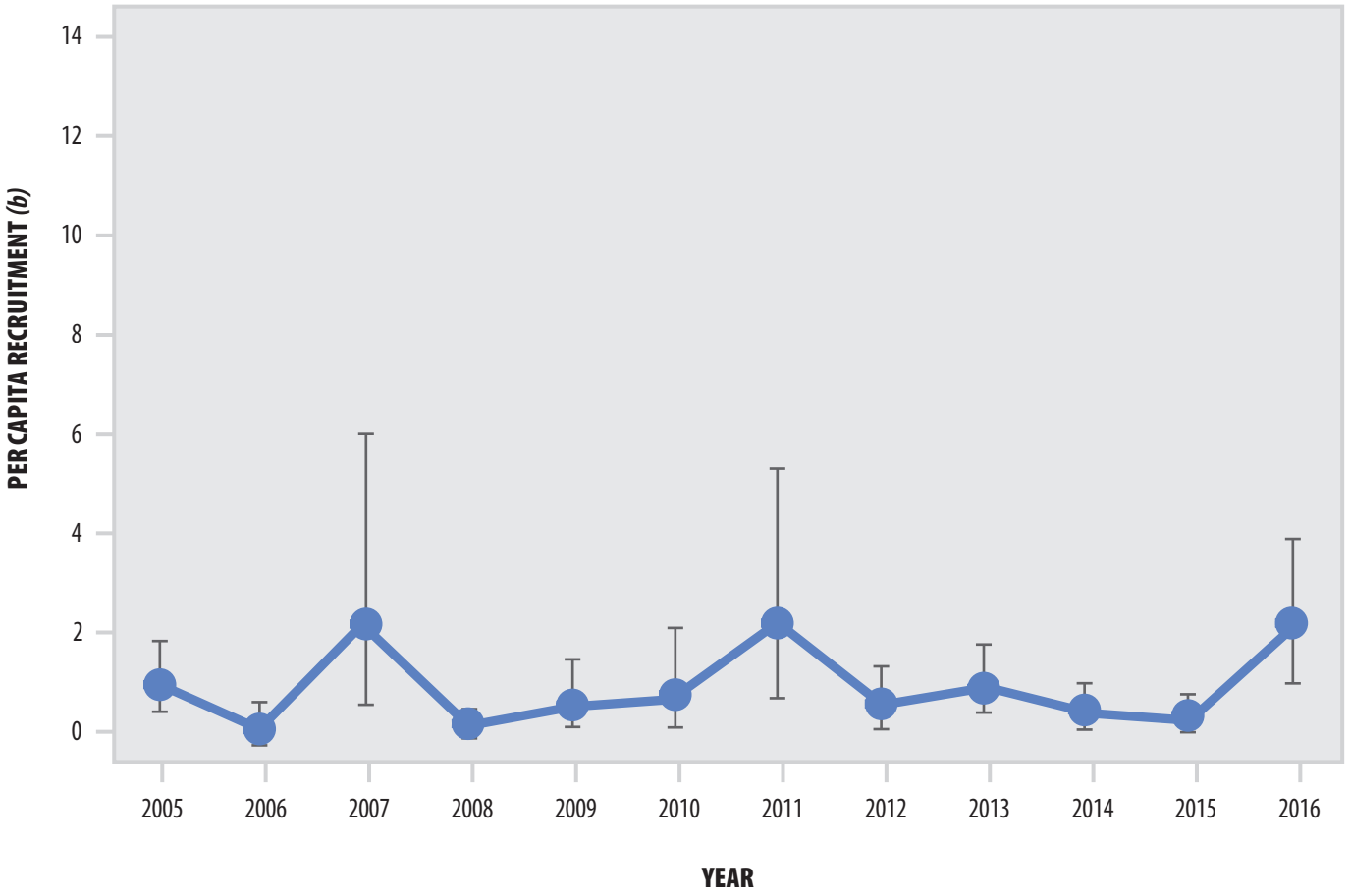
Figure 3-16

Annual Intrinsic Rate of Population Growth for Giant Gartersnake at Sills



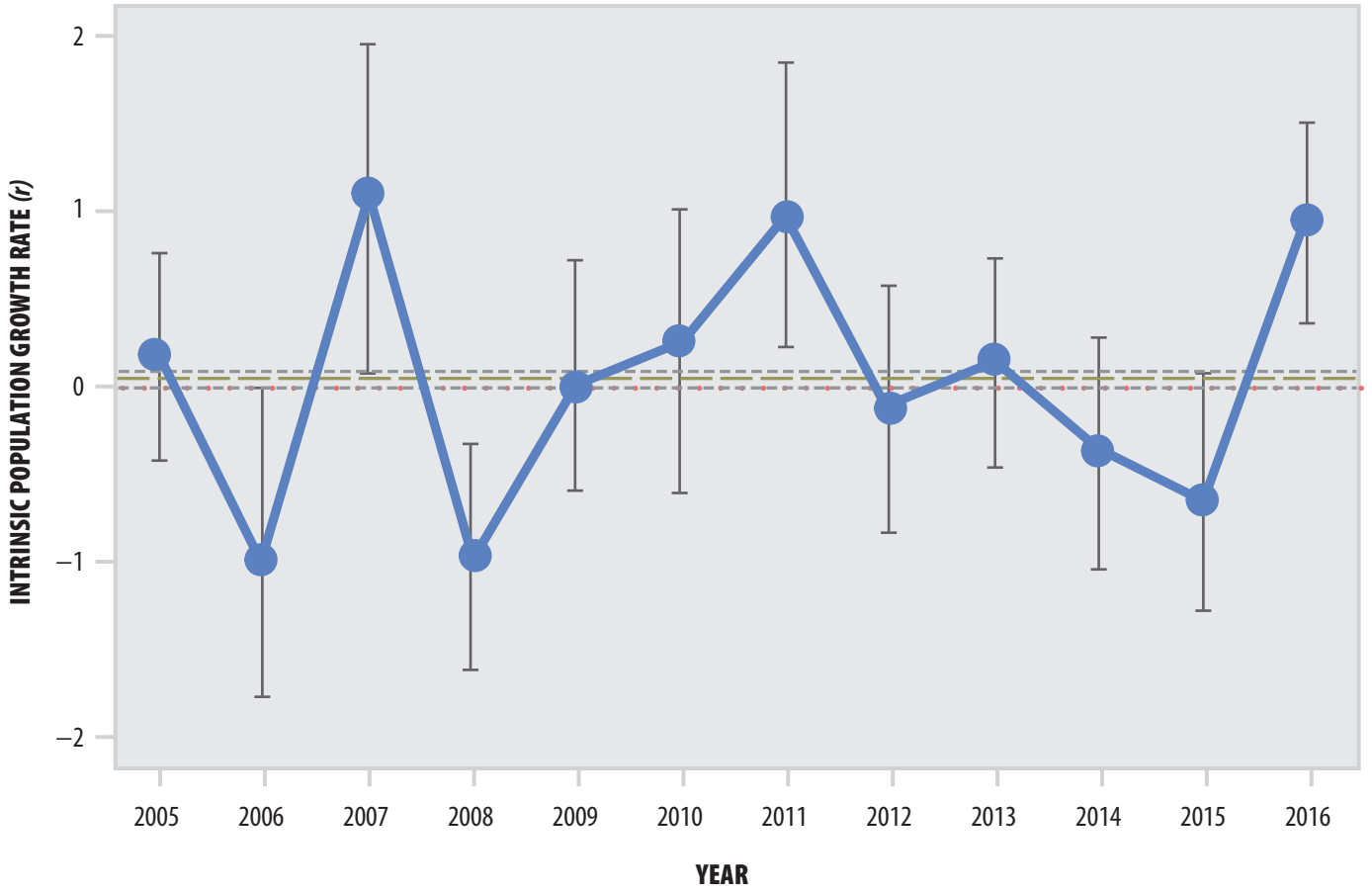
Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-17
Annual Giant Gartersnake Abundance at Lucich North Based on the Jolly-Seber Open Population Model



Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-18
Annual per Capita Recruitment of Giant Gartersnake at Lucich North

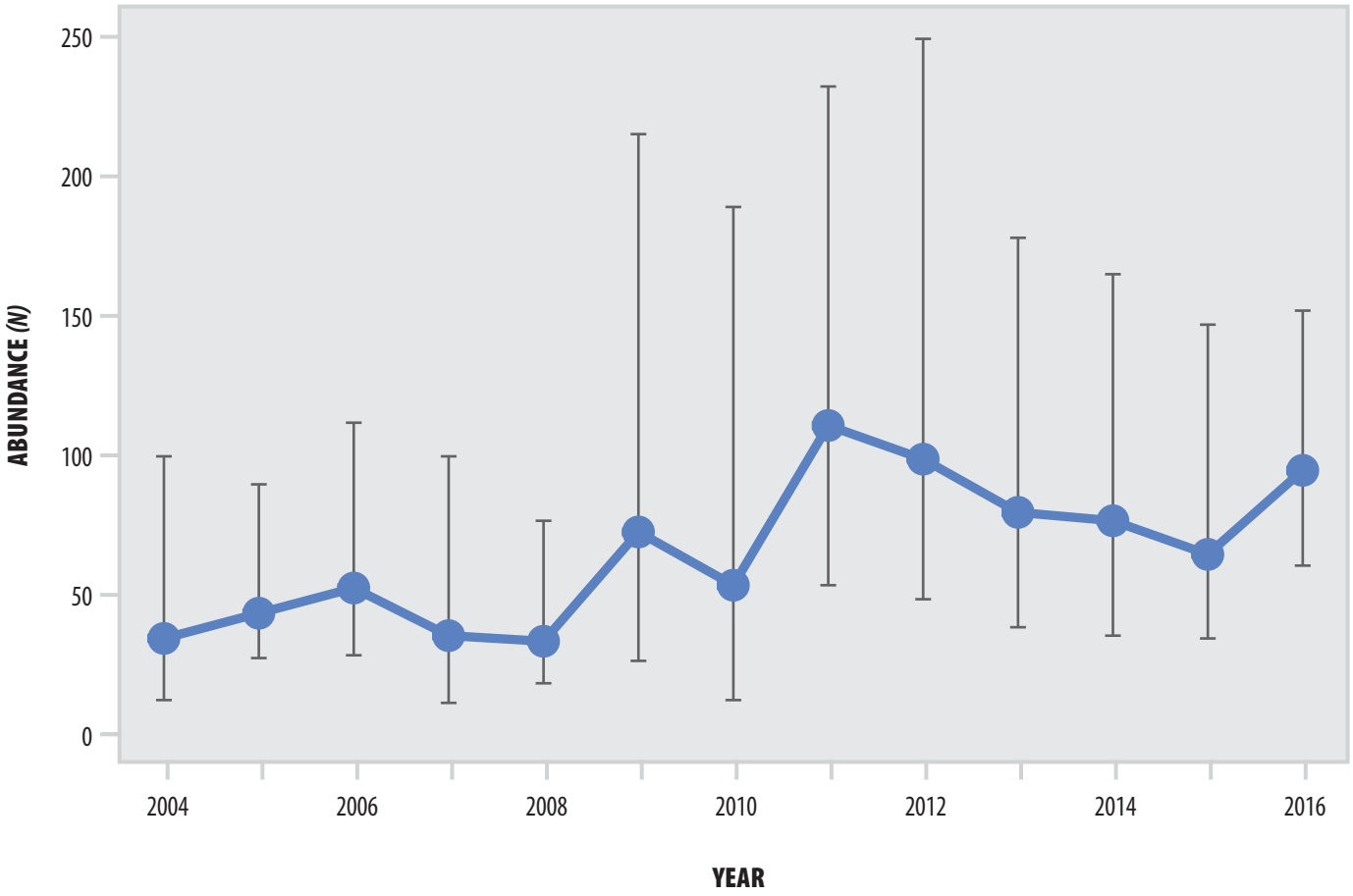


The dotted red horizontal line at 0 indicates no population change. The mean population growth rate from 2004 through 2016 is indicated by the long-dashed line (mode) and short-dashed dashed lines (95% credible interval).

Graphics ... 00890.10 NBC (4-3-17) TG

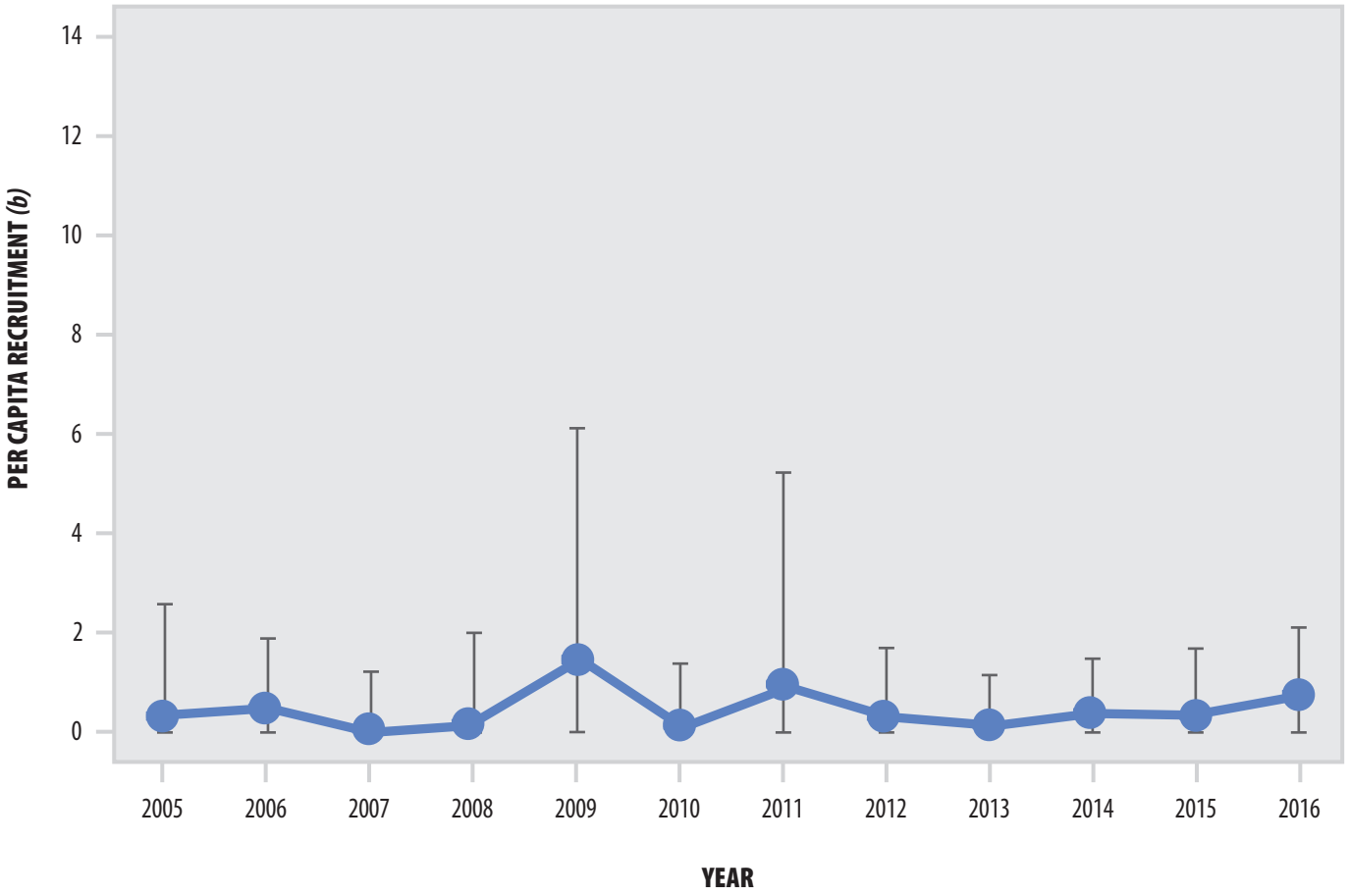
Figure 3-19

Annual Intrinsic Rate of Population Growth for Giant Gartersnake at Lucich North



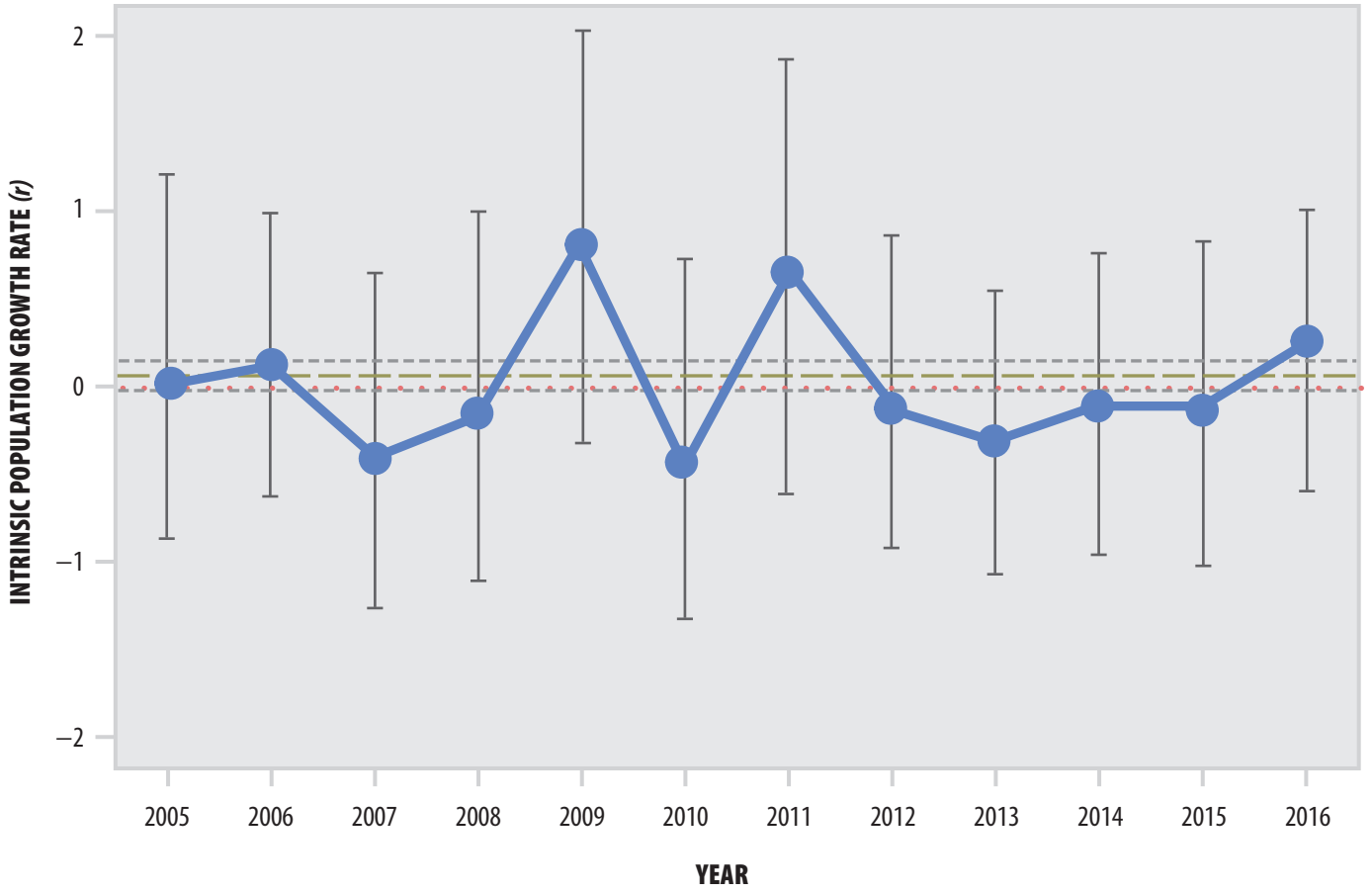
Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-20
Annual Giant Gartersnake Abundance at Lucich South Based on the Jolly-Seber Open Population Model



Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-21
Annual per Capita Recruitment of Giant Gartersnake at Lucich South

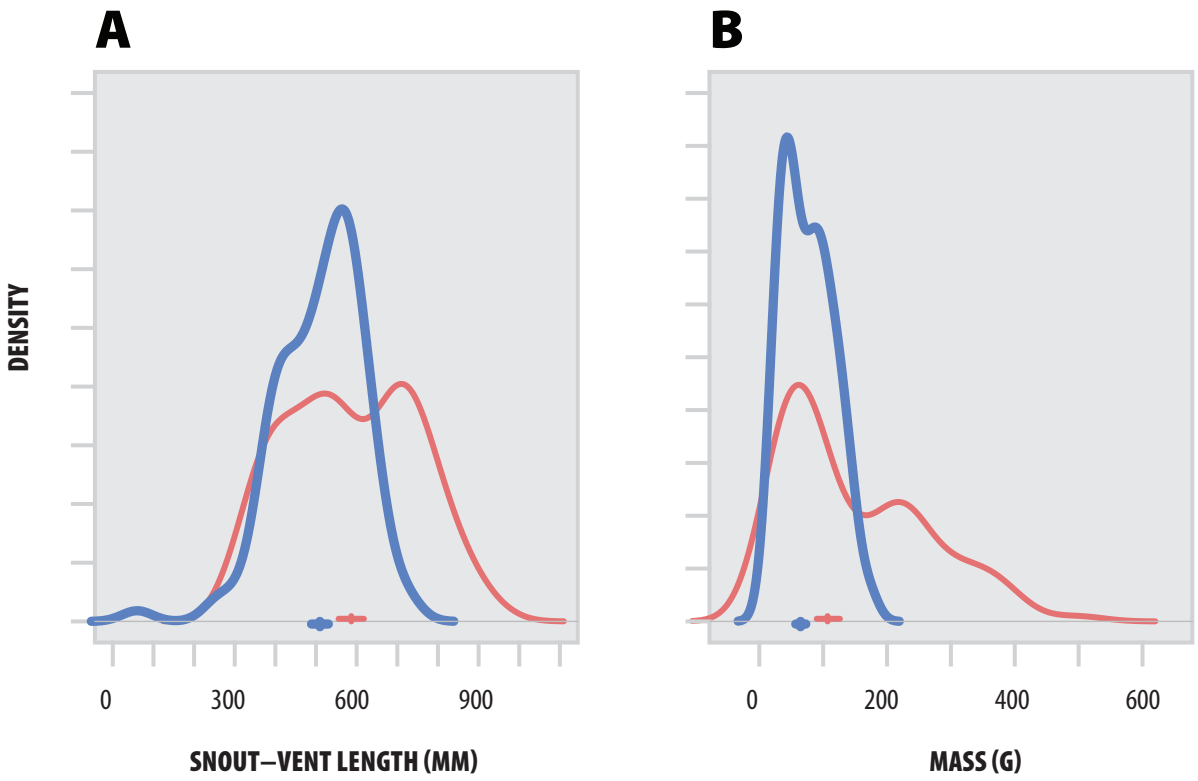


The dotted red horizontal line at 0 indicates no population change. The mean population growth rate from 2004 through 2016 is indicated by the long-dashed line (mode) and short-dashed dashed lines (95% credible interval).

Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-22

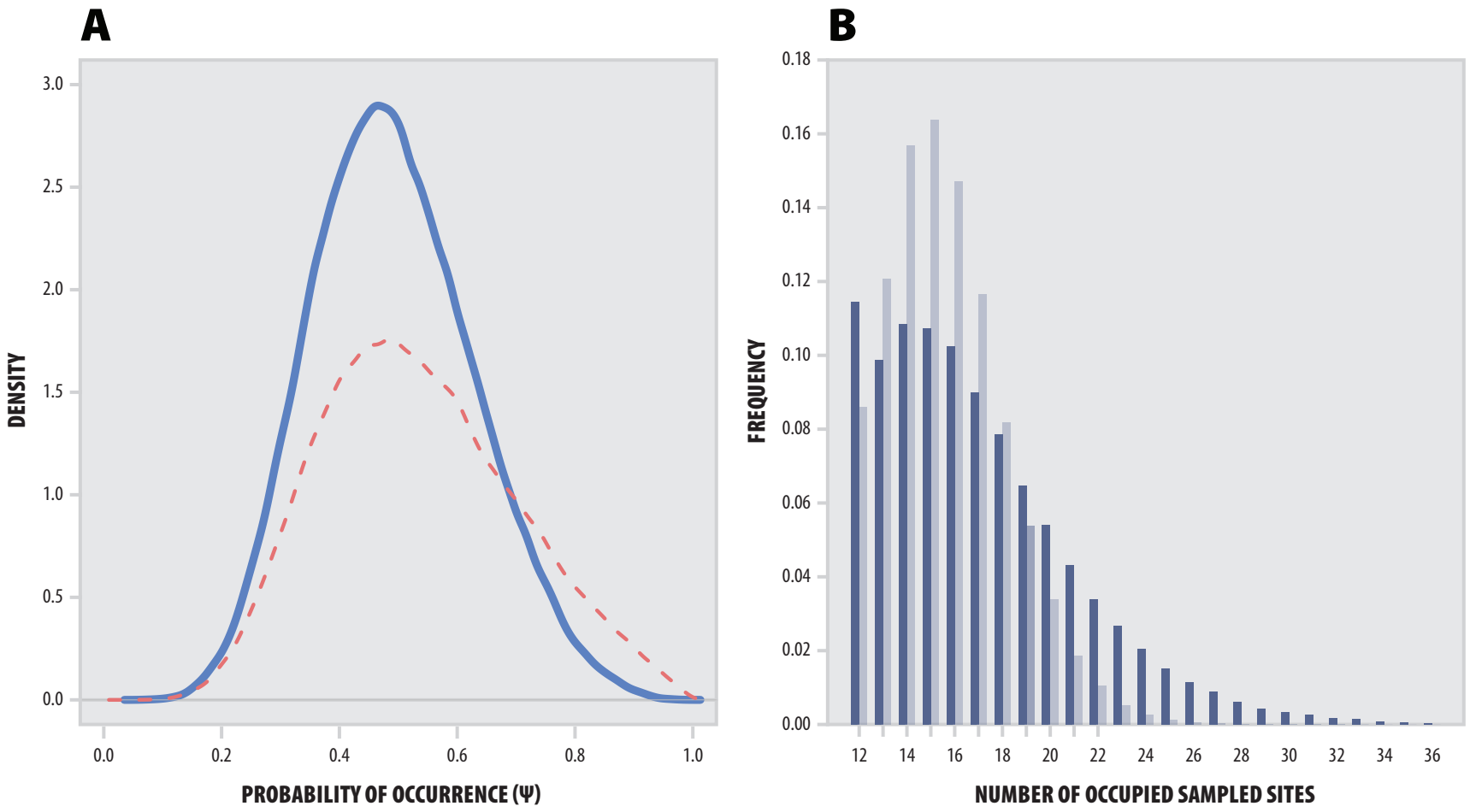
Annual Intrinsic Rate of Population Growth for Giant Gartersnake at Lucich South



Vertical and horizontal lines near the x-axis indicate the median and 95% credible interval of the mean snout-vent length and mass for each sex.

Graphics ... 00890.10 NBC (3-24-17) TG

Figure 3-23
Distribution of Male (Blue) and Female (Red) Snout-Vent Length (A) and Mass (B) in the Natomas Basin, 2016

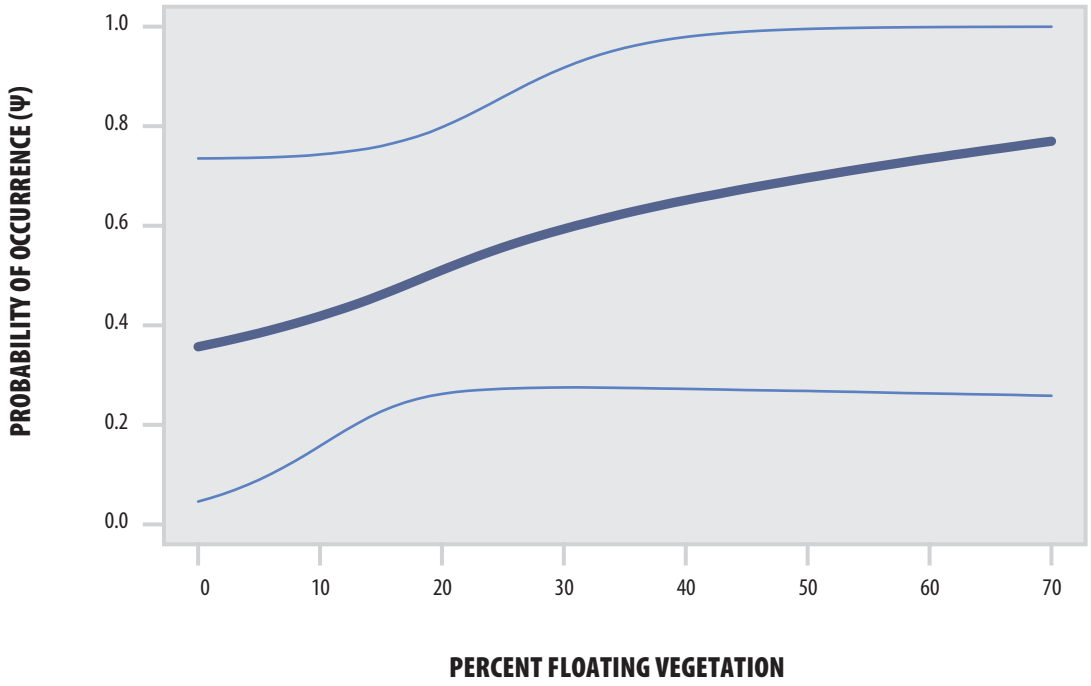


A. Solid blue line is from the model with informative priors and dashed red line is from the model uninformative priors.
B. Light blue bars are from the model with informative priors and dark blue bars are from the model with uninformative priors.

Graphics ... 00890.10 NBC (3-24-17) TG

ICF

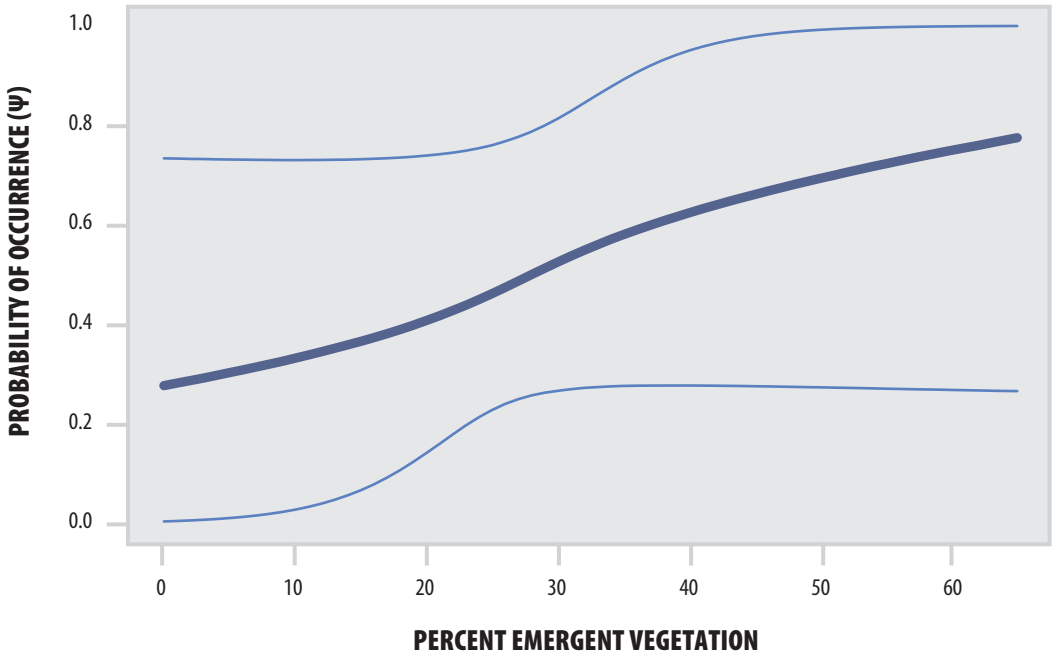
Figure 3-24
Proportion of Reserve Sites Occupied (A) and Number of Occupied Sites (B) Based on Static Occupancy Models for the Natomas Basin, 2016



From the static occupancy model with informative priors. The thick line represents the median predicted occupancy, the thin lines represent 95% credible intervals.

Graphics ... 00890.10 NBC (3-24-17) TG

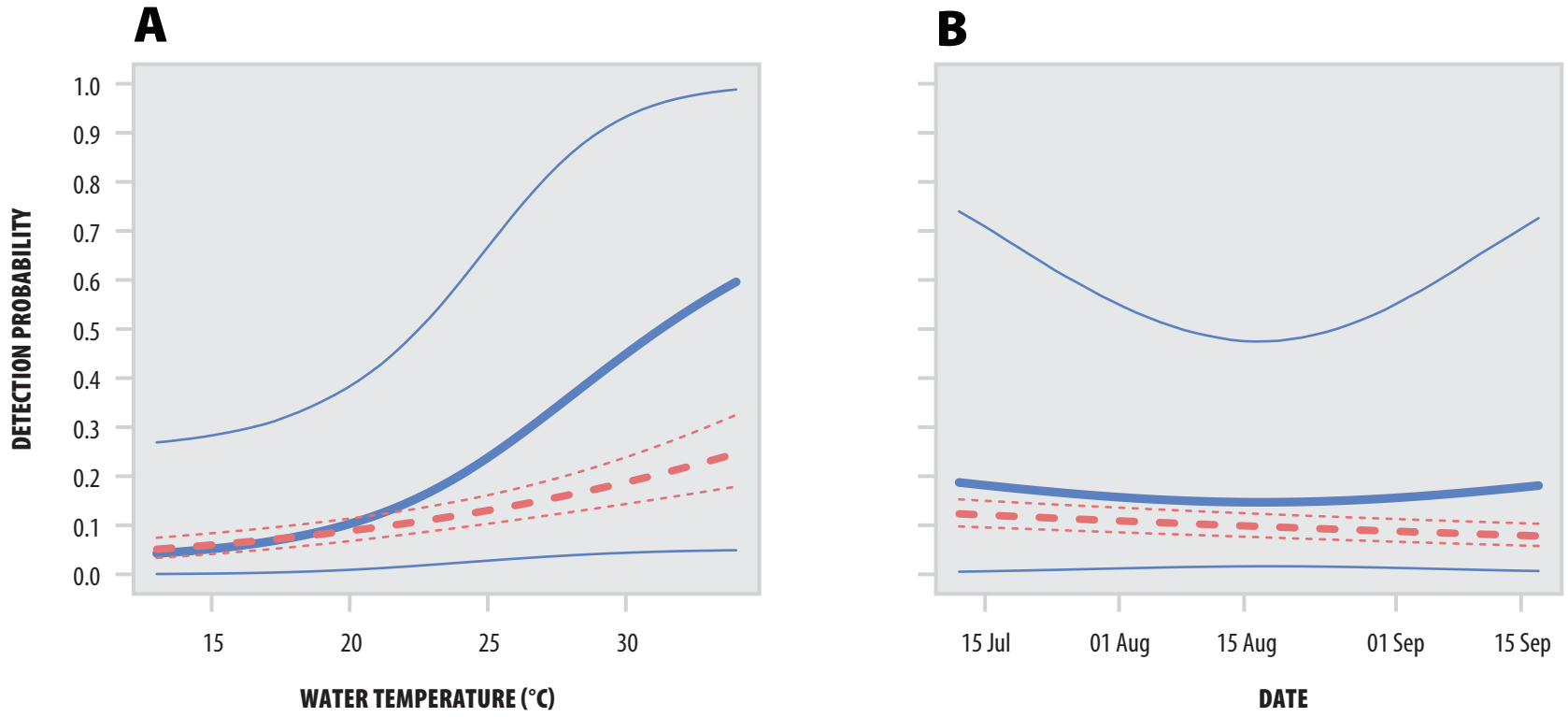
Figure 3-25
Effect of the Percent Cover of Floating Vegetation on the Probability of Occurrence of Giant Gartersnake in the Natomas Basin, 2016



From the static occupancy model with informative priors. The thick line represents the median predicted occupancy, the thin lines represent 95% credible intervals.

Graphics ... 00890.10 NBC (3-24-17) TG

Figure 3-26
Effect of the Percent Cover of Emergent Vegetation on the Probability of Occurrence of Giant Gartersnake in the Natomas Basin, 2016

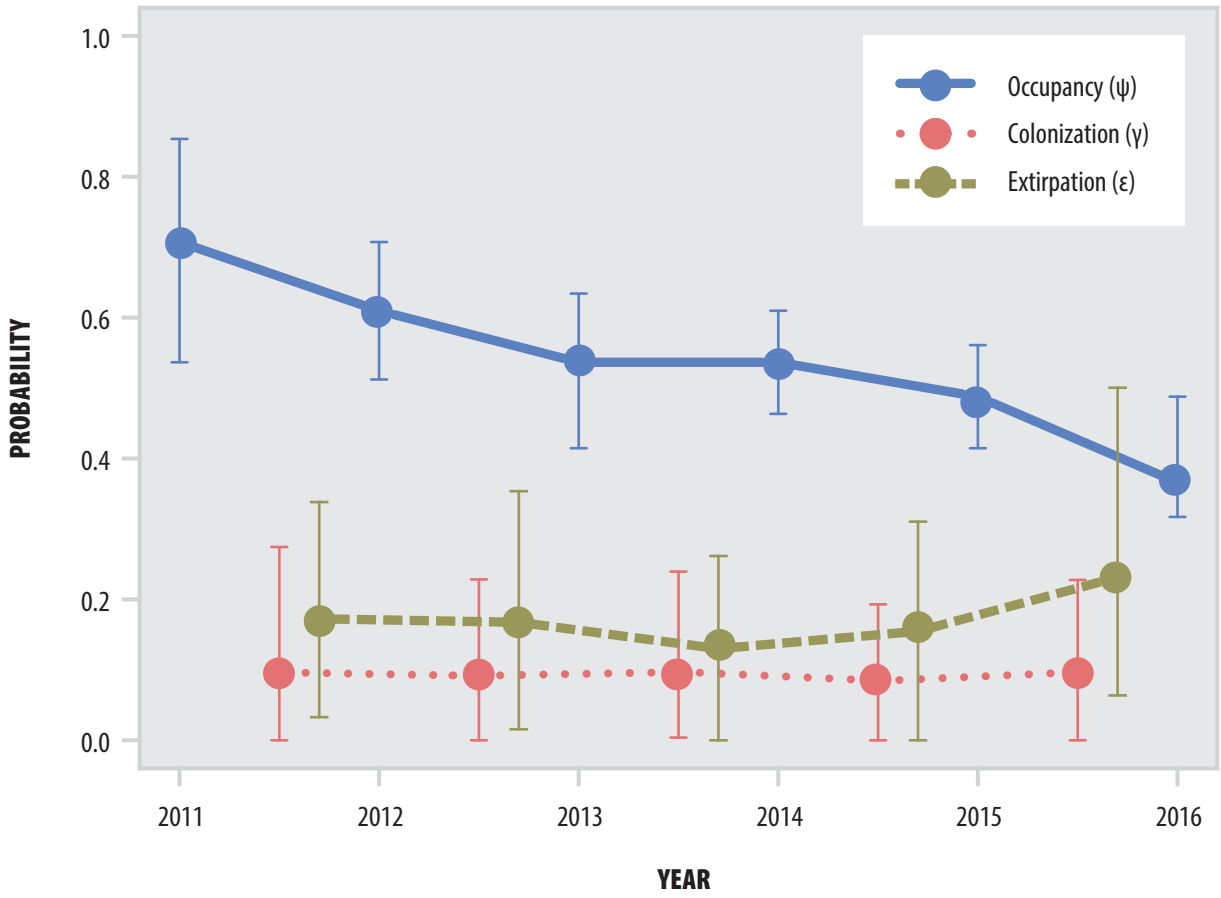


Thick lines represent the median detection probability, the thin lines represent 95% credible intervals.
Solid lines represent the model with uninformative priors, dashed lines represent the model with informative priors.

Graphics ... 00890.10 NBC (3-24-17) TG

ICF

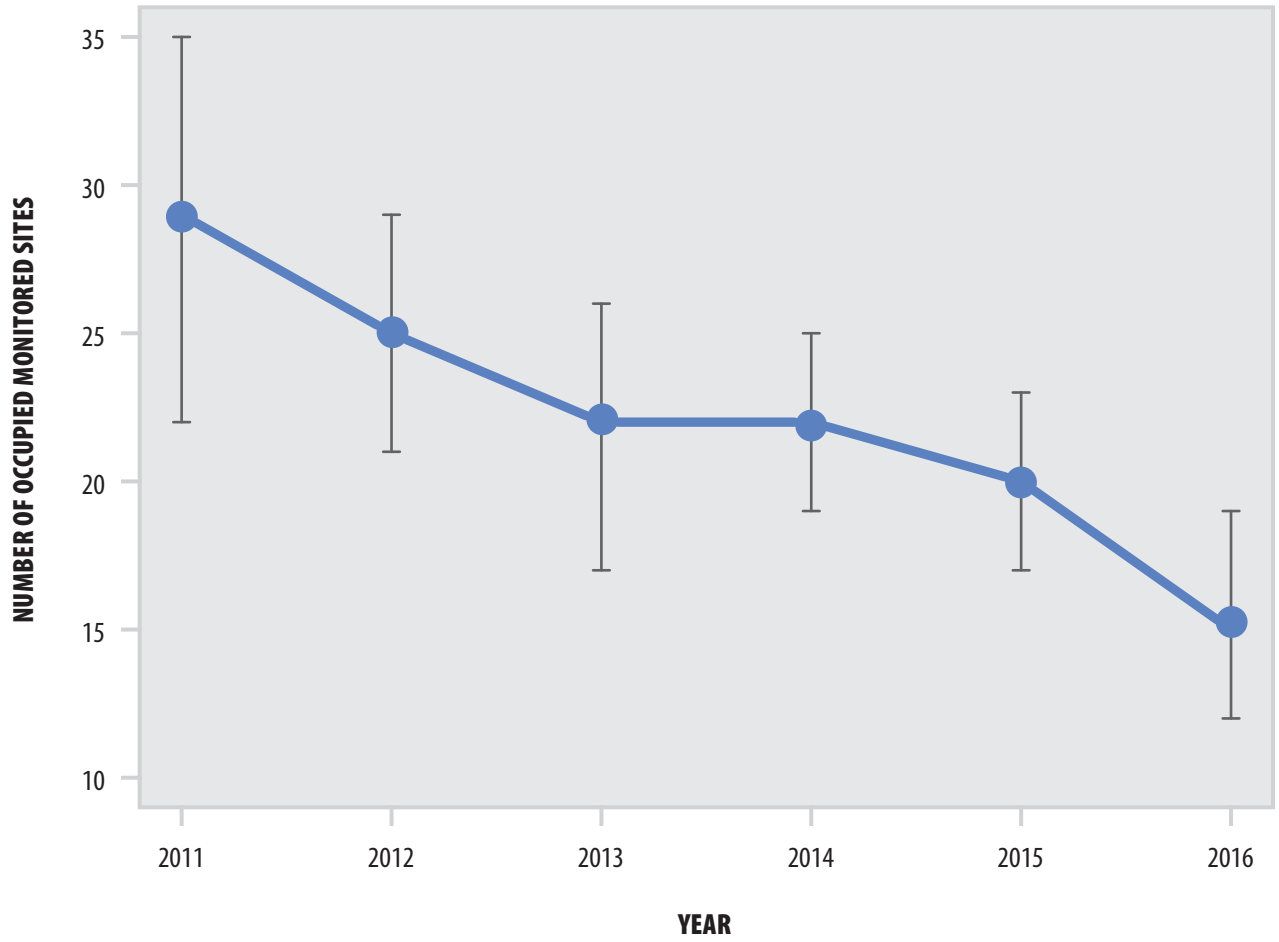
Figure 3-27
Effect of (A) Water Temperature and (B) Date on the Detection Probability of Giant Gartersnake in the Natomas Basin, 2016



Probability of occurrence are the circles and solid line; colonization of unoccupied sites are the circles and dotted line; extirpation of occupied sites are the circles and dashed line. Points represent posterior modes (occurrence) or posterior medians (colonization and extirpation); error bars represent 95% credible intervals.

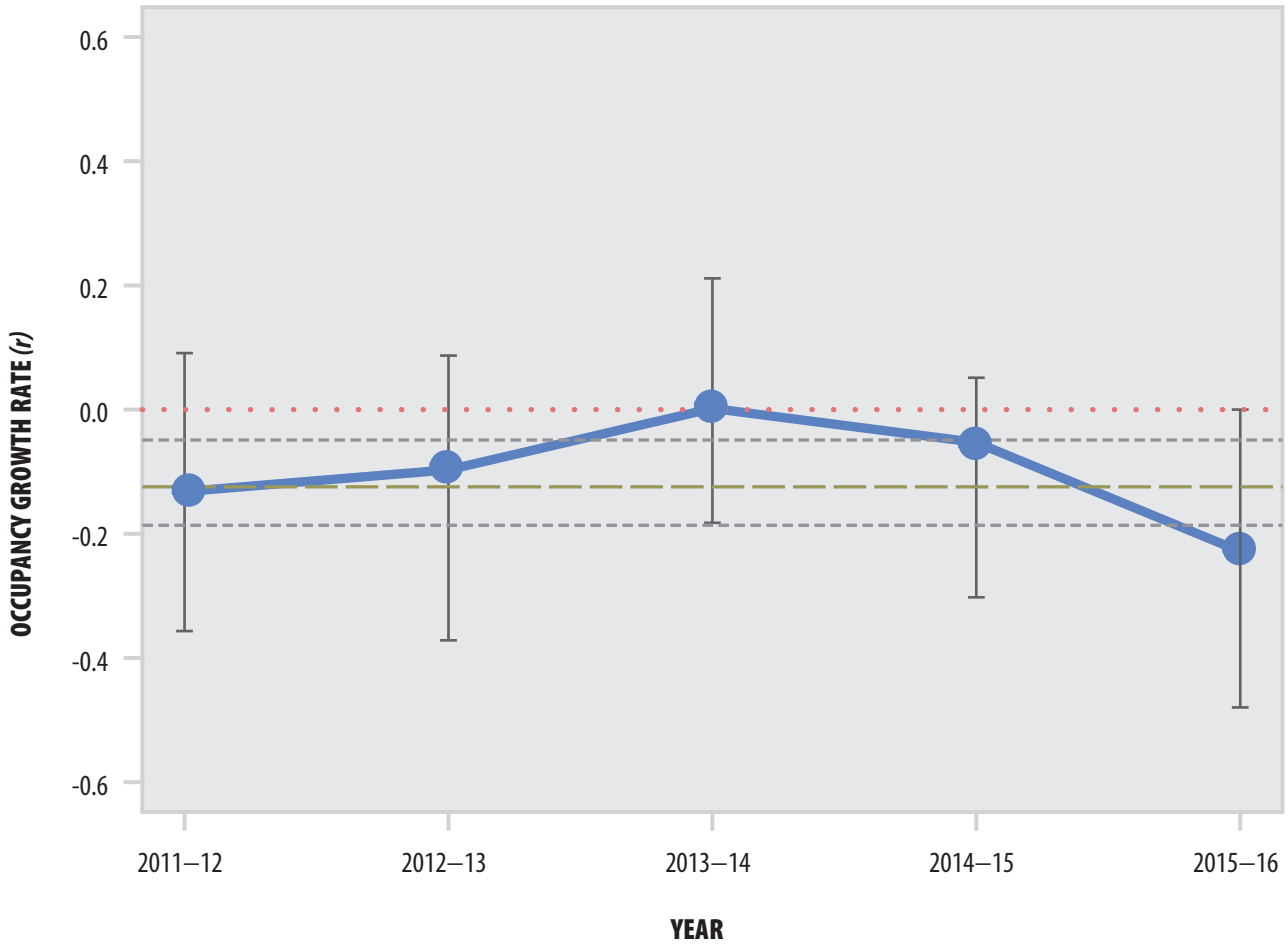
Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-28
Annual Probability of Occurrence of Giant Gartersnake on TNBC Reserves Based on the Dynamic Occupancy Model



Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-29
Estimated Number of Sampled TNBC Reserve Sites (out of 41) Occupied by Giant Gartersnake

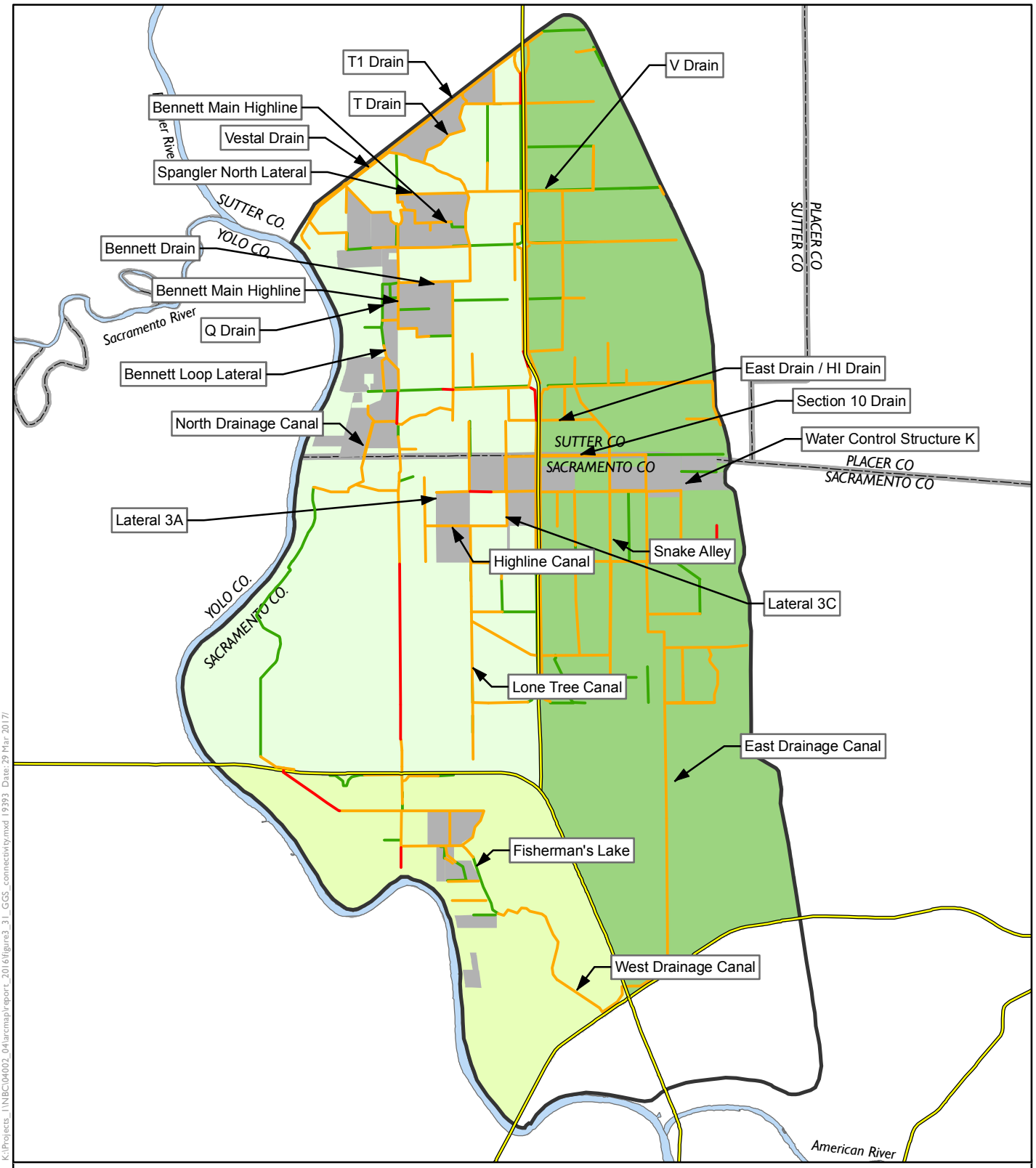


The red dotted line at 0 indicates no change in occupancy. The mean annual occupancy growth rate from 2011–2016 is indicated by the long-dashed line (mode) and short-dashed lines (95% credible interval).

Graphics ... 00890.10 NBC (4-3-17) TG

Figure 3-30

Annual Intrinsic Rate of Occupancy Growth for Giant Gartersnake in Reserves, 2011–2016



K:\Projects_1\NBC\04002_04\arcmap\report_2016\figure3_31_GGS_connectivity.mxd 19393 Date: 29 Mar 2017/

Figure 3-31
Suitability of Habitat in the Canals of the Natomas Basin for Giant Gartersnake in 2016

Chapter 4
Swainson's Hawk

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 to 2016.

It should be noted that the study area for this species differs slightly from the study area used in all other surveys. 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

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 (England et al. 1997; Airola et al. in preparation). 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 has caused a substantial reduction in the breeding range and in the size of the breeding population in California (Bloom 1980; England et al. 1997).

The results of the most recent (2005–2006) statewide survey conducted by DFW and the Swainson's Hawk Technical Advisory Committee indicate the state currently supports an estimated 2,081 (± 158.8) breeding pairs (Anderson et al. 2007), or between 10% and 40% of the historic population (Bloom 1980).

The Central Valley population (an estimated 1,948 ± 149.5 breeding pairs; Anderson et al. 2007) extends from Tehama County south to Tulare and Kings Counties. Yolo, Sacramento, and San Joaquin Counties support the bulk of this Central Valley population (Estep 1989; Anderson et al. 2007) (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.

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 occasionally 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; England et al. 1997). 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 (Estep unpublished data), and banding studies conducted since 1986 confirm a high degree of nest site and mate fidelity (Estep in preparation).

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; Anderson et al. in preparation [a]). 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 and orchards) are rarely used (Estep 1989; Babcock 1995). 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.

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 (England et al. 1997). Studies conducted in the Sacramento Valley indicate that one or two—and occasionally three—young typically fledge from successful nests (Estep in preparation, Estep 2007) (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 et al. in preparation [b]). 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 the rest of the species, which migrates to southern Argentina for the winter, the Central Valley population winters from Central Mexico to central South America (Airola et al. in preparation).

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, the surveys were conducted on foot. All potential nesting trees were searched for nests and adult Swainson's hawks using binoculars and/or a spotting scope.

Surveys were conducted in three phases. Phase 1 surveys were conducted early in the breeding season (late March to mid-April) to detect Swainson's hawk activity at previously known nest sites as well as in all other suitable nesting habitats, and 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 determine whether potentially breeding pairs detected during Phase 1 surveys were nesting, and to resurvey all previously unoccupied potential nesting habitat for active nests that may have been missed during Phase 1 surveys and for late-nesting pairs. Phase 3 surveys were conducted in July to determine nest success and record the number of young fledged per nest.

An *occupied territory* is defined as a nest site that was occupied by a pair of Swainson's hawks, regardless of the reproductive outcome. A *successful nest* is defined as a nest in which young were fledged. A *failed nest* is defined as a nest in which egg were laid but from which no young were fledged. Incidental observations, such as foraging, roosting, and other sightings of adult Swainson's hawks, were also noted.

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, Floristic 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 in 2016. The nest sites are predominately 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 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 134 current and historical Swainson's hawk nesting territories were monitored in 2016 (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 2016 are depicted in 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 = 0.425, P = 0.005, Figure 4-7). Fifty-six territories were occupied in 2016, which is five less than in 2015, but above the average of 53.6 occupied territories over the 16-year monitoring period.

All measures of reproductive success decreased slightly in 2016, but remained at or above the average value from 1999 through 2016. Decreases were very modest, especially in comparison to the unprecedented drops in reproductive success in 2011 and 2013 (Table 4-2, Figures 4-6 and 4-8). In 2016, the number of successful nests and total number of young fledged were the third and fifth highest values, respectively, that have been recorded since monitoring began in 1999. Beginning in 2010, there has been a noticeable increase in the variance of most metrics of reproductive success, although the change in values from 2015 to 2016 were more typical of the pre-2010 period (Figure 4-8). With the inclusion of results from 2016, the variance in the number of young fledged per occupied territory and per active nest were moderately significantly higher from 2011 through 2016 than from 1999 through 2010 ($F_{9,5}$ = 0.353, P = 0.08, $F_{9,5}$ = 0.278, P = 0.05, respectively), while there was no significant difference in variance in the number of young fledged per successful nest between the two time periods ($F_{9,5}$ = 1.00, P = 0.47).

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 = 0.273, P = 0.045, Figure 4-9). The cause(s) and relevance of this decline in reproductive performance are unknown.

In 2016, there were 26 active nesting territories along the Sacramento River, a decrease of 3 from 2015 (Table 4-3, Figure 4-10). Although the total number of nesting pairs along the Sacramento River fluctuates substantially from year to year, there is no discernible trend over time; the mean number of pairs is approximately 28. 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. Of note is that since 2007, the variation in the total number of active territories along the river has been driven primarily by changes in the number of pairs on the east side (Figure 4-10), while the number of active territories along the west side have been relatively stable over the same period. An increase in disturbances from new home construction and tree trimming/removal was noted in 2016, which may explain what appears to be a shift in nesting pairs from the east side to the west side of the river over the last 2 years.

Swainson's hawks often use alternate nest sites within the breeding territory. Of the 50 pairs that nested in 2016, 5 pairs selected alternate nest trees that had no previously documented use. All the alternate nest trees were in the immediate vicinity of previously used nest trees. Many pairs used alternate nest sites that have been documented to be used in previous years.

No Swainson's hawk nest trees were removed in 2016; however, two nest trees (NB-113 and NB-133) were trimmed during the winter of 2015–16, making them unsuitable for nesting. Neither of these territories were active in 2016. Although many potential nest trees were removed during levee construction activities associated with the SAFCA NLIP, restoration actions have successfully established new replacement trees near the toe of the new levee. These trees are expected to provide new potential nesting habitat when they reach maturity. A total of eight Swainson's hawk nest trees have been removed since implementation of the NBHCP, seven of which resulted in the apparent abandonment of the nesting territory (Table 4-1).

Competition with other nesting raptors also influences the distribution and abundance of nesting Swainson's hawks. In 2016, nine previously documented Swainson's hawk territories were occupied by nesting red-tailed hawks.

Sources of 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. Airplane collisions have been documented but are difficult to quantify. However, in 2014, SMF reported four adult Swainson's hawk fatalities resulting from airplane collisions, including the banded (i.e., identifiable) adult female from territory NB-107, immediately west of the airport perimeter fence.

4.3.2 Habitat Assessment

Table 4-4 lists the total acreages in the Basin from 2004 to 2016 of three general habitat categories (upland agriculture, fallow lands, and grasslands) that provide suitable Swainson's hawk foraging habitat. Changes in these habitats over time are depicted in Figure 4-11. The total amount of suitable foraging habitat in the Basin increased by over 40% in 2006, when approximately 32% of the active rice fields in the Basin were fallowed. In 2006, fallowed fields comprised 42% of the total suitable

foraging habitat in the Basin. Beginning in 2009, increases in upland agriculture offset losses of suitable foraging habitat caused by the resumption of rice production on fields fallowed in 2006. The result has been a slow but steady decline in suitable foraging habitat, although the total amount still exceeds the amount of habitat present in the Basin prior to the fallowing of rice fields. The amount of foraging habitat comprised of upland agriculture has varied substantially since 2004, but the value in 2016 is still above the average of 10,719 acres for the previous 12 years and has slightly increased since 2015. The areal distribution of suitable Swainson's hawk foraging habitat is shown in Figure 4-12.

There is no correlation between the total acreage of suitable forging habitat in the Basin each year and the number of occupied territories (R^2 = 0.060, P = 0.453). However, there is a positive correlation between the total number of occupied territories and the total acreage of upland agricultural crops (R^2 = 0.713, P < 0.001) and total acreage of alfalfa each year (R^2 = 0.361, P = 0.037). Conversely, the total number of occupied territories is negatively correlated with the total acreage of fallow lands (R^2 = 0.367, P = 0.035). 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 2016. 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 comprise 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 in 2016, the proportion of suitable foraging habitat in alfalfa remains substantially higher on reserve than non-reserve lands (Table 4-5). Despite the establishment of a substantial number of acres of grasslands on non-reserve lands by the SAFCA NLIP, the proportion of grasslands is higher on reserve lands than non-reserve lands. The overall proportion of suitable foraging habitat basin-wide remained unchanged since 2015 (32.4% in 2015 versus 32.8% in 2016), and the proportion of suitable foraging habitat on reserves increased slightly from 24.0% in 2015 to 26.4% in 2016.

The reserve system currently accounts for approximately 6.0% 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

The 2016 results indicate continuing stability in the breeding population of Swainson's hawks in the Natomas Basin, and a return to stability in reproductive metrics over the last three breeding seasons from the record lows reported in 2013. Results from 2014 indicated the population recovered quickly from the record lows in 2013, and results from 2015 and 2016 support this determination.

Although the decline in the number of occupied nesting territories from 2012 to 2013 was well within the range of variation documented over the monitoring period, every measure of reproductive performance of the Natomas Basin breeding population plummeted at that time to the lowest values recorded since monitoring began. While anecdotally attributed to a reduction in food resources on the breeding or wintering grounds (or both), evidence in support of these hypotheses is lacking. Although hypotheses regarding the reasons for the recovery over the last 2 years are similarly unsupported, anecdotal evidence from several sources in the Central Valley indicates that California vole (*Microtus californicus*) populations also recovered, which may have contributed to an increase in food resources and a corresponding rise in Swainson's hawk reproductive success.

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 which coincided with a decline in the principal prey species Richardson's ground squirrel (*Urocitellus richardsonii*) (Houston and Schmutz 1995). Although annual variation in clutch or brood size is common among some raptor species, like the 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, 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 Swainon's hawk food resources. Other possible, but less likely factors include increasing predation and disease.

The generally increasing trend in the number of occupied Swainson's hawk nesting territories is positively correlated with the total acreage of alfalfa and upland agricultural crops in the Basin; however, there is no corresponding relationship with the total acreages of grassland habitats or suitable foraging habitat. These findings may indicate that fallow habitats and/or grassland habitats are less important to Swainson's hawk than upland agricultural habitats. Alternatively, the trend may reflect the foraging behavior of Swainson's hawks and the extensive use of out-of-Basin habitats by individuals nesting within the Basin.

The 2016 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. After several years of planned and proposed urbanization being on hold due to the building moratorium and levee-related restrictions from the U.S. Army Corps of Engineers (USACE), the moratorium has recently been lifted and development plans are now allowed to continue. As a result, suitable nesting and foraging habitat is expected to decline more rapidly within the Basin 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. As in previous years, several new home construction projects removed trees along the Sacramento River in 2016; these projects,

along with tree and brush clearing for vegetation management purposes 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, the Sacramento County Airport System (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 hawk as nest sites. No active nest trees were removed by SCAS in 2016. SCAS also implements a 2007 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. Airplane collisions at SMF are also sources of mortality that could potentially affect the Natomas Basin 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 nesting population.

Impacts on the Swainson's hawk population resulting from implementation of the SAFCA NLIP have occurred, but 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 the SAFCA—have been completed; however, additional work is planned. 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—such as the continuation of the SAFCA NLIP south of Powerline Road, bird control actions by SCAS, airplane-related collision mortality, continued disturbance and habitat removal along the east side of the Sacramento River, possible unforeseen future urbanization of county lands, or possibly factors affecting hawks outside the breeding season (i.e., on wintering habitats)—continue.

Swainson's hawk habitat goals continue to be met through establishment and management of suitable upland habitat on reserve lands. Site-specific management activities have been undertaken for purposes of maximizing habitat potential for Swainson's hawk. For example, tracts producing upland crops have long-term crop/fallow programs to maximize production of rodent prey (see the Site-Specific Management Plans for details).

As discussed in Section 4.4, 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.

4.6 Recommendations

- Although TNBC has not been in a position to acquire new reserve lands for several years due to the building moratorium and is currently ahead of NBHCP requirements for acquiring lands within 1 mile of the Sacramento River, it should continue to strategize future acquisition efforts with the goal of sustaining the existing Swainson's hawk population. Acquisition efforts for Swainson's hawk habitat 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.
- 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 comprised 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 which currently appear to provide this refugia, this recommendation may be dropped in the future if these habitats continue to function adequately.

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Table 4-1. Results of 2016 Swainson's Hawk Surveys, NBHCP Area

Territory Number	Status[a]	Number of Young	Nesting Habitat	Nest Tree Species[b]
NB-1	A-S	1	Urban	Eucalyptus
NB-2	A-S	2	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	A-X		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-S	1	Riparian	Willow
NB-13	A-S	1	Riparian	Cottonwood
NB-14	I		Tree row - ornamental	Eucalyptus
NB-15	NLE		Isolated tree - removed in 2002	Valley oak
NB-16	A-S	1	Oak grove	Valley oak
NB-17	NLE		Isolated tree - removed in 1998	Valley oak
NB-18	I		Isolated tree	Cottonwood
NB-19	A-X		Tree along irrigation canal	Valley Oak
NB-20	NLE		Isolated tree - removed in 2002	Cottonwood
NB-21	I		Riparian	Cottonwood
NB-22	I		Isolated tree	Willow
NB-23	A-S	2	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	A-S	2	Riparian	Cottonwood
NB-28	I		Riparian	Cottonwood
NB-29	A-S	1	Riparian	Willow
NB-30	A-S	2	Riparian	Cottonwood
NB-31	I		Riparian	Valley Oak
NB-32	I		Riparian	Cottonwood
NB-33	I		Riparian	Cottonwood
NB-34	I		Riparian	Cottonwood
NB-35	A-S	2	Riparian	Cottonwood
NB-36	I		Riparian	Cottonwood
NB-37	I		Riparian	Cottonwood
NB-38	A-S	1	Riparian	Cottonwood
NB-39	A-S	2	Riparian	Cottonwood
NB-40	I		Riparian	Cottonwood
NB-41	I		Riparian	Willow
NB-42	I		Riparian	Cottonwood
NB-43	A-S	1	Riparian	Cottonwood
NB-44	A-S	2	Riparian	Cottonwood
NB-45	I		Riparian	Cottonwood
NB-46	A-S	1	Riparian	Cottonwood
NB-47	A-S	2	Riparian	Cottonwood

Table 4-1. Continued

Territory Number	Status[a]	Number of Young	Nesting Habitat	Nest Tree Species[b]
NB-48	I		Riparian	Cottonwood
NB-49	I		Riparian	Cottonwood
NB-50	I		Riparian	Sycamore
NB-51	A-S	1	Riparian	Cottonwood
NB-52	A-S	1	Riparian	Cottonwood
NB-53	I		Riparian	Cottonwood
NB-54	I		Riparian	Cottonwood
NB-55	A-S	2	Riparian	Cottonwood
NB-56	I		Riparian	Cottonwood
NB-57	A-U		Riparian	Valley oak
NB-58	I		Riparian	Cottonwood
NB-59	I		Riparian	Cottonwood
NB-60	A-S	1	Riparian	Cottonwood
NB-61	I		Riparian	Cottonwood
NB-62	I		Riparian	Cottonwood
NB-63	A-F	0	Isolated tree	Willow
NB-64	A-S	1	Riparian	Cottonwood
NB-65	A-S	2	Cottonwood grove	Cottonwood
NB-66	I		Riparian	Cottonwood
NB-67	I		Riparian	Cottonwood
NB-68	A-S	1	Riparian	Cottonwood
NB-69	I		Urban ornamental	Willow
NB-70	I		Riparian	Valley oak
NB-71	A-S	2	Riparian	Willow
NB-72	I		Riparian	Cottonwood
NB-73	I		Tree row	Ornamental conifer
NB-74	A-S	2	Roadside tree	Willow
NB-75	I		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
NB-83	A-S	1	Riparian	Willow
NB-84	A-S	2	Riparian	Cottonwood
NB-85	A-S	1	Riparian	Cottonwood
NB-86	A-U		Riparian	Cottonwood
NB-87	A-S	1	Riparian	Cottonwood
NB-88	I		Riparian	Cottonwood
NB-89	I		Riparian	Valley Oak
NB-90	I		Riparian	Willow
NB-91	I		Riparian	Cottonwood
NB-92	I		Riparian	Cottonwood
NB-93	I		Riparian	Cottonwood

Table 4-1. Continued

Territory Number	Status[a]	Number of Young	Nesting Habitat	Nest Tree Species[b]
NB-94	I		Riparian	Cottonwood
NB-95	I		Riparian	Valley Oak
NB-96	I		Riparian	Valley Oak
NB-97	A-S	1	Tree row	Eucalyptus
NB-98	I		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-F	0	Riparian	Cottonwood
NB-105	A-U		Riparian	Cottonwood
NB-106	A-S	2	Roadside	Willow
NB-107	A-X		Riparian	Cottonwood
NB-108	A-X		Ornamental (freeway rest stop)	Cottonwood
NB-109	I		Tree row	Valley Oak
NB-110	I		Riparian	Cottonwood
NB-111	A-F	0	Tree Row	Cottonwood
NB-112	A-S	2	Riparian	Valley Oak
NB-113	I		Riparian	Valley Oak
NB-114	A-S	1	Channelized riparian/tree row	Valley Oak
NB-115	A-S	2	Riparian	Valley Oak
NB-116	A-X		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	Cottonwood
NB-122	I		Tree row	Valley Oak
NB-123	A-S	2	Isolated tree	Valley Oak
NB-124	A-S	2	Riparian	Cottonwood
NB-125	A-S	1	Riparian	Valley Oak
NB-126	I		Riparian	Cottonwood
NB-127	A-S	1	Riparian	Cottonwood
NB-128	I		Riparian	Willow
NB-129	I		Roadside tree row	Willow
NB-130	I		Isolated tree	Locust
NB-131	I		Riparian	Cottonwood
NB-132	A-S	2	Cottonwood grove	Cottonwood
NB-133	A-X		Isolated roadside tree	Willow
NB-134	A-S	2	Channelized riparian/tree row	Valley oak

[a] A = active; I = inactive; NLE = no longer extant; S = successful; F = failed; X = did not nest; U = undetermined.

[b] For territories designated as I or X, tree species shown reflects last active nest tree.

Table 4-2. Reproductive Data for Active Swainson's Hawk Territories in the NBHCP Area, 1999–2016

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

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

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

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

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

Table 4-3. Number of Active Territories on the Sacramento River, 2001–2016

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

Table 4-4. Swainson's Hawk Foraging Habitat in the NBHCP Area (acres), 2004–2016

Habitat Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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	11,889
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
Grasslands[a]	7,847	7,766	7,263	5,669	5,461	5,794	4,853	4,608	4,491	4,832	4,961	4,344	4,157
Total	**16,921**	**16,957**	**23,826**	**23,621**	**23,830**	**23,355**	**21,628**	**22,031**	**20,792**	**19,088**	**18,166**	**18,007**	**17,758**

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

Table 4-5. Extent and Proportion of Suitable Swainson's Hawk Foraging Habitat on and off TNBC Reserve Lands, 2016

	Alfalfa	Row, Grain, and Other Hay Crops[a]	Grasslands[b]	Fallow	Total
On-reserve acreage (acres)	348	213	312	214	1,087
On-reserve percentage of cover type (%)	32.0	19.6	28.7	19.7	100
Off-reserve acreage (acres)	1,038	10,290	3,845	1,498	16,672
Off-reserve percentage of cover type (%)	6.2	61.7	23.1	9.0	100
Total	**1,386**	**10,503**	**4,157**	**1,712**	**17,758**

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

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Figure 4-1
Adult Swainson's Hawk

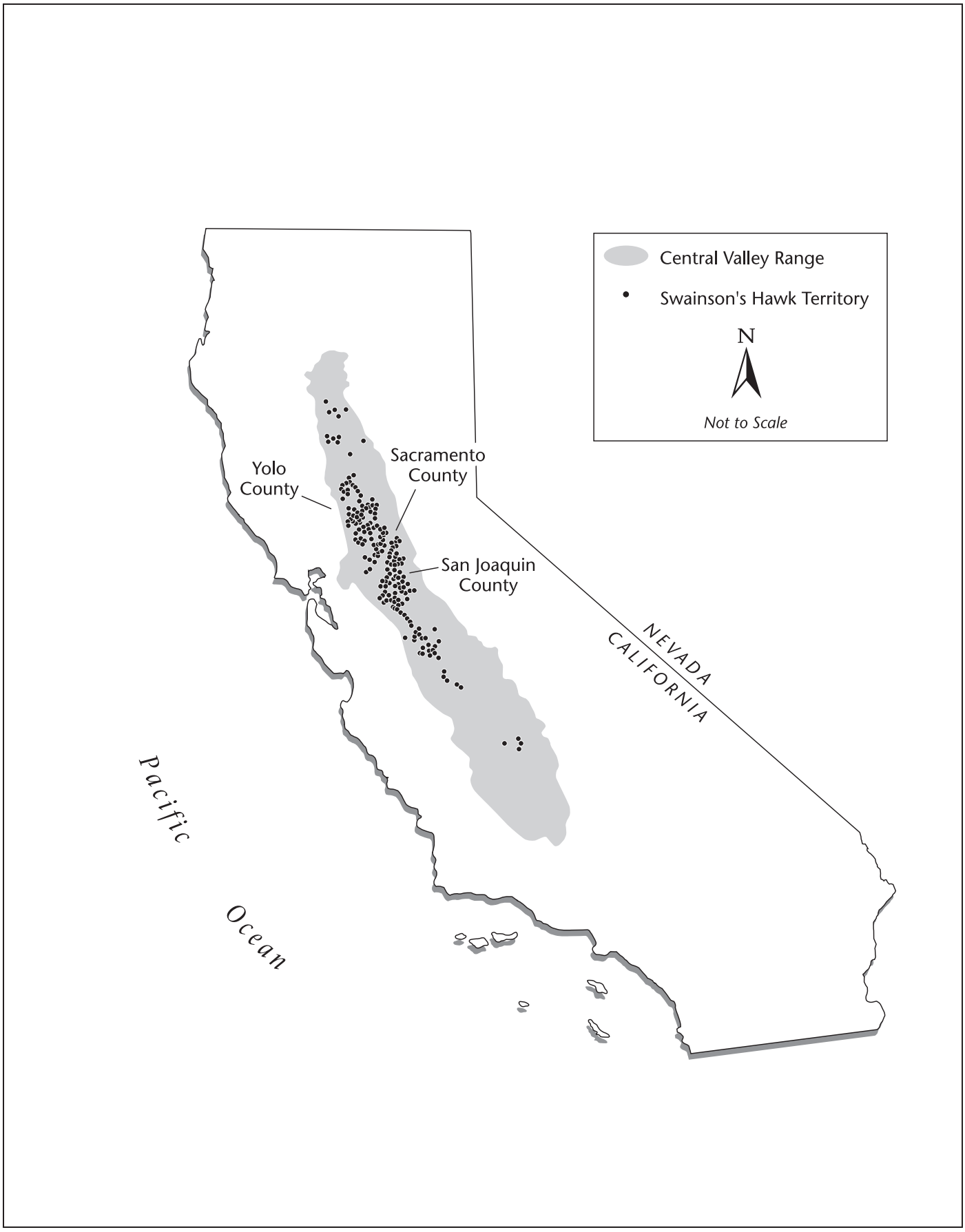

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Figure 4-2
Distribution of Swainson's Hawk in the Central Valley

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

Typical Swainson's hawk nest

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Figure 4-3
Swainson's Hawk Nesting Habitat

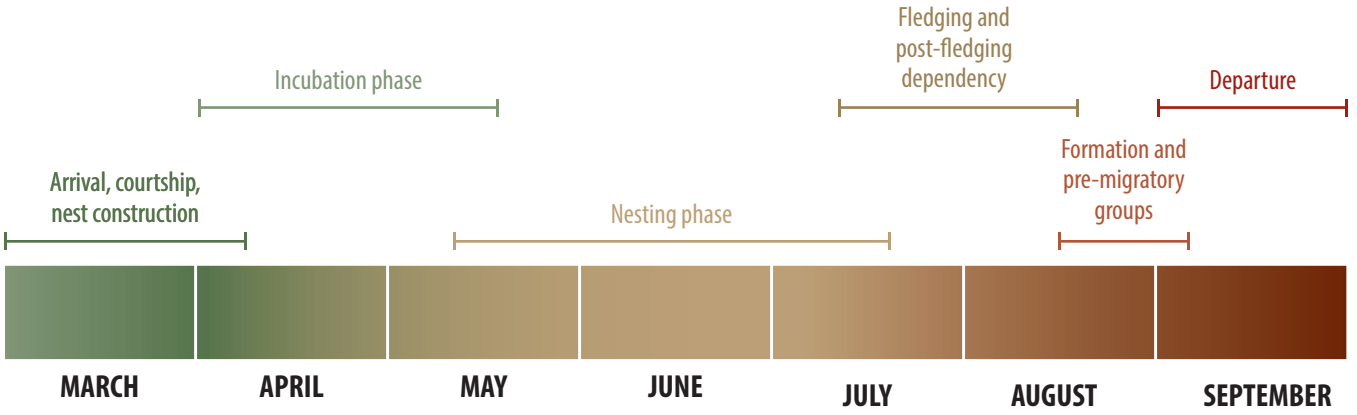

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Figure 4-4
General Representation of Swainson's Hawk Breeding Cycle in the Central Valley

Swainson's hawk nest with eggs

Nestling Swainson's hawks

Nearly fledged Swainson's hawks

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Figure 4-5
Swainson's Hawks in the Nest

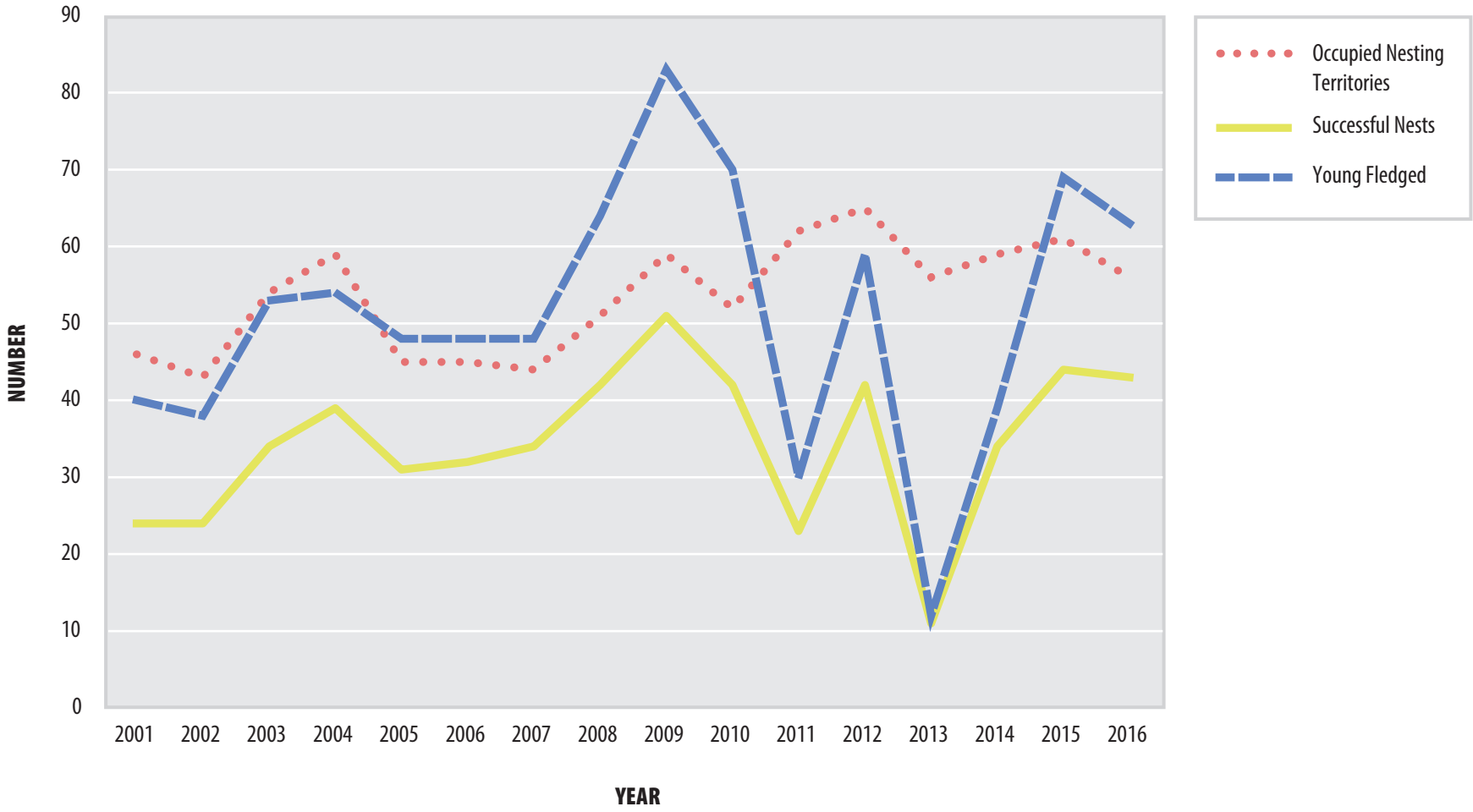

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Figure 4-6
Number of Occupied Swainson's Hawk Nesting Territories, Successful Nests, and Total Young Fledged in the Natomas Basin, 2001–2016

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Figure 4-7
Trends in the Number of Occupied Territories in the Natomas Basin Nesting Population, 2001–2016

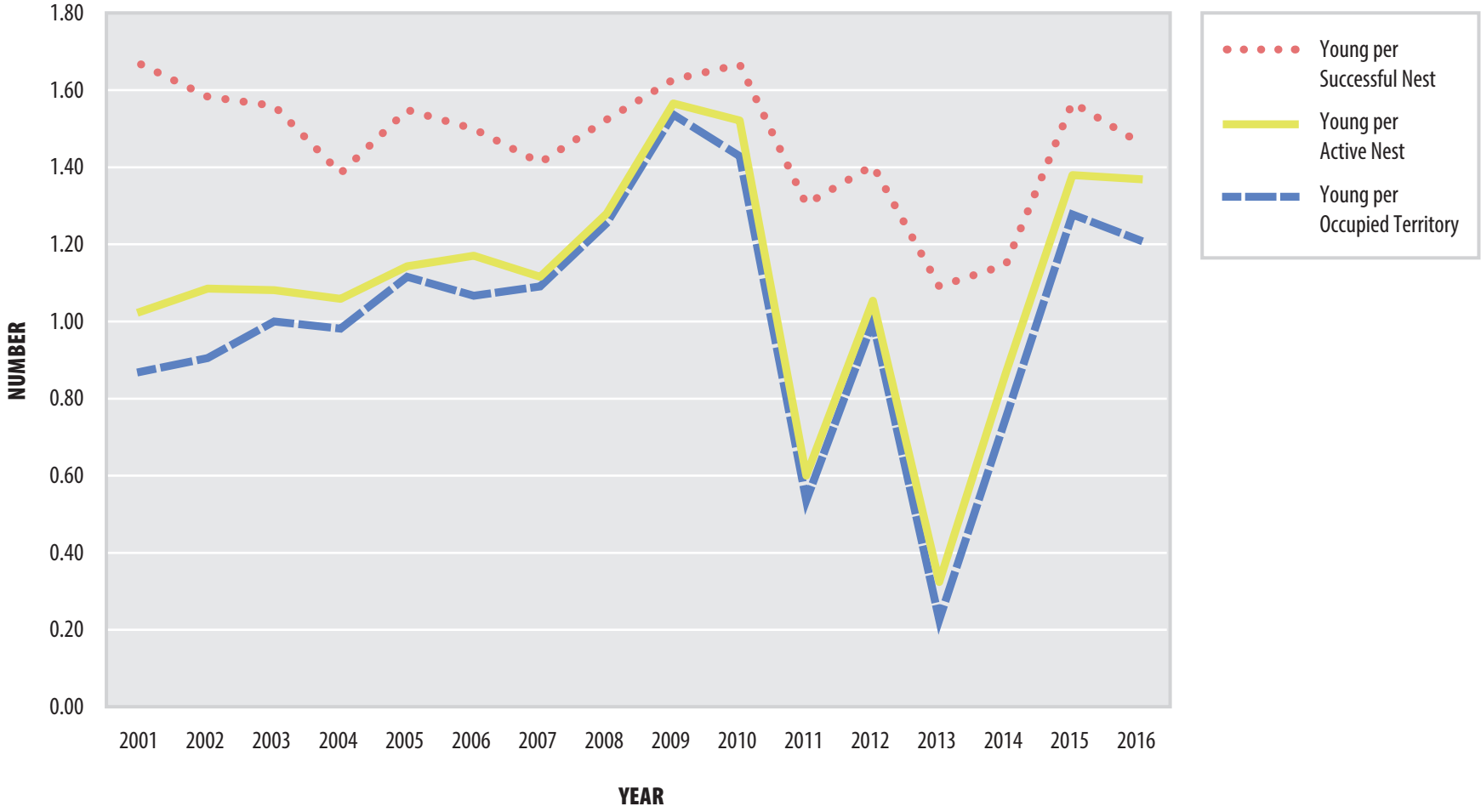

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Figure 4-8
Various Measures of Swainson's Hawk Reproductive Success in the Natomas Basin, 2001–2016

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Figure 4-9
Trends in the Number of Young Fledged Per Successful Nest in the Breeding Population of Swainson's Hawk in the Natomas Basin, 1999–2016

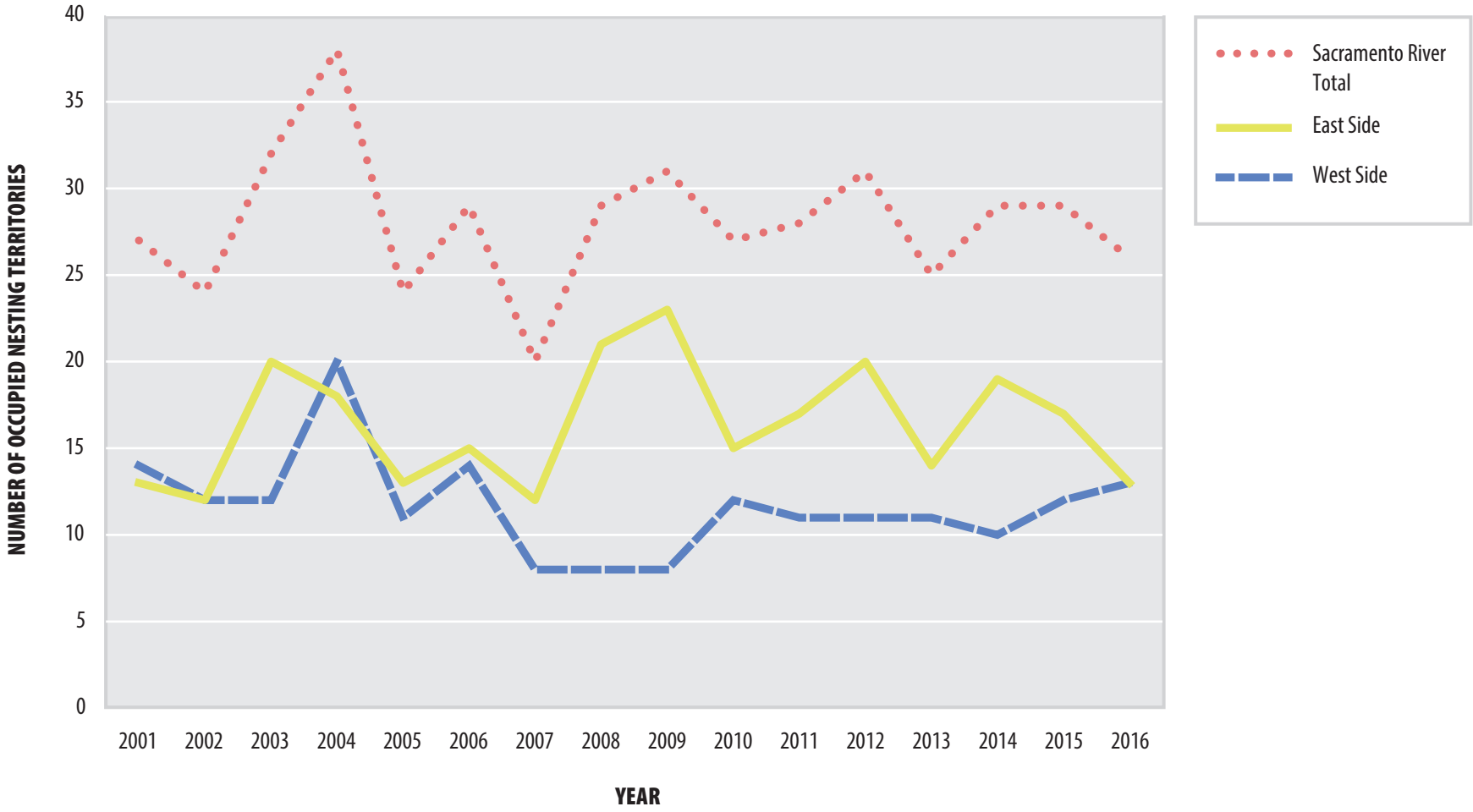

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Figure 4-10
Number of Occupied Swainson's Hawk Nesting Territories along the Sacramento River in the Natomas Basin, 2001–2016

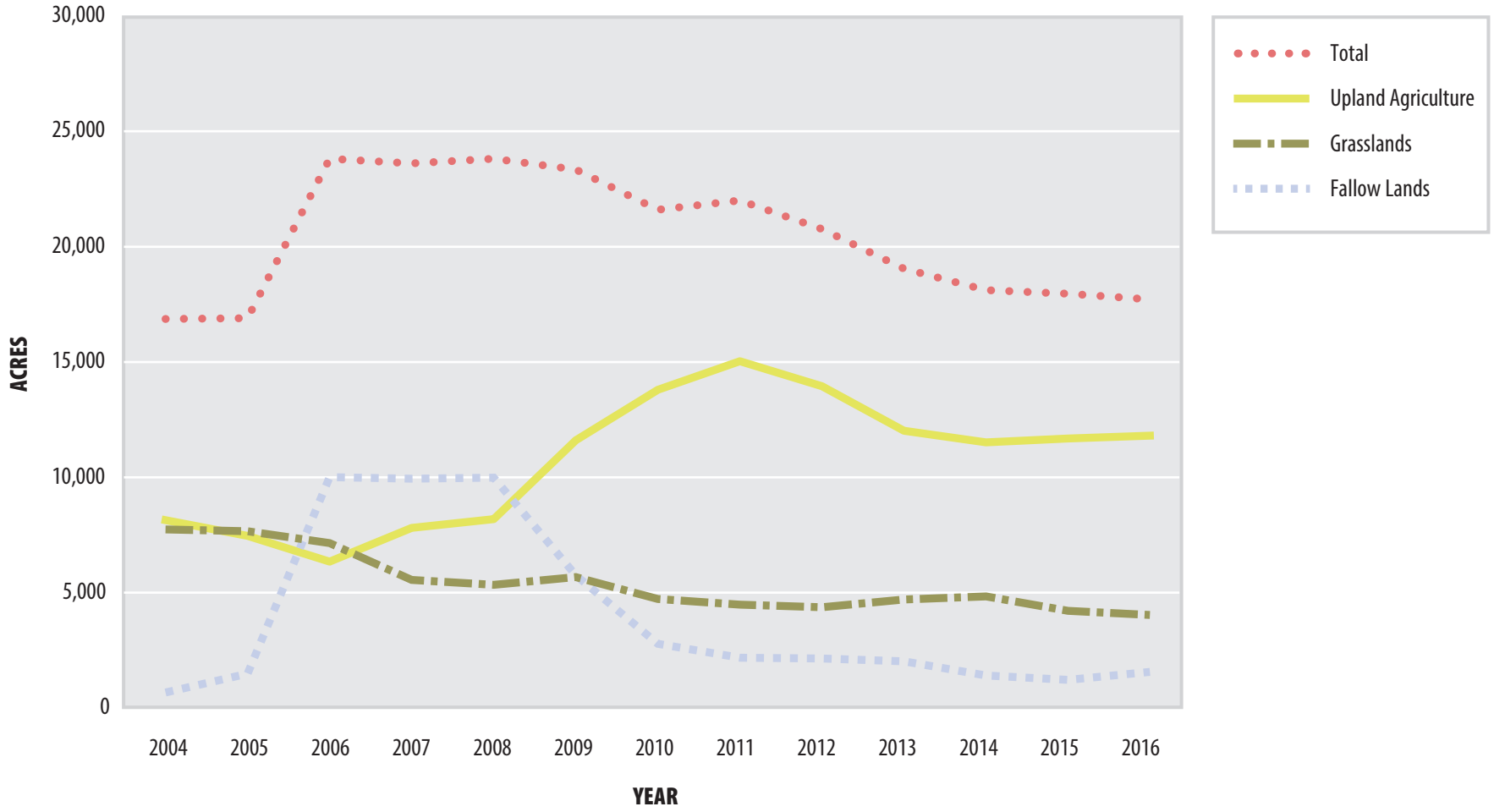

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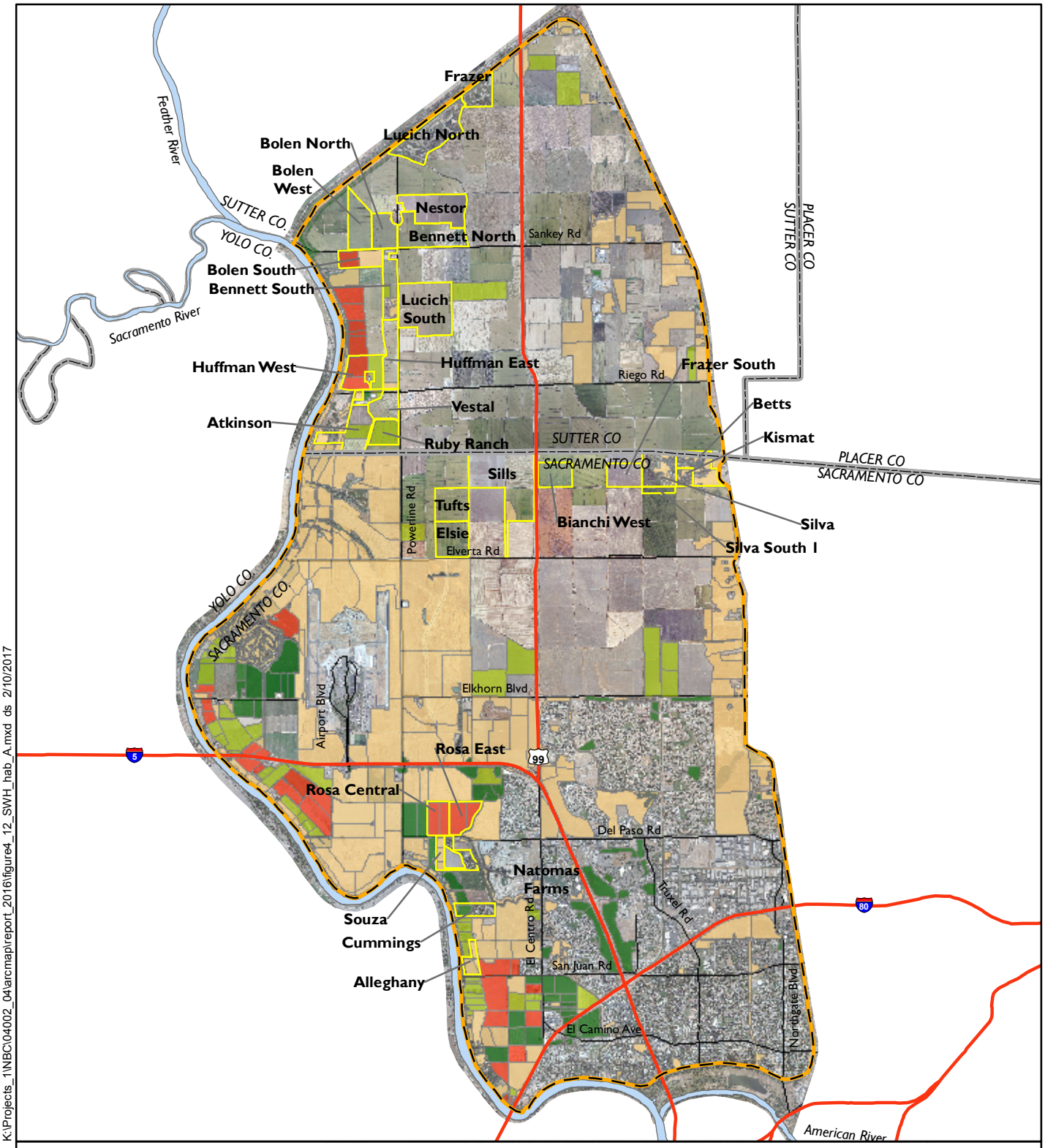
Figure 4-11
Changes in the Abundance of Three Categories of Swainson's Hawk Foraging Habitat in the Natomas Basin, 2004–2016



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

N

0 1 2 Miles

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Figure 4-12
Suitable Swainson's Hawk Foraging Habitat in the Natomas Basin in 2016

Chapter 5

Other Covered Wildlife Species and Avian Surveys

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 generalized avian surveys on reserves. Two general types of monitoring were conducted to meet the NBHCP goals and objectives: monitoring on reserve lands and non-reserve land monitoring. 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 created ecosystems.

Monitoring of newly-created freshwater emergent marshes that were constructed in soil-mined areas as part of the NLIP began in July of 2015. One of the primary differences between these marshes and other marsh complexes created and managed by TNBC is that these marshes were constructed below grade. Another main difference is that the new marshes have been fully functional for only a short period of time, while the other marshes are over 10 years old. An additional reserve monitoring objective is to compare species use of the newly created marshes to the corresponding use of the other marshes of the Fisherman's Lake Reserve.

Non-reserve land monitoring 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.

Surveys for covered avian species are conducted monthly 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). Covered Species observed off the tract during the survey or before or after the survey are recorded separately as incidental observations. 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).

Surveys for Pacific pond turtles are conducted during avian surveys and are recorded incidentally whenever they are observed. Blue elderberry shrubs, the host plant for valley elderberry longhorn beetle, are documented during floristic inventory and noxious weed surveys (see Chapter 2, *Land Cover Mapping, Floristic Inventory, and Noxious Weed Surveys*).

5.2.2 Non-Reserve Land Surveys

Surveys for Other Covered Species off reserves are specifically designed to obtain maximum geographic and temporal coverage of the Basin and to ensure repeatability and consistency. These surveys are conducted monthly.

The Basin is divided into three regions for purposes of this survey (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 are 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.

5.2.3 Analytical Methods

The average number of detections per survey (i.e., total number of individuals counted per 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 of Other Covered Species are 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 2016 is provided in Appendix C-2.

5.3.1 Generalized Avian Surveys

In 2016, 123 avian species were detected on reserves compared to 118 in 2015. No new avian species were added to the cumulative list of species observed on reserves. The number of species observed each monitoring year has ranged from a low of 116 in 2010 to a high of 139 in 2009. Table 5-1 summarizes the number of individuals and number of avian species recorded from 2011 through 2016 on each tract (by reserve) for selected taxonomic groups: raptors, waterfowl, neotropical migrants, and shorebirds.

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.

Red-tailed hawk continues to be the most abundant raptor on reserve lands, followed by northern harrier and American kestrel, white-tailed kite, and red-shouldered hawk. The annual average number of raptors detected per survey on reserve lands fluctuated between 2005 and 2016; the mean value was highest in 2009 (0.16) and lowest in 2015 (0.07) (Figure 5-2). There has been a significant overall decline in raptor detections since 2005 (R^2=0.506, P=0.008); however, the decline has been only modestly significant since 2010 (R^2=0.476, P=0.090). Although the numbers of red-tailed hawks and white-tailed kites have remained relatively constant, there have been statistically significant declines in the numbers of northern harriers (R^2=0.589, P=0.002) and American kestrels (R^2=0.602, P=0.002), although populations have been steady since 2010 (R^2=0.368, P=0.159 and R^2=0.360, P=0.166, respectively). The largest mean numbers of raptors detected per survey in 2016 were observed on the BKS (0.30 raptors per survey) and Atkinson tracts (0.22 raptors per survey), followed by Lucich South and Rosa. Raptors are most abundant on reserves from October through February when large numbers of them come into the Central Valley to spend the winter.

Waterfowl

The waterfowl group—comprising geese, swans, and ducks—is an important aesthetic and sporting resource in the Basin. Sixty percent 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.

Greater white-fronted goose continues to be the most abundant species of waterfowl on reserve lands over the course of the monitoring period, followed by the American coot, snow goose, mallard, and northern shoveler. The average number of waterfowl detected per survey on reserve lands from 2005 through 2016 exhibits a large increase over the years 2007 through 2009 (Figure 5-3). This pattern holds for species that occur in very large flocks such as greater white-fronted goose and snow goose, but not for species that occur in smaller flocks such as mallards (Figure 5-3). The period of increase also corresponds with a change in observer conducting the surveys and is likely to be an artifact of counting bias that occurs only when estimating the number of individuals in very large flocks.

There is no evidence for substantive change in the numbers of waterfowl detected on reserve lands since comprehensive monitoring began or in the period subsequent to 2009. The exception is for mallard, which exhibits a significant decline on reserve lands over the entire monitoring period (R^2=0.625, P<0.001), but not in years following 2009 (R^2=0.106, P<0.498). However, most species, including northern pintails, which have been a species of concern to waterfowl ecologists, have not exhibited a significant change in the number of detections on reserve lands over the course of the monitoring period.

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

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 on 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 been increasing 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.

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). There has been no significant increase or decrease in the numbers of neotropical migrants recorded during the monitoring period. The increases in neotropical migrants observed from 2010 through 2014 were due primarily to growing numbers of cliff swallows breeding on the BKS tract of the Central Basin Reserve. Cliff swallows began nesting in large numbers under the carport on the BKS tract 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. Despite the disappearance of the

nesting colony in 2015 and 2016, there has been a moderately significant increase in cliff swallow detections on reserve lands over the course of the monitoring period (R^2=0.322, P=0.054). Although there was substantial annual variation in the average number of detections per survey for barn swallows, tree swallows, and western kingbirds, there was no significant increase or decrease over the course of the monitoring period (Figure 5-4). However, there has been a significant decrease in tree swallow detections over the last 7 years (R^2=0.587, P=0.043).

The largest numbers of neotropical migrants are found on the BKS, Frazer, Rosa, and Lucich North tracts, which have wooded habitats near streams or wetlands.

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 the TNBC 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.

Long-billed dowitcher, killdeer, dunlin, and least sandpipers are the most abundant shorebirds using reserve lands. Overall, shorebird numbers have been relatively stable (R^2=0.210, P=0.137, Figure 5-5). Long-billed dowitcher, dunlin, and least and western sandpiper numbers show no evidence of an increase or decrease over the course of the monitoring period, but killdeer exhibit a significant decline in the mean number detected per survey (R^2=0.587, P=0.002) (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, Bolen North, and Lucich North.

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.

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). The mean number of detections per survey has declined significantly over the monitoring period (R^2=0.837, P<0.001), and has declined every year since 2009 (Figure 5-6). Although yellow-billed magpies have been detected on most reserve tracts during the period of the study, 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 Atkinson, Alleghany 50, and BKS. However, even on these reserves, there was a significant decline in the number of individuals observed per survey over the course of the monitoring period (R^2=0.376, P=0.032).

Conversely, there has been a significant increase in the numbers of Canada geese detected on reserves during the monitoring period (R^2=0.683, P<0.001; Figure 5-6). 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 are nesting Canada geese on several reserve tracts, including the BKS tract.

For the eighth year in a row, a nesting colony of snowy egrets and black-crowned night herons occurred on the BKS tract in the Central Basin Reserve. The estimated number of snowy egret nesting pairs has continued to decrease since the white-faced ibis nesting colony abandoned the site. The estimated numbers of black-crowned night heron nesting pairs appears to be stable, although no attempt has been made to formally estimate the number of active nests.

Use of Newly Created SAFCA Mitigation Wetlands

Monthly reserve surveys began on the AKT, Sharma, and Natomas Farms West tracts—which were created and until recently managed by SAFCA—in July of 2015. These newly-created marshes were considered fully functional in terms of habitat values at the end of 2014. 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).

Fifty-nine species were detected on SAFCA sites, compared to 76 on TNBC sites. Species found on TNBC sites that were not found on SAFCA sites tended to be riparian species that are regularly detected in TNBC oak woodlands but not on SAFCA sites. SAFCA sites had nearly twice the number of waterfowl species, including common merganser and wood duck. Other species groups had comparable numbers of species between the two site categories. Additional differences that were evident after the first 6 months of monitoring (ICF 2016) tended to even out, with equal numbers of most species in each site category except for marsh wren, great blue heron, and snowy egret, which were significantly more abundant on SAFCA sites.

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 (but not inoculated) 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. None of the covered plant species have been detected in the Basin (see Chapter 2, *Land Cover Mapping, Floristic 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 strongly suspected.

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.

Loggerhead Shrike

The mean number of loggerhead shrikes detected per survey on reserve lands has been cyclic over the course of the monitoring period, peaking in 2009 and again in 2012 (Table 5-3, Figure 5-7). However, shrike detections on reserve lands have declined for 4 consecutive years, and 2016 was the lowest number of shrike detections per survey since comprehensive monitoring began. However, there is no significant increase or decrease over the course of the monitoring period in either the mean number of detections per survey or the proportion of surveys on reserve lands with shrike detections.

In contrast to 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=0.725, P<0.001 and R^2=0.783, P<0.001, respectively; Table 5-4; Figure 5-7).

A significant decline in shrike detections over the monitoring period becomes evident when the reserve and basin-wide surveys are combined (R^2=0.571, P=0.003).

One pair of shrikes was seen in late April on the Rosa tract, but no shrikes were subsequently detected until September, when a single individual was observed. One individual was observed on the Atkinson tract from February to late May, but was not detected again in 2016. The only other shrike detection was on Lucich South in mid-August. Individual shrikes routinely detected on the Nestor, Lucich North, and Frazer tracts are no longer regularly detected.

Two pairs that were regularly detected along Pacific Avenue through 2012, and a pair that occupied the area southwest of the SR 99/Elkhorn Boulevard intersection, disappeared in 2013 and have not returned. Construction and vegetation removal along Pacific Avenue and tree and shrub removal within the Elkhorn Boulevard territory may have contributed to the loss of these shrike pairs.

White-Faced Ibis

White-faced ibis were 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. However, no ibis have nested in the Basin since 2013.

The mean number of ibis detected per survey on reserve lands exhibits no significant increase or decrease over time. Although the number of ibis detected has decreased since the nesting colony at

BKS was abandoned, it has remained higher than the pre-nesting colony number (Table 5-3, Figure 5-8). Similarly, although the proportion of surveys on which ibis were detected dropped substantially in 2016, it has remained relatively high, indicating that TNBC reserve lands, while currently not used for nesting, are used extensively for foraging.

Comparably, the mean number of ibis detected per survey on non-reserve lands and the proportion of surveys on which ibis were detected exhibits no significant increase or decrease over time (Figure 5-8). Both metrics increased in 2016.

Seasonal patterns in the abundance of ibis have changed over the course of the monitoring period. Ibis generally begin showing up in the Basin in April, reach peak numbers in July, and taper off substantially by October. Prior to the establishment of a nesting colony in the Basin, ibis were generally not detected in the winter months. However, when nesting occurs in the Basin, ibis are detected throughout the year.

Tricolored Blackbird

Tricolored blackbirds were first documented nesting in the Basin in 2005 on the BKS tract in a small patch of Himalayan blackberry. They 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. Nesting tricolored blackbirds have not been documented in the Basin since 2013.

Although the mean number of tricolored blackbirds detected per survey on reserve lands exhibits a moderately significant decline over the monitoring period (R^2=0.284, P<0.074), the proportion of surveys on which tricolored blackbirds were detected exhibits no significant increase or decrease (Table 5-3, Figure 5-9).

Neither the mean number of tricolored blackbirds detected per survey nor the proportion of surveys on which tricolored blackbirds were detected on non-reserve lands exhibit a significant increase or decrease over the course of the monitoring period (Figure 5-9).

Western Burrowing Owl

Burrowing owls are known to breed and winter in low densities in the Basin. 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. Land management personnel reported seeing a burrowing owl regularly on the BKS tract during the 2010 breeding season, but breeding status could not be confirmed. 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.

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 of 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 was comprised of a single owl that was detected in 9 of the 12 surveys throughout the year.

The second colony occurs near the eastern edge of the Basin just north of Del Paso Boulevard 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 2 pairs by April of 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 1 to 3. In 2016, no more than 2 adults were observed throughout most of the year with the exception of the September survey, when 6 birds were observed, indicating a single pair that successfully fledged 4 young.

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.

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 3 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.

Although the mean number of burrowing owls detected per survey on reserve lands and the proportion of surveys on which burrowing owls were detected exhibit no significant increase or decrease over the course of the monitoring period, there has been a substantial decline from the peaks in 2009 and 2011, respectively (Table 5-3, Figure 5-10). This is primarily due to the decline in the number of owls occupying the Highline Canal between the Elsie and Tufts tracts.

Conversely, while the mean number of burrowing owls detected per survey on non-reserve lands exhibits no significant increase or decrease over time (R^2=0.210, P=0.138), the proportion of surveys on which burrowing owls were detected indicates a significant increase over time (R^2=0.585, P=0.002)(Table 5-4; Figure 5-10).

Although the proportion of surveys on which owls are detected reflects the fact that none of the burrowing owl nesting colonies have been completely abandoned, there has been a significant decline in the number of owls detected since 2012, reflecting a loss in the number of breeding pairs and a possible decrease in reproductive success.

Pacific Pond Turtle

Pacific pond turtles were known to occur in several areas of the Basin, including Fisherman's Lake and near the Prichard Lake and Elkhorn pumping stations, prior to the onset of comprehensive monitoring in 2005. 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 BKS tract, in the canal adjacent to the Lucich North tract, and on the Natomas Farms, Bennett South, Frazer, and Sills tracts.

Both the mean number of pond turtles detected per survey on reserve lands and the proportion of surveys on which pond turtles were detected exhibit a significant increase over the course of the monitoring period (R^2=0.717, P < 0.001 and R^2=0.803, P<0.001, respectively; Table 5-3; Figure 5-11). It should be noted that small events can strongly influence these results, such as when a tree fell across one of the marshes on the BKS tract and was subsequently used extensively for basking by turtles, which greatly increased the probability of detecting them. In most years during the monitoring period, pond turtles have rarely been detected on non-reserve land surveys, with detections confined to the Del Paso Road crossing of Fisherman's Lake and sighting of a large female on Metro Air Parkway.

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, reaching its lowest point in 2016 since comprehensive monitoring began. A similar but more dramatic decline has been observed on non-reserve lands. The seasonal pattern in shrike detections indicates that little to no reproduction has occurred over the past several years.

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.

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). Although ibis have not nested in the Basin in the last few years, 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). The relatively late arrival dates for tricolored blackbirds in the Basin may indicate that these birds were originally coming from nesting colonies to the south and attempting to raise a second brood. Tricolored blackbirds have not nested in the Basin since 2011. However, it should be noted that prior to the establishment of the TNBC reserve system, nesting habitat for tricolored blackbirds was extremely limited in the Basin. Tricolored blackbird populations have experienced significant declines throughout their range, and have petitions under review for listing under both the California and Federal Endangered Species Acts.

Although detections of tricolored blackbird on reserves and basin wide do not exhibit a decline 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. 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 prey resources (insects) that are available at the right time of year to facilitate breeding. Tricolored blackbirds continue to use habitats on both reserve and non-reserve lands each year, even when breeding does not occur.

The decline in the mean number of burrowing owls detected per survey on reserve lands that began in 2010 continued in 2016, driven primarily by the decline in the number of individuals and reproductive performance of the owls on the Elsie and Tufts tracts. 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. Because none of the colonies has been completely abandoned, there has been no significant decline in the proportion of surveys on which owls are detected. Habitat suitability at Sleep Train Arena has probably 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 2014, owl numbers have not rebounded. Finally, the owl colony at the end of Aimwell Road also suffered a major disturbance when the road separating two fields underwent maintenance that resulted in the collapse of nearly all the burrows being used by the owls.

Pacific pond turtle detections on reserve lands have continued to increase and it is now clear that they are using the marsh and associated uplands habitats created by TNBC and are now breeding in 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. Ponding of the vernal pools created on the BKS tract, like other vernal pools throughout California, has been limited due to the drought. 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 extensively. The first nesting of ibis and tricolored blackbirds in the Basin occurred on reserve lands. The persistence of the burrowing owl nesting colony 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. Loggerhead shrikes have been documented using reserve lands extensively, and hatchling Pacific pond turtles have been documented adjacent to Lucich North, BKS, and Natomas Farms, while adults have been observed on the Rosa and Frazer tracts. It is clear that the creation and management of habitats by TNBC have provided substantial conservation benefits to these species.

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.

- Continue to allow natural colonization of new habitats by California ground squirrels in suitable upland habitats.
- 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.
- Consider allowing development projects where burrowing owls occur to actively relocate their burrowing owls onto TNBC reserves.

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 when white-faced ibis and tricolored blackbird are not nesting to minimize the potential for nest 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 or maintain, where possible, irrigated pasture, open grasslands, and alfalfa for foraging tricolored blackbirds that minimizes the use of insecticides that would reduce insect prey populations.

5.7 References

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Table 5-1. Summary of Results of Monthly Avian Surveys by Reserve and Tract,[a] 2014–2016

Reserve	Waterfowl			Raptors			Neotropical Migrants			Shorebirds			All Bird Species		
	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016
North Basin Reserve															
Atkinson	9 (1)	5 (1)	2 (1)	53 (7)	40 (8)	53 (8)	131 (7)	97 (6)	100 (7)	21 (1)	25 (1)	20 (1)	2,942 (60)	2,217 (60)	2,421 (58)
Bennett North	1,323 (10)	2,102 (14)	915 (15)	13 (4)	15 (7)	20 (6)	52 (4)	27 (4)	13 (2)	284 (4)	126 (3)	143 (3)	4,402 (49)	5,203 (52)	3,245 (46)
Bennett South	123 (5)	151 (6)	386 (7)	16 (6)	10 (5)	18 (4)	16 (3)	23 (2)	8 (3)	24 (3)	21 (4)	253 (4)	4,931 (43)	2,838 (38)	4,091 (40)
Bolen North	9 (1)	55 (4)	804 (4)	2 (2)	8 (2)	2 (2)	1 (1)	4 (1)	7 (2)	37 (2)	32 (3)	31 (3)	859 (22)	925 (26)	1,856 (23)
Bolen South	—	500 (1)	—	13 (4)	12 (4)	14 (6)	48 (4)	26 (3)	81 (3)	2 (1)	13 (1)	185 (2)	534 (34)	1,003 (31)	730 (35)
Bolen West	—	2 (1)	6 (1)	2 (2)	4 (4)	8 (4)	1 (1)	11 (3)	8 (3)	7 (1)	13 (2)	126 (5)	348 (18)	177 (21)	648 (25)
Frazer	739 (13)	1,299 (11)	1.079 (14)	14 (5)	10 (3)	13 (4)	298 (4)	87 (5)	82 (4)	69 (2)	10 (2)	16 (1)	2,383 (46)	2,328 (40)	2,525 (41)
Huffman East	9 (1)	104 (3)	1,783 (4)	17 (5)	13 (3)	10 (3)	16 (3)	4 (2)	18 (2)	9 (2)	3 (1)	32 (3)	1,976 (33)	740 (28)	5,108 (29)
Huffman West	2 (1)	2 (1)	4 (1)	27 (5)	13 (3)	12 (3)	24 (3)	15 (4)	32 (3)	125 (2)	8 (1)	2 (1)	767 (34)	471 (27)	2,335 (31)
Lucich North	3,864 (14)	2,705 (17)	4,670 (15)	24 (3)	24 (4)	25 (4)	71 (4)	57 (4)	76 (4)	238 (5)	122 (3)	556 (5)	9,827 (53)	6,861 (53)	9,311 (52)
Lucich South	1,448 (9)	1,982 (8)	1,346 (5)	35 (7)	28 (6)	29 (6)	45 (3)	3 (1)	32 (3)	183 (7)	132 (5)	449 (8)	6,100 (50)	4,734 (43)	11,267 (48)
Nestor	1,632 (5)	504 (3)	953 (5)	9 (3)	13 (3)	20 (4)	2 (2)	5 (2)	5 (1)	53 (3)	98 (3)	868 (5)	2,510 (33)	1,681 (29)	3,663 (31)
Ruby Ranch	7 (2)	114 (2)	188 (2)	12 (5)	9 (3)	5 (3)	4 (2)	1 (1)	9 (2)	18 (1)	14 (1)	9 (1)	903 (33)	1,630 (25)	1,114 (26)
Vestal	6 (2)	6 (2)	—	7 (6)	4 (4)	9 (4)	3 (2)	6 (2)	5 (3)	7 (1)	6 (1)	3 (1)	3,826 (34)	673 (34)	780 (29)
Central Basin Reserve															
BKS	6,233 (17)	7,135 (15)	4,368 (18)	82 (10)	69 (8)	71 (8)	1,600 (5)	449 (5)	402 (4)	737 (8)	987 (7)	1,331 (8)	24,979 (81)	18,879 (75)	17,636 (80)
Bianchi West	22 (1)	142 (5)	3,671 (6)	3 (1)	5 (1)	6 (2)	13 (2)	—	—	12 (2)	40 (5)	128 (5)	436 (25)	1,359 (27)	4,309 (28)
Elsie	9 (1)	12 (1)	6 (1)	10 (4)	7 (4)	11 (4)	4 (1)	1 (1)	7 (1)	11 (2)	11 (3)	1 (1)	764 (23)	748 (21)	561 (17)
Frazer South	97 (5)	404 (3)	593 (5)	13 (2)	12 (2)	19 (3)	2 (1)	2 (1)	—	26 (2)	92 (4)	106 (4)	1,164 (26)	1,970 (29)	1,881 (31)
Sills	25 (2)	51 (4)	32 (3)	21 (5)	13 (2)	17 (4)	7 (1)	5 (1)	7 (2)	21 (2)	29 (2)	65 (3)	990 (29)	1,178 (27)	1,242 (29)
Tufts	16 (2)	17 (2)	2 (1)	14 (3)	7 (3)	9 (3)	—	—	11 (2)	41 (2)	—	62 (4)	441 (18)	260 (15)	434 (21)
Fisherman's Lake Reserve															
Allegheny	1 (1)	—	—	2 (1)	8 (2)	3 (2)	6 (4)	11 (5)	9 (3)	3 (1)	4 (1)	3 (1)	622 (37)	500 (36)	481 (34)
Cummings	51 (8)	186 (9)	129 (7)	21 (6)	15 (3)	19 (6)	53 (9)	73 (7)	87 (6)	16 (1)	11 (1)	10 (1)	1,066 (66)	1,477 (60)	1,971 (60)
Natomas Farms	79 (8)	139 (8)	89 (6)	9 (6)	13 (4)	10 (5)	90 (6)	35 (5)	58 (4)	10 (1)	2 (1)	18 (3)	1,017 (53)	768 (52)	769 (49)
Rosas	7 (2)	96 (5)	149 (4)	40 (7)	20 (6)	29 (5)	66 (7)	88 (7)	112 (6)	5 (1)	151 (2)	13 (1)	1,223 (49)	1,378 (50)	1,565 (49)
Souza	—	—	2 (1)	11 (4)	8 (4)	8 (2)	7 (2)	9 (3)	9 (2)	1 (1)	—	—	503 (27)	607 (24)	293 (22)
SAFCA Wetlands[b]															
AKT		210 (8)	314 (10)		3 (2)	4 (3)		9 (2)	371 (3)		4 (1)	9 (1)		594 (33)	1,449 (38)
Sharma		101 (6)	550 (13)		2 (1)	5 (4)		7 (2)	139 (5)		3 (1)	1 (1)		332 (31)	1,047 (48)
Natomas Farms West		29 (8)	213 (9)		—	2 (1)		14 (3)	16 (4)		10 (2)	5 (2)		385 (29)	605 (33)

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

[b] Surveys on these reserves were conducted monthly from July through December, 2015. Other reserves were surveyed monthly from January through December in 2015.

Table 5-2. Number of Pairs of Other Covered Species on TNBC Mitigation Lands, 2004–2016

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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
Loggerhead shrike	4 (3 BKS, 1 Brennan)	3 (2 BKS, 1 Brennan)	3 (1 BKS, 1 Alleghany, 1 Brennan)	3 (1 BKS, 1 Alleghany, 1 Huffman West)	1 (Alleghany)	1 (Atkinson)	1 (Atkinson)	1 (Atkinson)	3[a]	3[a] (1 Lucich North, 1 Rosa, 1 Souza)	4[a] (Lucich North, Bennett North, Atkinson, Rosa)	1[a] (Rosa)	0
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
White-faced ibis	0	0	0	~750 (BKS)	~1,500 (BKS)	~2,500 (BKS)	~2,500 (BKS)	0	0	0	0	0	0

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

Table 5-3. Average Number of Observations per Survey of Other Covered Species Recorded during Monthly Avian Surveys on Reserves, 2005–2016

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
White-faced ibis[a]	0.064	0.042	0.060	0.204	0.217	0.150	0.115	0.107	0.157	0.138	0.140	0.092
Burrowing owl	0.020	0.029	0.003	0.117	0.200	0.168	0.128	0.060	0.043	0.030	0.003	0.012
Loggerhead shrike	0.074	0.038	0.097	0.204	0.240	0.055	0.128	0.183	0.157	0.060	0.036	0.027
Tricolored blackbird	16.990	1.546	21.387	38.609	12.677	1.967	4.030	1.203	5.010	4.195	3.387	0.693
Pacific pond turtle	0.000	0.000	0.000	0.007	0.000	0.000	0.007	0.053	0.063	0.104	0.073	0.060

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

Table 5-4. Average Number of Observations per Survey of Other Covered Species Recorded during Monthly Basin-Wide Surveys, 2005–2016

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
White-faced ibis[a]	0.250	0.088	0.265	0.233	0.229	0.143	0.059	0.156	0.156	0.226	0.267	0.308
Burrowing owl	0.312	0.588	0.029	1.600	3.286	3.810	4.647	6.719	5.031	3.548	1.833	1.423
Loggerhead shrike	3.00	2.529	2.235	1.800	3.314	2.000	2.059	2.125	1.438	0.710	0.467	0.077
Tricolored blackbird	5.8	1.0	2.2	200.7	222.3	0.0	14.7	3.8	5.1	26.8	49.7	4.2

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

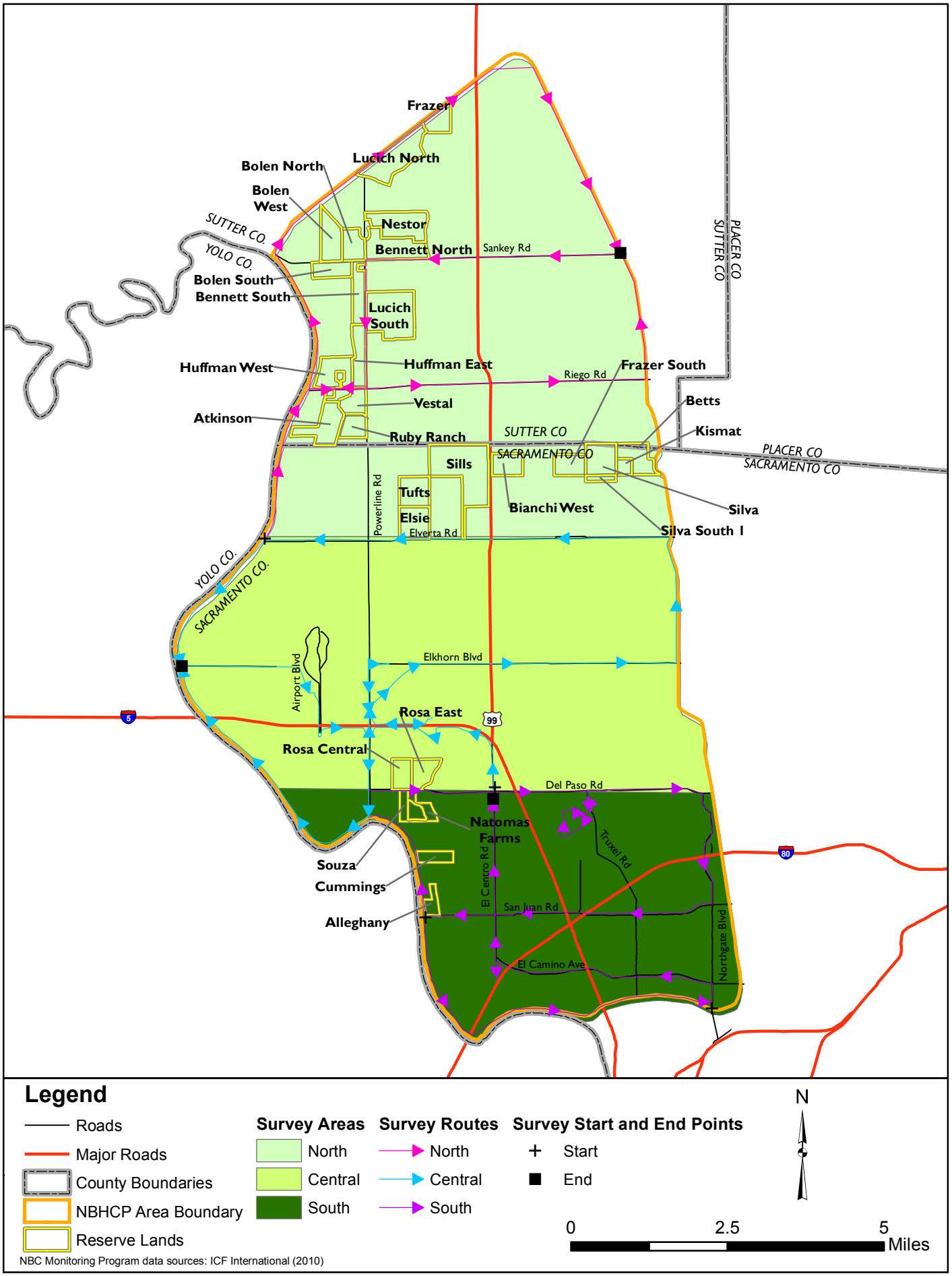

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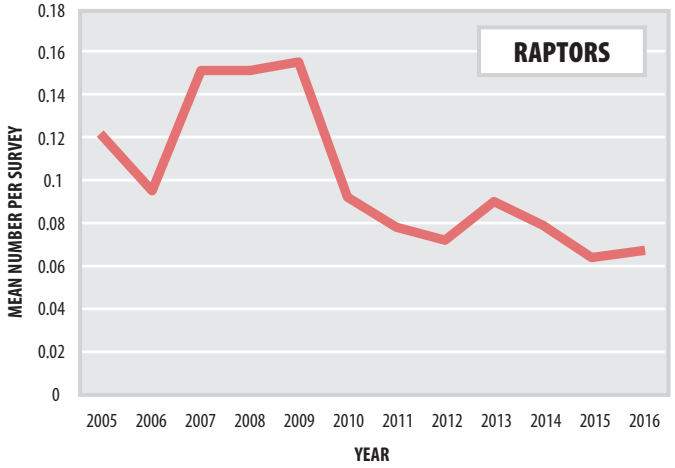
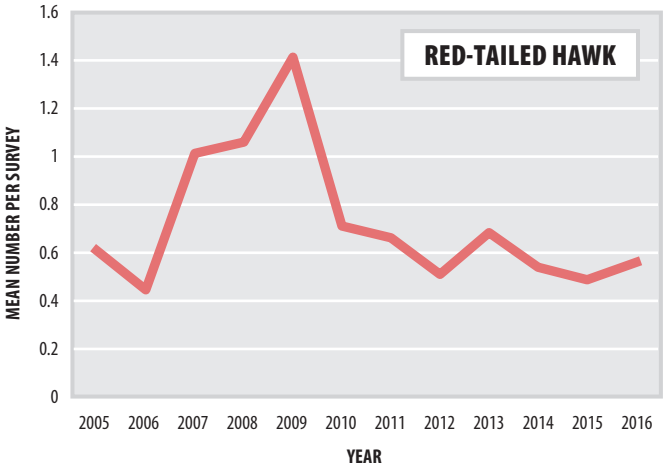
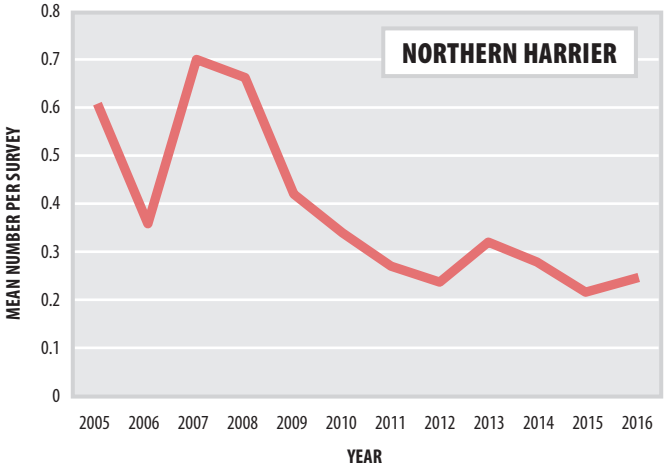
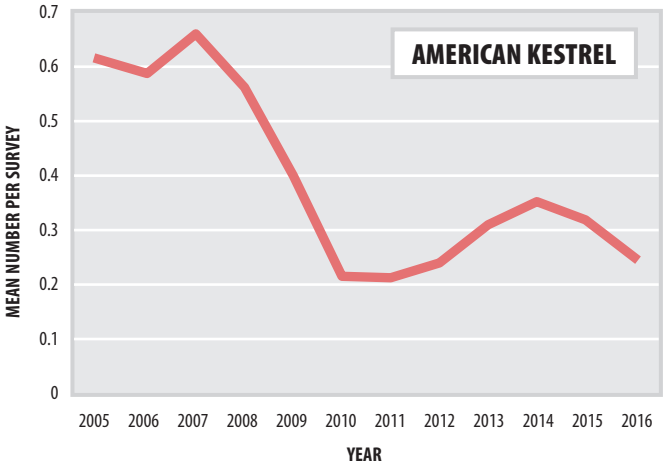
Figure 5-1
Monthly Basin-Wide Survey Routes









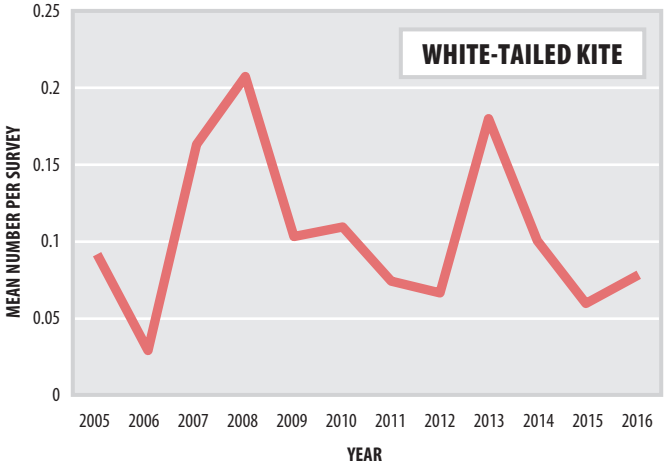


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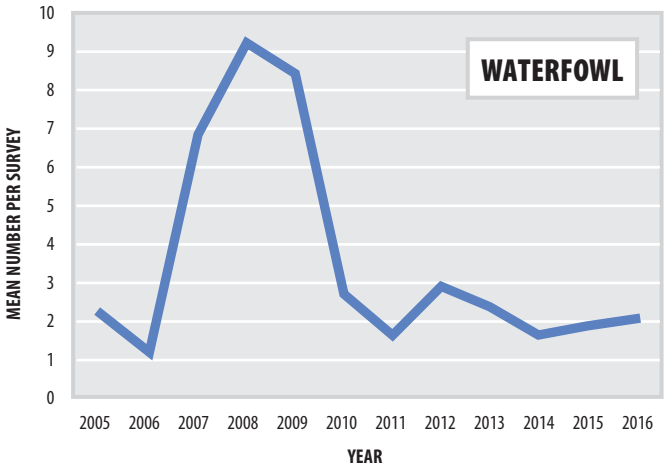
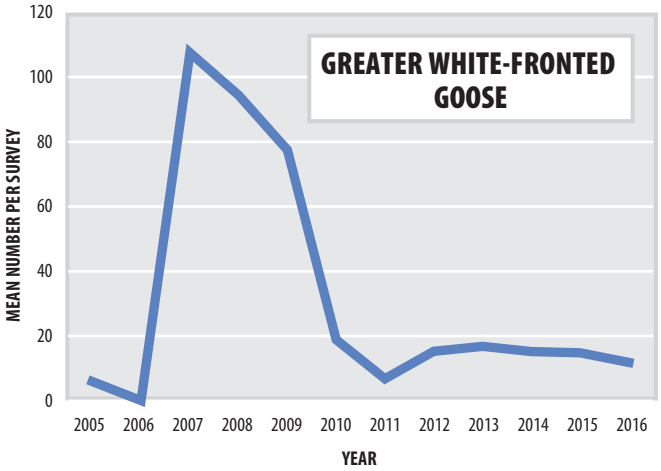
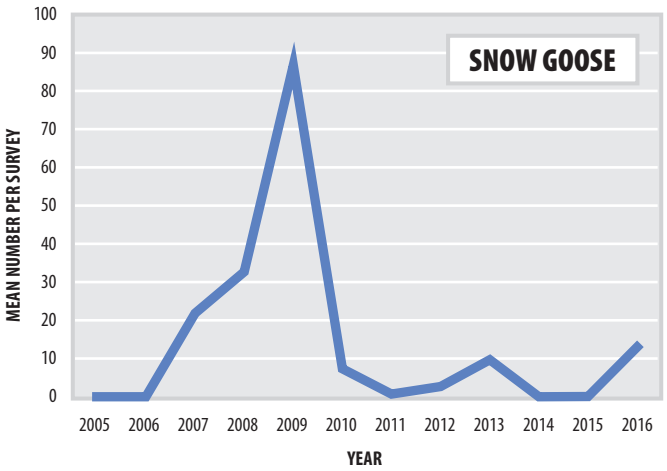
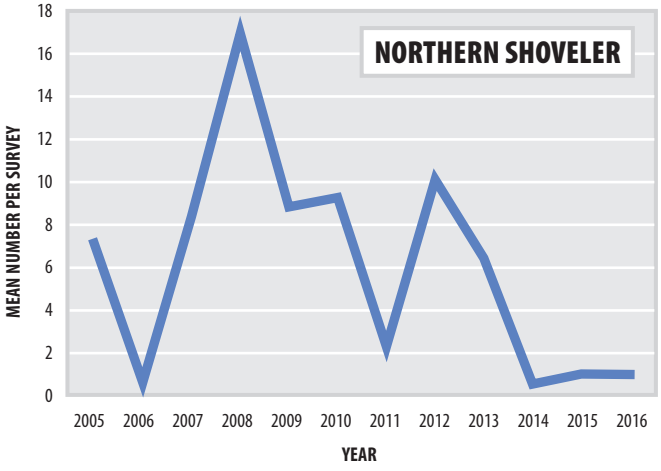
Figure 5-2
Mean Number of Raptors Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2016









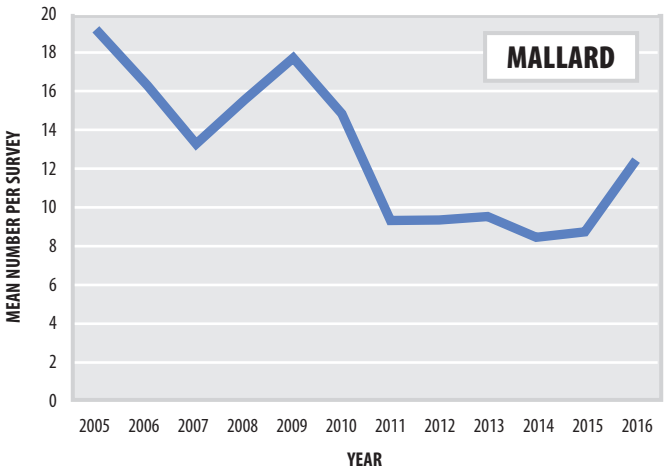


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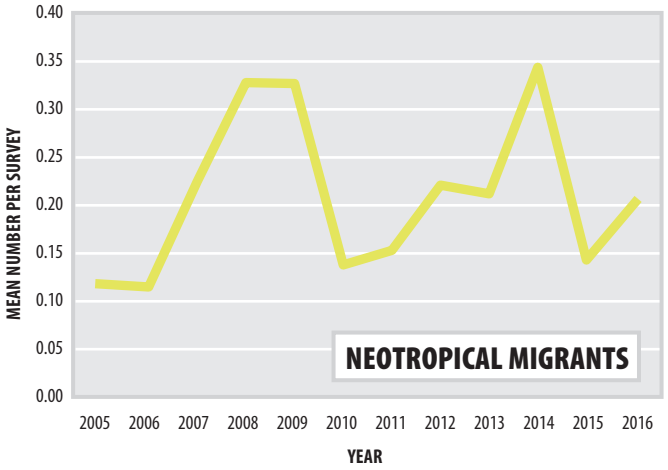
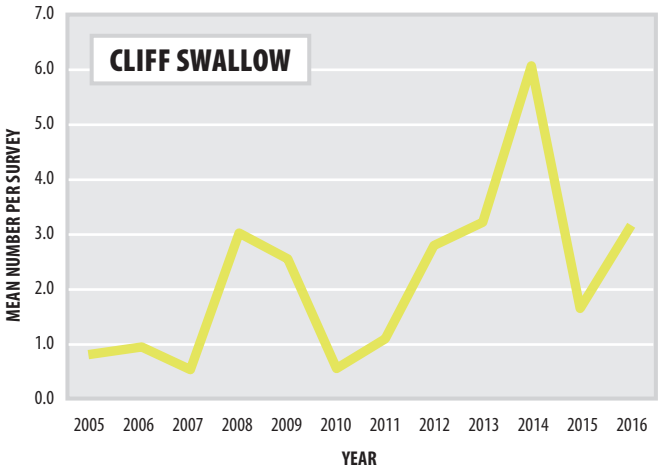
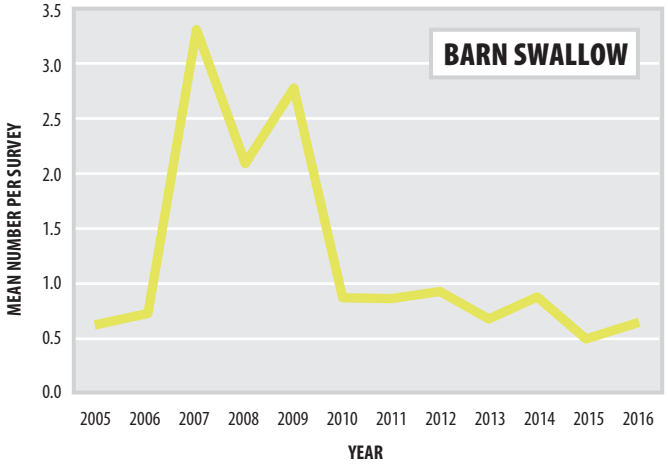
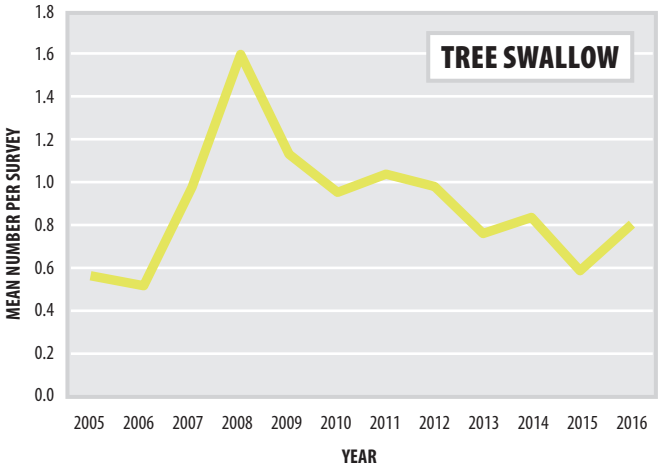
Figure 5-3
Mean Number of Waterfowl Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2016









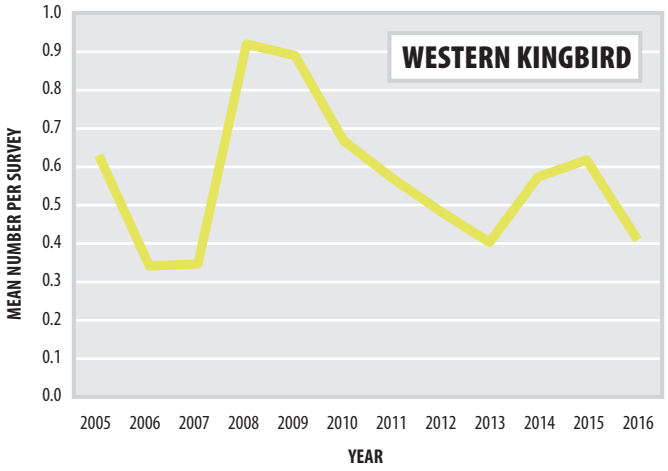


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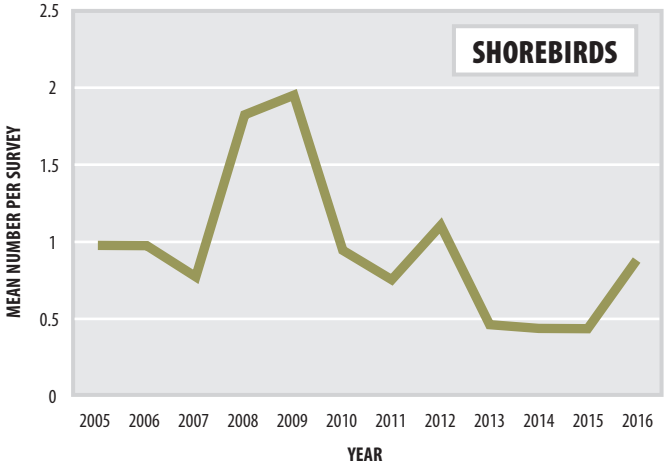
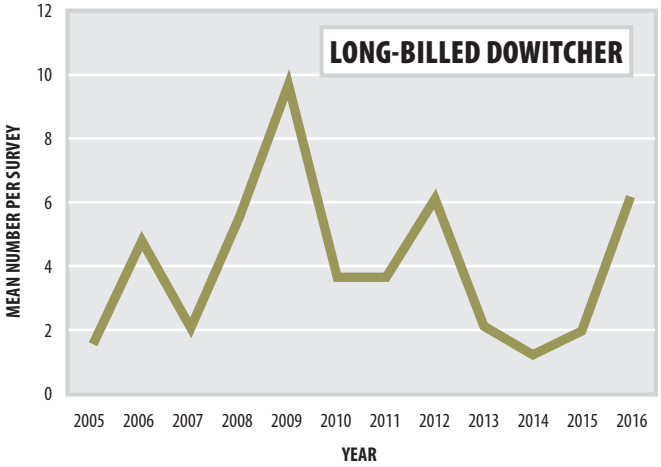
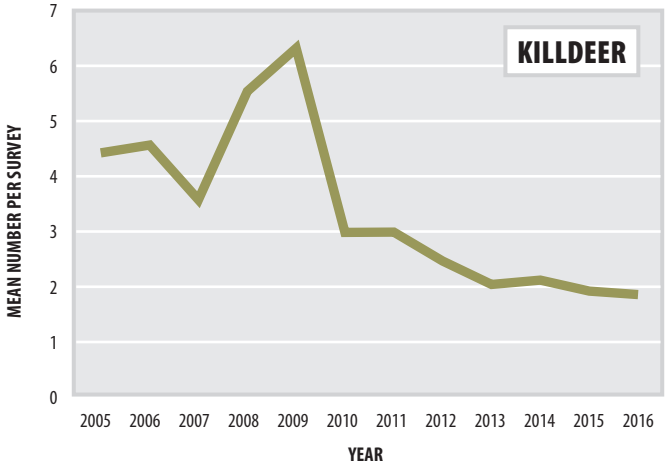
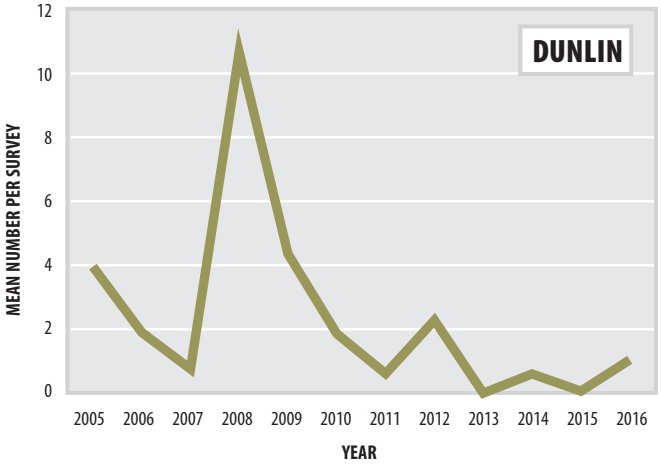
Figure 5-4
Mean Number of Neotropical Migrants Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2016









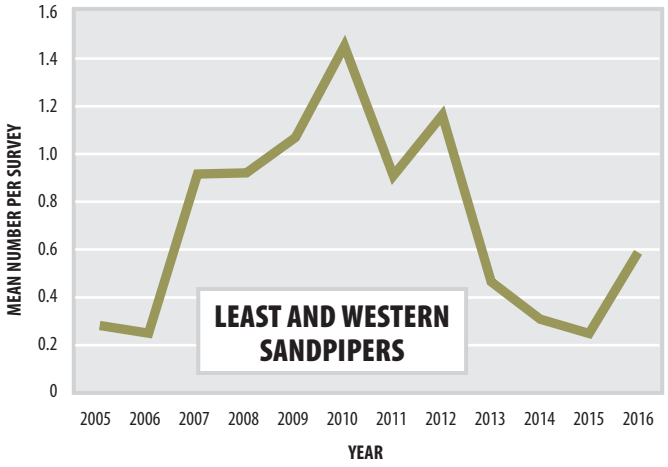


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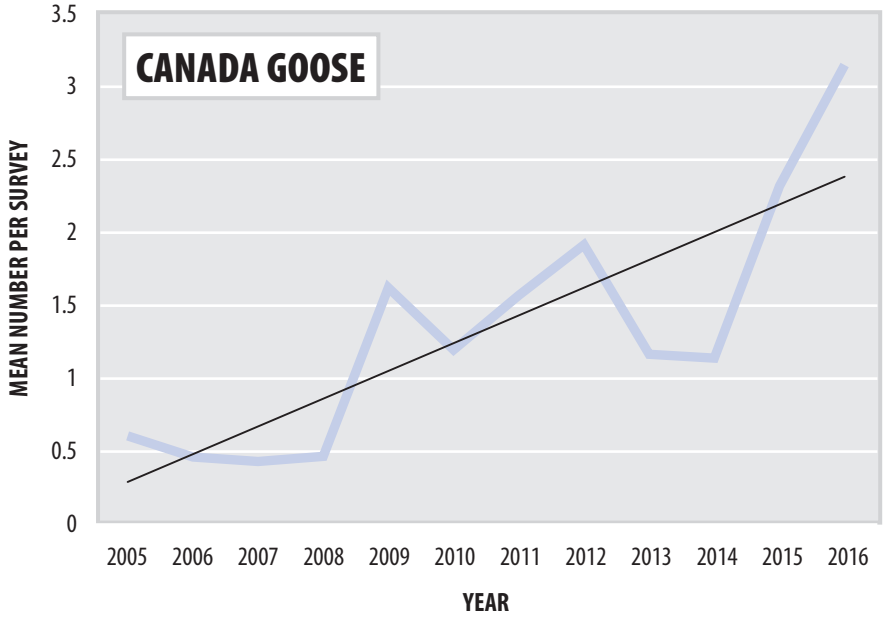
Figure 5-5
Mean Number of Shorebirds Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2016



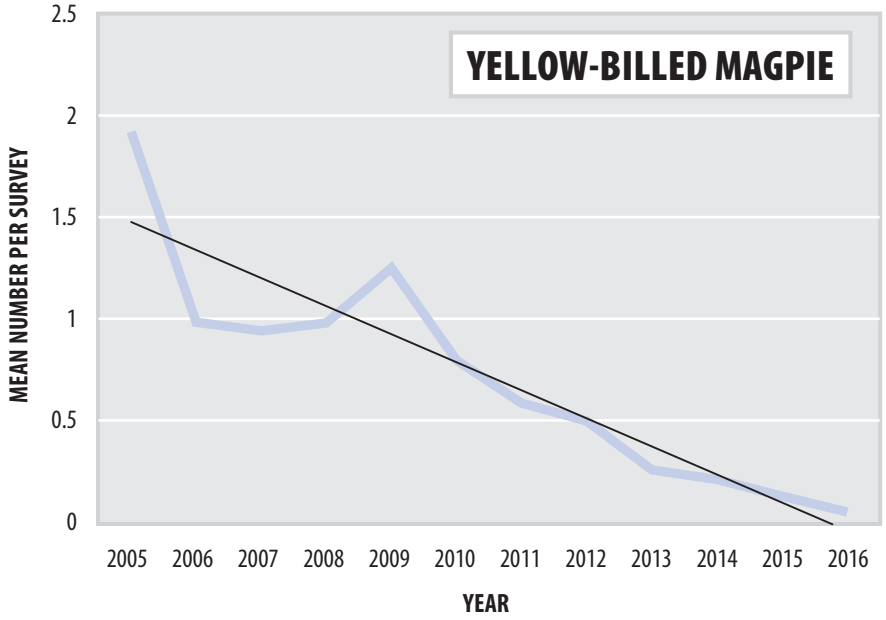


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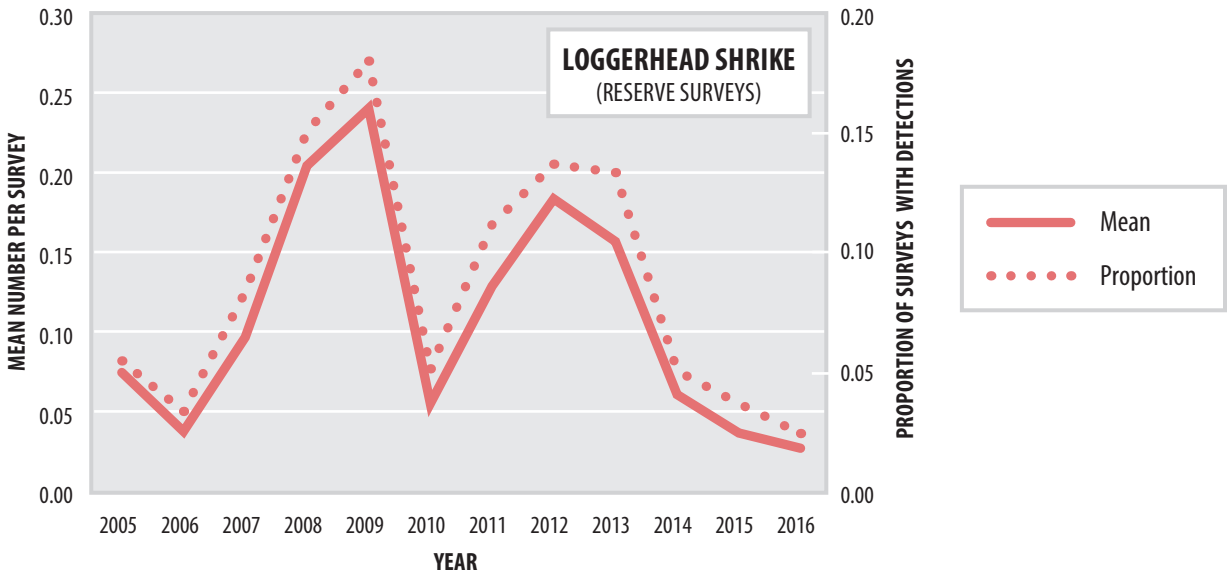
Figure 5-6
Mean Number of Yellow-Billed Magpies and Canada Geese Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2016



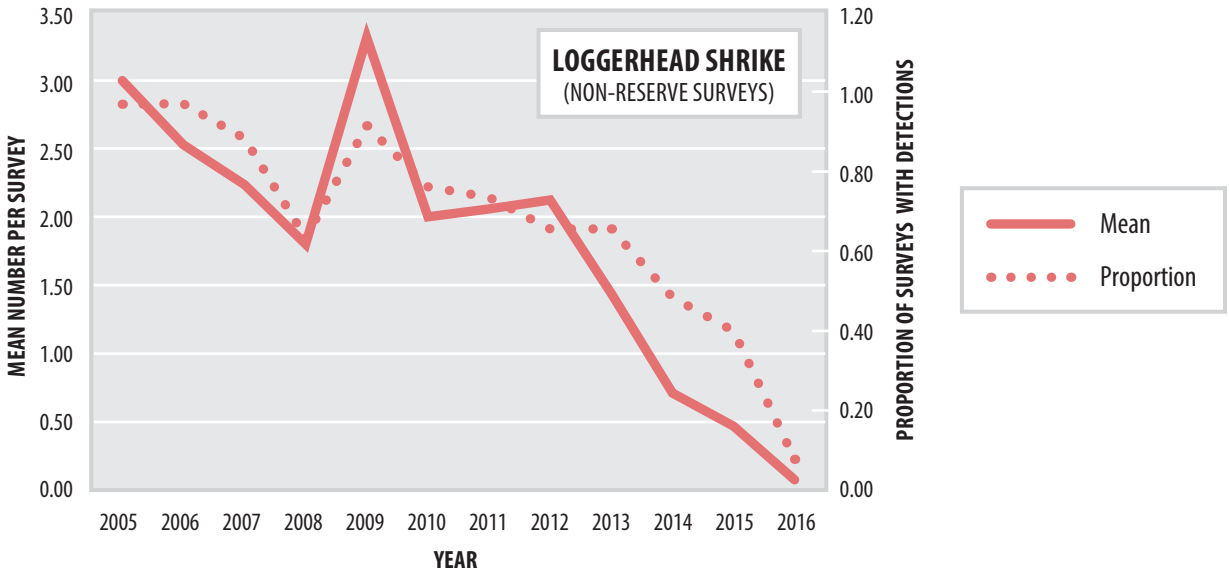


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Figure 5-7
Loggerhead Shrike Detections on Reserves and Non-Reserve Lands in the Natomas Basin, 2005–2016

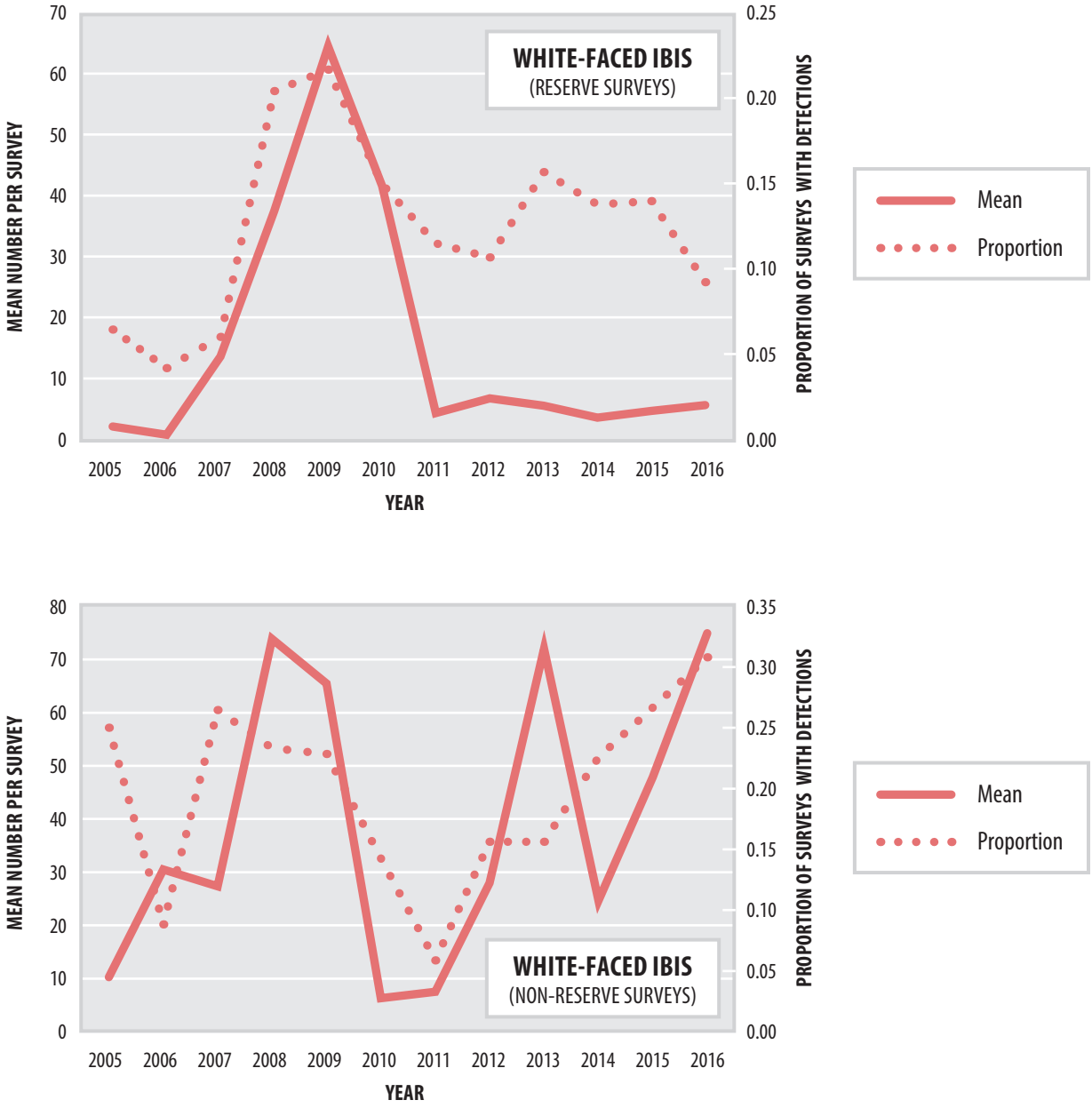

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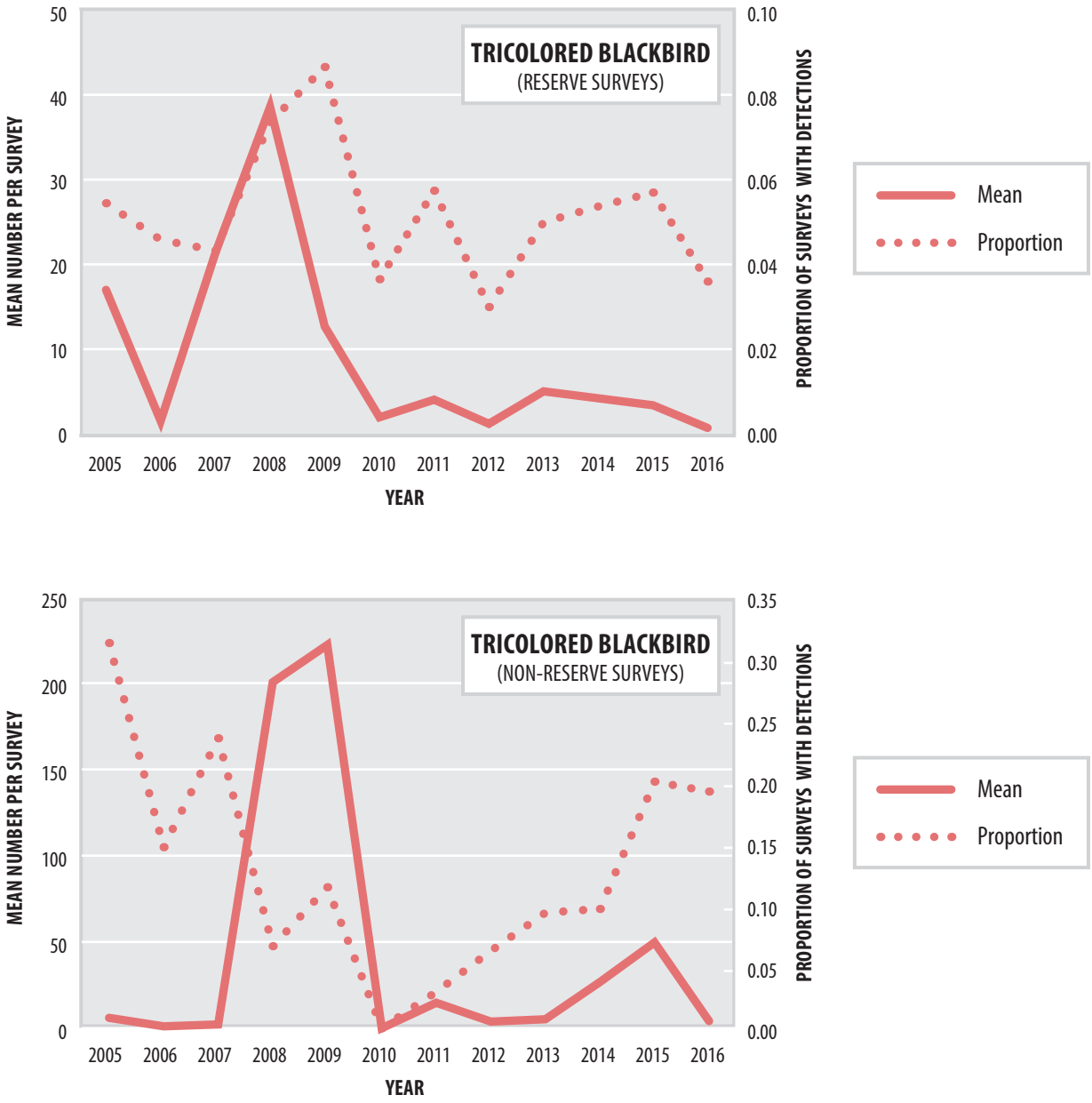
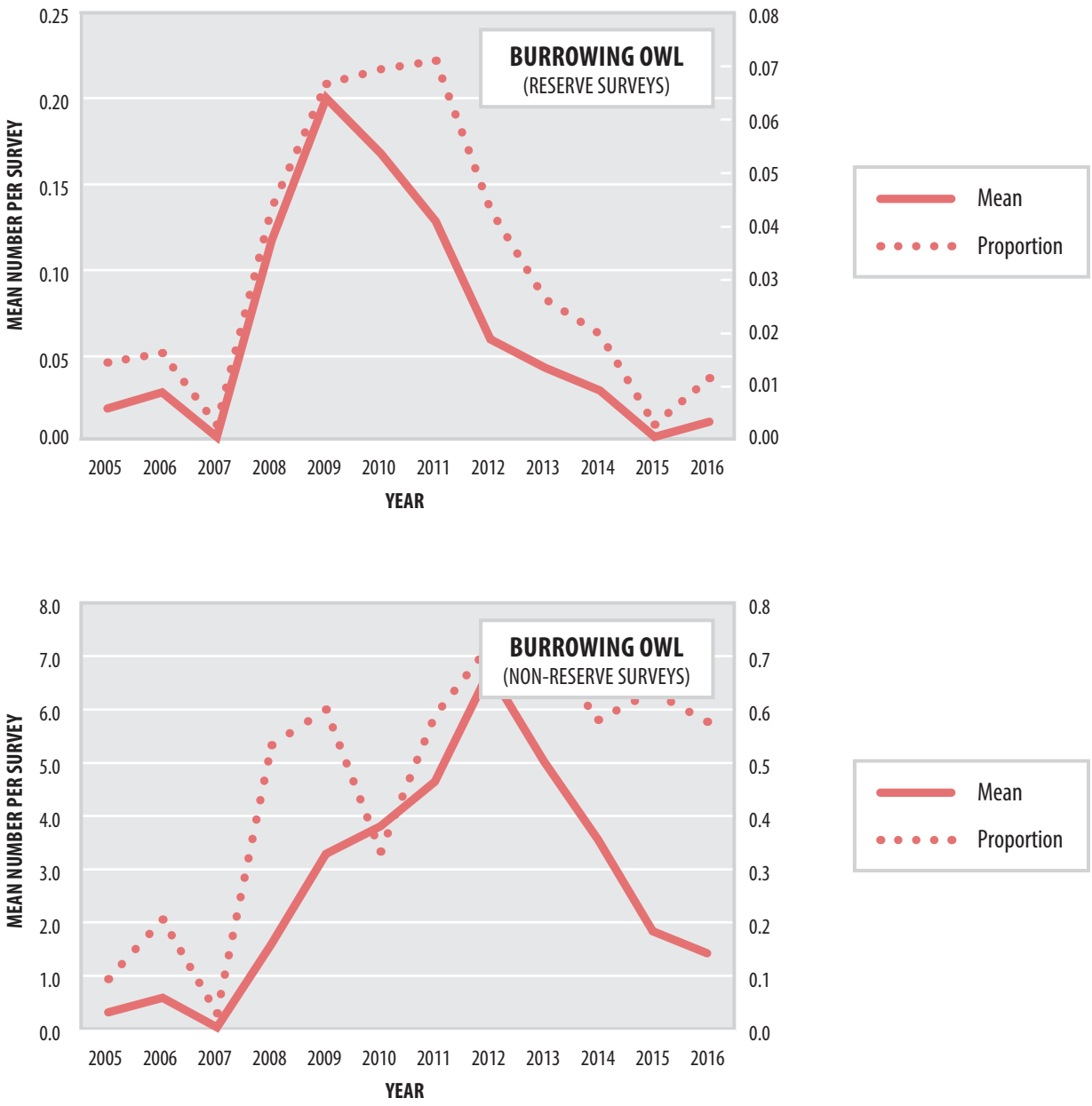
Figure 5-8
Mean Number of White-Faced Ibis Detected on Reserves and Non-Reserve Lands in the Natomas Basin, 2005–2016



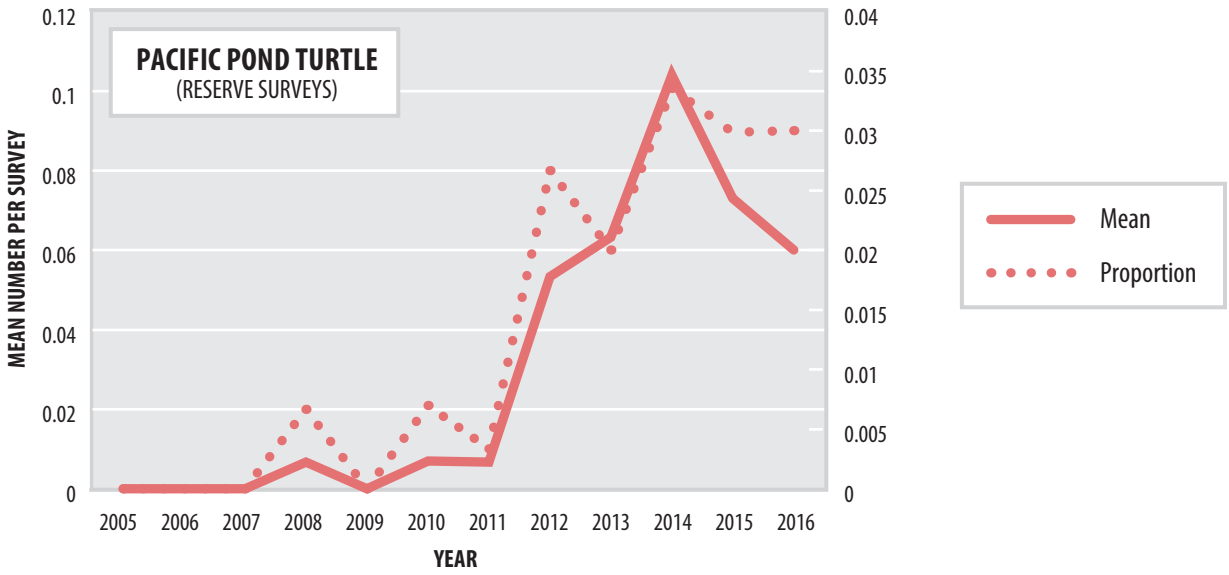
Graphics ... 00890.10 NBC (3-6-17)

Figure 5-8
Mean Number of Tricolored Blackbird Detected on Reserves and Non-Reserve Lands in the Natomas Basin, 2005–2016



Graphics ... 00890.10 NBC (3-20-17)

Figure 5-10
Burrowing Owl Detections on Reserves and Non-Reserve Lands in the Natomas Basin, 2005–2016



Graphics . . . 00890.10 NBC (3-20-17)

Figure 5-11
Pacific Pond Turtle Detections on Reserves in the Natomas Basin, 2005–2016

Appendix A

NBHCP Reserve Land Cover Data

Appendix A-1. Reserve Lands: Extent (acres) of Each Land Cover Type, 2005–2016

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
North Basin Reserve												
Atkinson[a]												
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
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
Grass hay	–	–	21.3	–	–	–	–	–	–	15.5	15.5	15.5
Grassland (created)	–	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8
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
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
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
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
Ruderal	3.6	3.6	0.7	0.7	0.7	–	–	–	–	–	–	–
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
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
Wheat	21.3	–	–	21.3	–	–	–	–	–	–	–	–
Bennett North												
Fallow	–	67.0	147.8	10.8	10.8	–	–	–	–	–	–	–
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
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
Rice	213.8	146.9	–	137.0	137.0	147.8	147.8	147.8	147.8	147.8	147.7	147.8
Riparian scrub	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
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
Bennett South												
Fallow (including fallow rice)	87.2	–	–	–	–	4.4	26.9	–	13.2	–	–	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
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
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

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

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Rice	–	81.8	82.0	86.4	82.0	59.7	59.5	86.4	73.2	86.4	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
Ruderal	0.8	0.8	–	–	–	–	–	–	–	–	–	–
Bolen North												
Fallow (to allow field leveling)	–	–	–	–	–	–	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
Bolen South												
Alfalfa	–	–	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
Grass hay	–	–	–	–	–	–	–	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
Wheat	–	101.7	57.8	57.8	57.8	57.8	–	–	–	–	–	–
Bolen West												
Fallow (including fallow rice)	–	–	155.1	–	–	–	–	155.1	–	–	–	–
Rice	–	–	–	155.1	155.1	155.1	155.1	–	–	155.1	155.1	155.1
Milo	–	–	–	–	–	–	–	–	155.1	–	–	–
Frazer[b]												
Fresh emergent marsh (created)	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7
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
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
Open water	–	–	–	–	–	–	–	–	2.7	2.7	2.7	2.7
Huffman East												
Alfalfa	–	–	–	–	–	–	15.6	–	–	–	–	–
Fallow	15.6	–	–	–	–	–	–	–	15.6	27.3	14.9	–
Grass hay	–	–	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
Wheat	–	15.6	–	–	15.6	15.6	–	–	–	–	–	–

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

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Huffman West[c]												
Alfalfa	67.9	67.9	67.9	67.9	122.6	44.5	99.5	99.5	99.5	99.5	99.5	99.5
Grass hay							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	–	–	–	–	–	–	–	–
Wheat	113.1	113.1	–	–	58.4	113.3	–	–	–	58.4	–	–
Lucich North[d]												
Fresh emergent marsh (created)	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9	224.9
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
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
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
Seasonal wetland	3.5	3.5	–	–	–	–	–	–	–	–	–	–
Open water	–	–	–	–	–	–	–	–	16.3	16.3	16.3	16.3
Lucich South												
Rice	328.1	328.1	328.1	328.1	328.1	328.1	331.2	331.2	331.2	331.2	331.2	331.2
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
Ruderal	3.1	3.1	3.1	3.1	3.1	3.1	–	–	–	–	–	–
Nestor												
Fallow	–	–	–	233.1	–	233.1	233.1	–	–	–	–	–
Rice	–	–	233.1	–	233.1	–	–	233.1	233.1	233.1	233.1	233.1
Ruby Ranch												
Developed—low density	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
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	–
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

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

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

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Vestal												
Milo	–	–	–	–	–	–	–	–	–	93.9	–	–
Rice	–	93.8	93.8	93.8	93.8	93.8	93.8	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
Central Basin Reserve												
Betts-Kismat-Silva												
Developed—low density	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
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
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
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
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
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
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
Bianchi West												
Rice	–	–	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2	110.2
Elsie												
Fallow	–	–	158.0	–	–	158.0	158.0	–	–	–	–	–
Rice	–	–	–	158.0	158.0	–	–	158.0	158.0	158.0	158.0	158.0
Frazer South												
Fallow	–	–	110.3	110.3	–	–	–	–	–	–	–	–
Rice	–	–	–	–	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3
Sills												
Fallow	11.9	294.5	–	–	–	–	25.6	25.6	25.6	134.6	–	–
Grass hay	–	–	–	–	–	–	–	–	–	25.6	25.6	25.6
Other row and grain crops	–	–	12.3	280.8	–	–	–	–	–	–	–	–
Rice	420.2	137.6	436.4	167.9	448.7	448.7	410.6	410.6	423.1	288.6	423.1	423.1
Sunflower	–	–	–	–	–	–	12.6	12.6	–	–	–	–
Silva South 1												
Nonnative annual grassland									0.2	0.2	0.3	0.3
Rice	–	–	–	–	–	–	–	–	28.8	28.8	28.8	28.8

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tufts												
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
Fisherman's Lake Reserve												
Alleghany												
Alfalfa	27.5	27.5	27.5	27.5	27.5	27.5	–	–	–	–	–	–
Fallow	–	–	–	18.9	6.00	18.9	6.0	0.7	–	–	–	–
Grass hay	18.9	18.9	–	–	12.9	–	12.9	12.9	18.9	18.9	0.7	–
Other row and grain crops	–	–	–	–	–	–	26.8	6.0	26.8	–	26.8	0.7
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
Sunflower	–	–	–	–	–	–	0.7	26.8	0.7	27.5	–	–
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
Wheat	–	–	18.9	–	–	–	–	–	–	–	18.9	45.7
Cummings												
Fallow	17.7	–	–	–	–	–	–	–	–	–	–	–
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
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
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
Safflower	–	–	–	–	–	–	–	–	–	–	–	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
Wheat (hay crop)	–	17.7	–	–	–	–	–	–	–	–	–	–
Natomas Farms[e]												
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
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
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
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

[e] Acreage of reserve decreased in 2011 due to the Sacramento Area Flood Control Agency (SAFCA) acquiring property for the Natomas Levee Improvement Project (NLIP).

Reserve and Land Cover Type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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
Wheat	44.1	44.1	–	–	–	–	–	–	–	–	–	–
Rosa Central												
Alfalfa	–	–	–	–	–	–	–	–	–	100.1	100.1	100.1
Fallow	100.1	–	100.1	–	–	–	44.6	–	–	–	–	–
Grass hay	–	–	–	100.1	100.1	100.1	–	55.4	44.6	–	–	–
Sunflower	–	–	–	–	–	–	55.4	44.6	55.4	–	–	–
Wheat	–	100.1	–	–	–	–	–	–	–	–	–	–
Rosa East												
Alfalfa	–	–	–	–	–	–	–	104.3	104.3	104.3	104.3	104.3
Fallow	104.3	–	–	–	–	–	–	–	–	–	–	–
Other row and grain crops	–	–	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
Safflower	–	–	–	–	104.3	–	67.2	–	–	–	–	–
Sunflower	–	–	–	–	–	104.3	36.7	–	–	–	–	–
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
Wheat	–	104.3	–	–	–	–	–	–	–	–	–	–
Souza												
Alfalfa	10.8	10.8	10.8	10.8	10.8	10.9	10.9	11.0	–	–	–	–
Disturbed/bare	–	–	–	–	–	–	17.7[c]	17.7	–	–	–	–
Fallow	–	12.0	12.0	–	–	–	–	–	–	–	–	11.0
Grass hay	–	–	–	–	–	–	–	–	39.7	16.7	–	–
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
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	–	–
Wheat	28.7	–	–	–	–	–	–	–	–	–	28.7	28.7

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Legend

- Reserve Lands
- NBHCP Area Boundary

Land Cover

- Fresh Emergent Marsh (Created)
- Grassland (Created)
- Non-native Annual Grassland
- Open Water
- Ruderal

N

0.3 0 0.3 Miles

Aerial Source: ESRI/NAIP (2014)

ICF

Figure A-1
North Basin Reserve—Frazer and Lucich North Tracts, 2016

K:\Projects_1\NBC\04002_04\arcmap\report_2016\Appendix_A\FigureA-2_bennett_north_nestor_hab.mxd 19393 Date: 09 Feb 2017/

Legend

Reserve Lands

Land Cover

Alfalfa
Fallow
Fresh Emergent Marsh (Created)
Grassland (Created)
Open Water
Rice
Riparian Scrub
Ruderal

N

0.3 0 0.3 Miles

Aerial Source: ESRI/NAIP (2014)

Figure A-2
North Basin Reserve—Nestor, Bennett North, Bennett South, and Lucich South Tracts, 2016

K:\Projects_1\NBC\04002_04\arcmap\report_2016\Appendix_A\FigureA-3_bolen_hab.mxd 19393 Date: 09 Feb 2017/

Legend

- Reserve Lands
- NBHCP Area Boundary

Land Cover

- Alfalfa
- Fallow
- Grassland (Created)
- Rice
- Ruderal
- Valley Oak Woodland

N

0.2 0 0.2 Miles

Aerial Source: ESRI/NAIP (2014)

ICF

Figure A-3
North Basin Reserve—
Bolen West, Bolen North, and Bolen South Tracts, 2016

K:\Projects_1\NBC\04002_04\arcmapreport_2016\Appendix A\figureA-4_huffmanE_lucsouth_bennetsouthA.mxd 19393_Date: 09 Feb 2017/

Legend

- Reserve Lands
- NBHCP Area Boundary
- County Boundary

Land Cover

- Alfalfa
- Fresh Emergent Marsh (Created)
- Grass Hay
- Grassland (Created)
- Nonnative Annual Grassland
- Other Row and Grain Crops
- Rice
- Riparian Scrub
- Riparian Woodland

N

0.1 0 0.1 Miles

Aerial Source: ESRI/NAIP (2014)

Figure A-4
North Basin Reserve—Huffman West and Huffman East Tracts, 2016

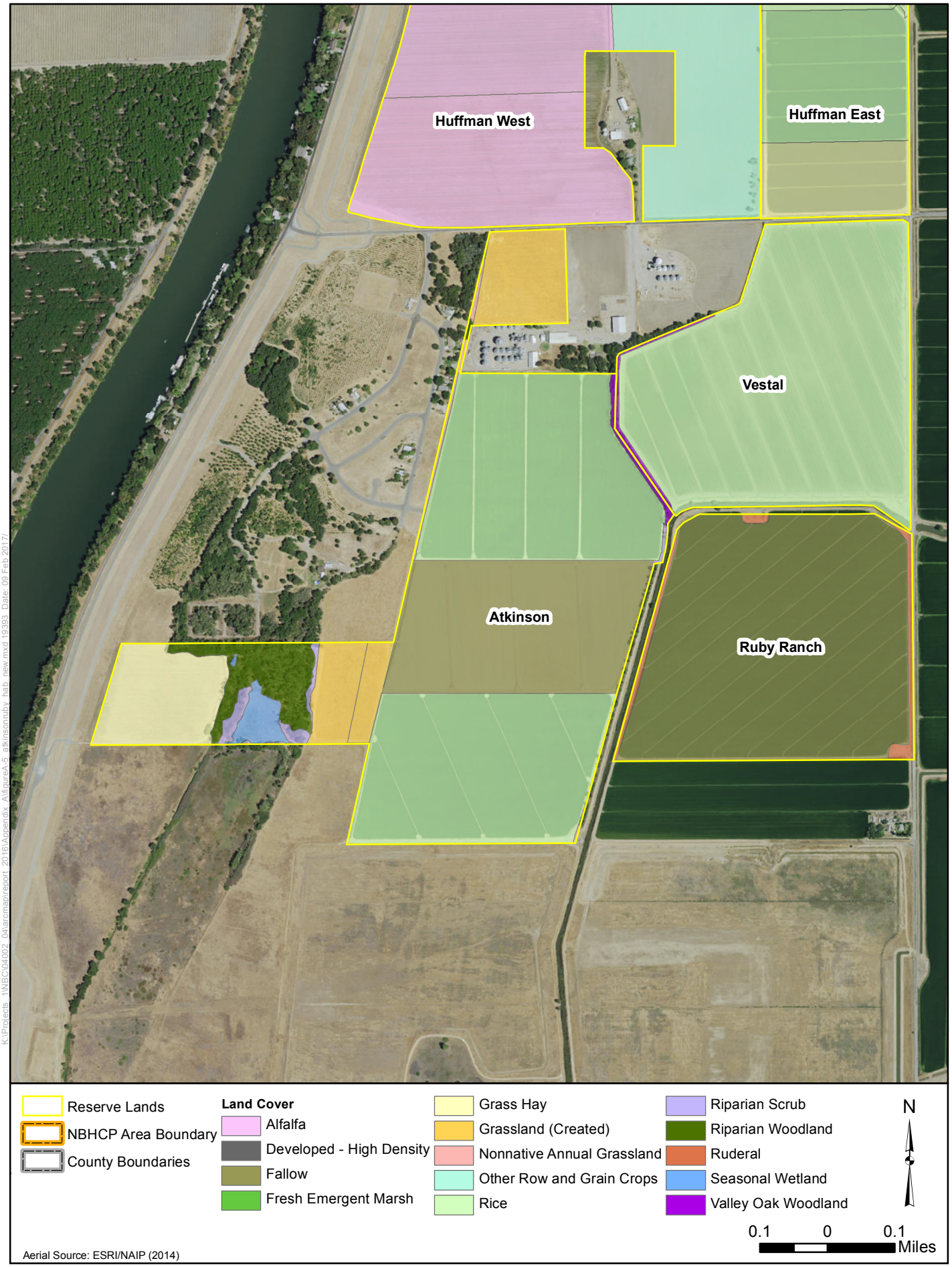
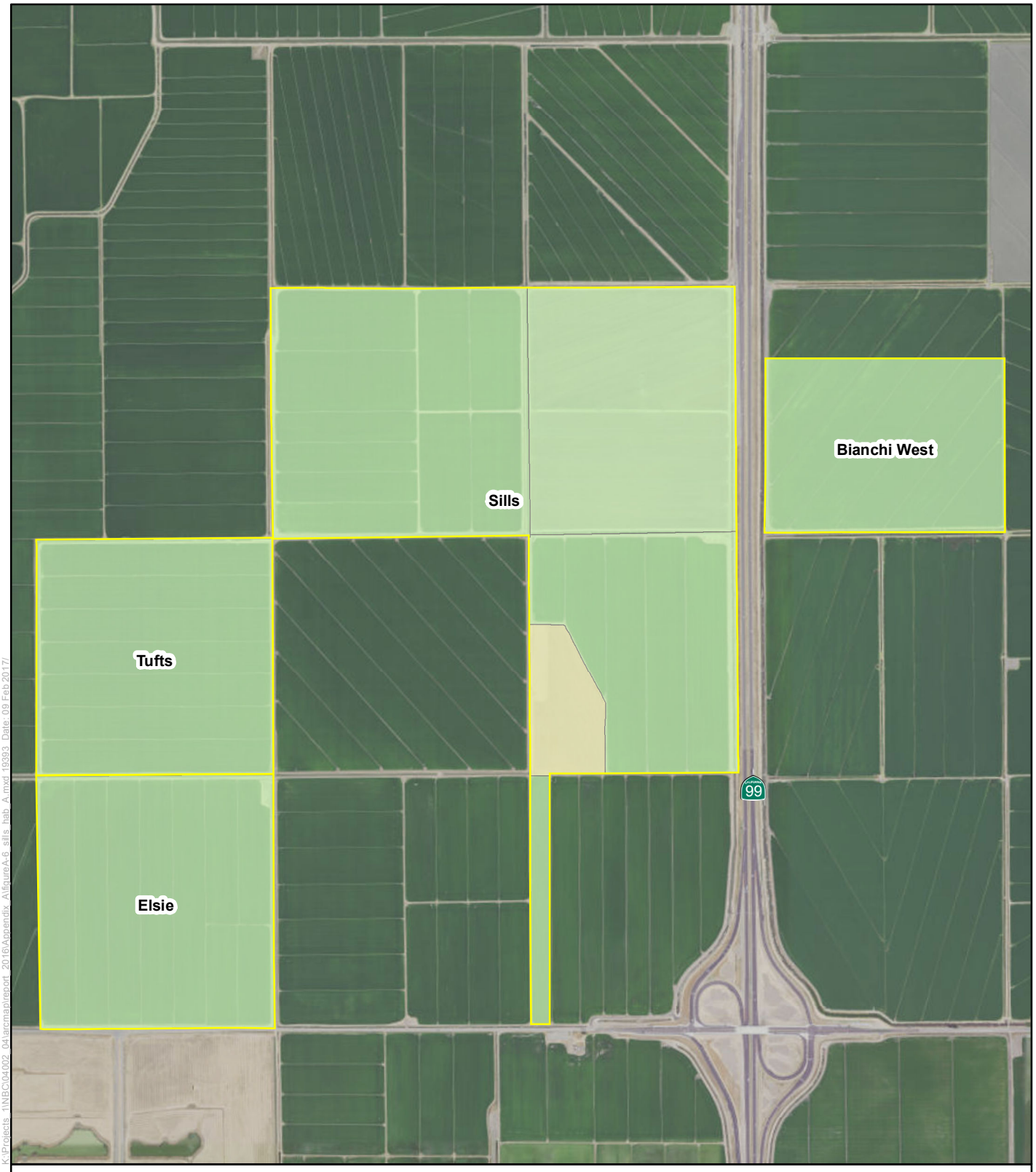


Figure A-5
North Basin Reserve—Atkinson, Vestal, and Ruby Ranch Tracts, 2016



K:\Projects_11NBC\04002_04\arcmap\report_2016\Appendix_A\figureA-6_sills_hab_A.mxd 19393_Date: 09 Feb 2017/

Legend

Reserve Lands
Major Road
County Boundary

Land Cover

Grass Hay
Open Water
Rice

N

0.3 0 0.3 Miles

Aerial Source: ESRI/NAIP (2014)

ICF

Figure A-6
Central Basin Reserve—Elsie, Sills, Bianchi West, and Tufts Tracts, 2016

K:\Projects_1\NBC\04002_04\arcmap\report_2016\Appendix_A\figureA-7_bks_hab.mxd 19393_Date: 09 Feb 2017/

Legend

- Reserve Lands
- County Boundary
- NBHCP Area Boundary

Land Cover

- Developed
- Fresh Emergent Marsh (Created)
- Nonnative Annual Grassland
- Nonriparian Woodland
- Rice
- Riparian Scrub
- Riparian Woodland
- Seasonal Wetland

N

0.2 0 0.2 Miles

Aerial Source: ESRI/NAIP (2014)

Figure A-7
Central Basin Reserve—Frazer South, Betts, Kismat, Silva, and Silva South 1 Tracts, 2016

K:\Projects_1\NBC\04002_04\arcmap\report_2016\Appendix_A\figureA-8_souza_nat_Rosa_hab.mxd 19393 Date: 09 Feb 2017/

Legend

Reserve Lands

NBHCP Area Boundary

Land Cover

- Alfalfa
- Fallow
- Fresh Emergent Marsh (Created)
- Grassland (Created)
- Nonnative Annual Grassland
- Nonriparian Woodland
- Open Water
- Riparian Woodland
- Ruderal
- Valley Oak Woodland
- Wheat

N

0.2 0 0.2 Miles

Aerial Source: ESRI/NAIP (2014)

ICF

Figure A-8
Fisherman's Lake Reserve—Rosa Central, Rosa East, Souza, and Natomas Farms Tracts, 2016

K:\Projects_1\NBC\04002_04\arcmap\report_2016\Appendix_A\figureA-9_all50_cummings_hab.mxd 19393 Date: 09 Feb 2017/

Legend

- Reserve Lands
- NBHCP Area Boundary

Land Cover

- Fresh Emergent Marsh (Created)
- Grassland (Created)
- Other Row and Grain Crops
- Row Crops
- Ruderal
- Valley Oak Woodland
- Wheat

N

0.1 0 0.1 Miles

Aerial Source: ESRI/NAIP (2014)

ICF

Figure A-9
Fisherman's Lake Reserve—Cummings and Alleghany Tracts, 2016

Appendix B

Floristic Survey Results

Appendix B. Cumulative List of Plant Species Observed on the Natomas Basin Conservancy Reserves, 2004–2016

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

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

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

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

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		Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*Festuca bromoides (Vulpia bromoides)**	Foxtail fescue			X					X							X							X			
Festuca microstachys (Vulpia microstachys)	Small fescue		X					X			X	X											X	X		
*Festuca myuros (Vulpia myuros)**	Rattail fescue		X					X								X										
*Festuca perennis (Lolium multiflorum)**	Italian ryegrass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Glyceria occidentalis	Sweet flotegrass			X				X			X	X		X		X	X		X	X					X	
*Holcus lanatus**	Velvetgrass										X													X		
Hordeum brachyantherum	Meadow barley		X					X			X	X				X							X	X		
Hordeum marinum ssp. *gussoneanum**	Mediterranean barley							X			X						X		X	X				X		
*Hordeum murinum**	Foxtail barley	X	X	X			X	X		X	X	X	X	X		X	X	X	X	X		X	X	X	X	X
Leersia oryzoides	Rice cutgrass							X			X															
Leptochloa fusca subsp. *Fascicularis (Leptochloa fascicularis)*	Bearded sprangletop	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							X	X	X	
Muhlenbergia rigens	Deergrass															X										
*Oryza sativa**	Rice	X	X	X	X		X		X			X	X	X			X	X	X	X	X				X	
*Paspalum dilatatum**	Dallisgrass	X	X	X	X		X	X	X		X	X	X	X		X	X	X	X		X	X			X	
Paspalum distichum	Knotgrass	X	X	X	X						X	X		X		X								X	X	
*Phalaris aquatica**	Harding grass																X					X				
*Phalaris minor**	Littleseed canarygrass	X	X					X	X	X	X									X			X	X	X	X
*Phalaris paradoxa**	Paradox canarygrass			X							X	X				X						X		X		
*Poa annua**	Annual bluegrass		X		X		X	X		X	X	X		X		X				X		X	X	X		

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*Polypogon interruptus**	Ditch beard grass	X	X			X		X			X												X	X		
*Polypogon monspeliensis**	Rabbit's-foot grass	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X		X	X	X	X	
*Setaria pumila**	Yellow bristle grass		X							X		X				X								X		
*Sorghum bicolor**	Milo	X								X																
*Sorghum halepense**	Johnsongrass	X	X	X	X	X	X	X	X		X		X	X	X		X	X	X	X		X	X	X	X	
Sporobolus indicus	Small smutgrass															X										
Stipa pulchra (Nassella pulchra)	Purple needlegrass		X													X										
*Triticum aestivum**	Wheat					X																		X		X
Pontederiaceae	**Mud Plantain Family**																									
*Heteranthera limosa**	Ducksalad							X			X			X												
Typhaceae	**Cattail Family**																									
Typha angustifolia	Narrow-leaved cattail			X					X											X						
Typha domingensis	Southern cattail	X	X	X	X	X	X	X				X	X		X		X	X	X		X		X	X	X	X
Typha latifolia	Broadleaf cattail		X	X				X	X		X	X	X	X		X		X	X	X	X		X	X		
DICOTYLEDONS																										
Aceraceae	**Maple Family**																									
Acer negundo	Box-elder					X																	X	X		
Adoxaceae	**Muskroot Family**																									
Sambucus nigra subsp. *canadensis (Sambucus mexicana)*	Blue elderberry	X																					X			
Amaranthaceae	**Amaranth Family**																									
*Amaranthus albus**	Pigweed amaranth															X										
Amaranthus sp.	Amaranth				X	X				X													X			

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Anacardiaceae	**Sumac Family**																									
Toxicodendron diversilobum	Poison-oak	X				X																				
Apiaceae	**Carrot Family**																									
*Ammi visnaga**	Bisnaga		X			X		X			X															
*Conium maculatum**	Poison hemlock																								X	
*Daucus carota**	Wild carrot								X																	
*Foeniculum vulgare**	Sweet Fennel									X												X		X	X	
*Torilis arvensis**	Hedge parsley	X																				X				
Araliaceae	**Ginseng Family**																									
*Hedera helix**	English ivy																									X
Asclepiadaceae	**Milkweed Family**																									
Asclepias fascicularis	Narrow-leaf milkweed															X								X		
Asteraceae	**Sunflower Family**																									
Achyrachaena mollis	Blow-wives			X								X				X				X				X		
Ambrosia sp.	Ragweed					X		X			X															
*Anthemis cotula**	Mayweed							X			X															
Baccharis pilularis	Coyote brush	X	X									X				X							X	X		
Baccharis salicifolia	Mulefat															X										
*Carduus pycnocephalus**	Italian thistle											X		X		X						X				
*Centaurea solstitialis**	yellow star-thistle	X	X	X				X	X	X	X	X		X	X	X	X			X	X	X				
Centromadia fitchii	Fitch's spikeweed			X		X										X										
*Cichorium intybus**	Chicory			X					X	X		X				X						X		X		
*Cirsium vulgare**	Bull thistle		X	X	X	X	X		X		X	X	X		X	X						X	X		X	X

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

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

Scientific Name (previous scientific name)[a]	Common Name	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
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Planodes virginicum (Sibara virginica)	Common rockcress															X							X			
*Raphanus sativus**	Wild radish	X	X	X		X			X		X	X	X			X						X	X	X	X	X
Rorippa curvisiliqua	Westwen yellowcress	X	X					X			X	X								X						
*Sinapis arvensis**	Charlock mustard		X			X					X									X				X		
*Sisymbrium officinale**	Hedge mustard				X	X																				
Callitrichaceae	**Water-Starwort Family**																									
Callitriche marginata	Water-starwort			X																						
Caryophyllaceae	**Pink Family**																									
*Cerastium glomeratum**	Mouse-ear chickweed			X																						
*Spergularia rubra**	Red sandspurry			X								X				X										
*Stellaria media**	Common chickweed							X						X		X				X			X	X		
Ceratophyllaceae	**Hornwort Family**																									
Ceratophyllum demersum	Hornwort								X		X	X											X			
Chenopodiaceae	**Goosefoot Family**																									
*Chenopodium album**	White goosefoot										X															
Chenopodium sp.	Goosefoot				X	X										X				X			X			X
*Salsola tragus** *(previous family – Asteraceae)*	Russian thistle, tumbleweed										X		X			X								X		
Convolvulaceae	**Morning Glory Family**																									
*Convolvulus arvensis**	Field bindweed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Cressa truxillensis	Alkali weed													X		X						X		X		
Crassulaceae	**Stonecrop Family**																									
Crassula aquatica/solieri	Water pygmy-weed										X	X														

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

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Trifolium gracilentum	Pinpoint clover															X										
*Trifolium hirtum**	Rose clover									X														X		
*Trifolium pratense**	Red clover															X										
*Trifolium repens**	White clover															X							X			
*Trifolium subterraneum**	Subterranean clover															X										
*Vicia sativa**	Common vetch			X						X				X		X				X						
*Vicia villosa**	Hairy vetch		X					X		X	X	X				X							X	X		
Fagaceae	**Oak Family**																									
Quercus lobata	Valley oak	X		X		X						X		X	X	X						X	X	X	X	X
Gentianaceae	**Gentian Family**																									
Zeltnera muehlenbergii (Centaurium muehlenbergii)	Monterey centaury			X				X	X		X												X			
Geraniaceae	**Geranium Family**																									
*Erodium botrys**	Big stork's-bill		X	X	X		X		X			X	X			X	X	X	X							
*Erodium cicutarium**	Red-stemmed filaree		X		X		X	X	X	X	X	X	X		X	X	X	X	X					X		
*Erodium moschatum**	White-stemmed filaree	X	X					X	X	X	X			X		X				X		X				
*Geranium dissectum**	Cut-leaf geranium	X	X	X	X		X	X	X	X	X		X	X		X	X	X	X	X		X	X	X		
*Geranium molle**	Dove's-foot geranium										X					X										
Haloragaceae	**Water-Milfoil Family**																									
Myriophyllum sp.	Water milfoil							X	X																	
Juglandaceae	**Walnut family**																									
Juglans hindsii (Juglans californica var. *hindsii)*	California black walnut															X						X	X	X		X

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Lamiaceae	**Mint Family**																									
*Lamium amplexicaule**	Henbit deadnettle									X		X								X						
Lycopus americanus	American bugleweed							X																		
*Mentha pulegium**	Pennyroyal										X					X										
Stachys ajugoides/albens	Hedge nettle	X																								
Trichostema lanceolatum	Vinegarweed			X												X										
Lythraceae	**Loosestrife Family**																									
Ammannia coccinea/robusta	Redstem	X		X	X		X	X			X	X				X							X	X	X	
*Lythrum hyssopifolia**	Hyssop loosestrife	X	X	X	X	X	X	X	X	X	X	X				X				X			X	X		
Malvaceae	**Mallow Family**																									
*Abutilon theophrasti**	Velvet-leaf	X			X	X	X	X		X	X	X										X	X	X	X	X
*Malva neglecta**	Common mallow		X		X		X	X					X				X	X	X			X				
*Malva nicaeensis**	Bull mallow	X	X	X		X		X	X		X	X	X	X		X				X			X	X	X	
Malvella leprosa	Alkali mallow	X	X	X	X	X	X	X	X	X	X			X	X	X	X		X	X	X	X		X	X	
*Modiola caroliniana**	Carolina bristle-mallow															X										
Montiaceae (Split from Portulacaceae)	**Miner's Lettuce Family**																									
Calandrinia ciliata	Red maids		X	X				X	X	X	X	X		X						X			X	X		
Claytonia perfoliata	Miner's lettuce			X										X		X								X		

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

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

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

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Rhamnaceae	**Buckthorn Family**																									
Frangula californica (Rhamnus californica)	California coffeeberry																							X		
Rosaceae	**Rose Family**																									
*Pyracantha angustifolia**	Firethorn															X										
Rosa californica	California wild rose	X	X	X												X						X				
*Rubus armeniacus**	Himalayan blackberry	X			X	X			X	X					X	X						X	X	X	X	X
Rubus ursinus	California blackberry	X	X			X						X				X						X	X	X		X
Rubiaceae	**Madder Family**																									
Cephalanthus occidentalis var. *californicus (formally in Rosaceae family)*	Buttonwillow		X	X				X			X	X										X	X		X	
Galium aparine	Bedstraw	X		X					X													X	X			X
Salicaceae	**Willow Family**																									
Populus fremontii	Fremont cottonwood	X		X		X		X	X	X	X			X		X						X	X	X	X	
Salix exigua	Narrow-leaved willow	X	X	X																						
Salix gooddingii	Black willow	X		X				X	X		X	X				X							X	X	X	
Salix lasiolepis	Arroyo willow	X		X								X											X		X	
Scrophulariaceae	**Figwort Family**																									
Limosella acaulis	Broad-leaved mudwort							X			X															
Simaroubaceae	**Quassia Family**																									
*Ailanthus altissima**	Tree-of-heaven															X										
Solanaceae	**Nightshade Family**																									
*Datura stramonium**	Jimson weed	X																					X			

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*Lycopersicon esculentum**	Tomato								X																	
*Physalis lancifolia**	Narrowleaf tomatillo	X	X										X			X									X	
*Physalis philadelphica**	Tomatillo							X			X					X										
Solanum americanum	Common nightshade			X	X	X					X		X	X		X									X	
Urticaceae	**Nettle Family**																									
*Urtica urens**	Dwarf nettle																						X			
Verbenaceae	**Vervain Family**																									
Phyla nodiflora var. *nodiflora*	Turkey tangle fogfruit										X					X										
*Verbena bonariensis****	Purpletop vervain		X		X	X	X	X			X	X	X				X	X	X							
Viscaceae	**Mistletoe Family**																									
Phoradendron serotinum (Phoradendron villosum)	Oak mistletoe	X																								
Vitaceae	**Grape Family**																									
Vitis californica	California wild grape	X																				X	X	X	X	
Zygophyllaceae	**Caltrop Family**																									
*Tribulus terrestris**	Puncture vine								X			X														
Total plant taxa for reserve		**96**	**84**	**96**	**53**	**53**	**45**	**108**	**64**	**56**	**123**	**94**	**46**	**53**	**26**	**158**	**42**	**35**	**41**	**53**	**19**	**60**	**81**	**101**	**58**	**32**

* Nonnative species.

Appendix C

Avian and Other Covered Species Survey Results

Appendix C-1. Common and Scientific Names of Wildlife Species Observed on NBHCP Reserves, 2004–2016

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

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

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

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

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

Appendix C-2. Total Numbers of Birds Detected on NBHCP Mitigation Lands during 2016 Avian Surveys

	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve					SAFCA			
Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	Betts Kismat Silva	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany 50	Cummings	Natomas Farms	Rosa Central	Souza	AKT	Sharma	Natomas Farms West	**Total**
Greater white-fronted goose		101	180	120			280	231		2012		289	140		600	10													3963
Snow goose		1						1350				3				3000													4354
Canada goose		146					52			183					268			2				16		138	2	40	187	24	1058
Tundra swan		29	90					165	4				48						12										348
Wood duck							3			5												4		4		5	1	23	45
American wigeon		10					12			20					22														64
Mallard	2	265	72	94		6	524	37		1679	142	9			709	77	6	23	19	2		36	19	3		142	200	47	4113
Blue-winged teal																											2		2
Cinnamon teal		16	4				12			97					75			3								3	2		212
Northern shoveler										2	210				62	60											2		336
Northern pintail		10		320						10	280					4													624
American green-winged teal							10			14					8														32
Canvasback		10													4														14
Redhead															8														8
Greater Scaup							4								8														12
Bufflehead							6								107											2			115
Common goldeneye		4					8								2							18	46			9	2	2	91
Common merganser																											3	23	26
Ruddy duck							1			2					45														48
Ring-necked pheasant	1		1																					1					3
Wild turkey	174												1																175
California quail	66				15																21			7					109
Pied-billed grebe		15	15				21			50					144							9	13			5	15	12	299
Eared grebe																											1		1
American white pelican		2								36					40														78
Double-crested cormorant		43	4				9			75	8	2			129			1				2	7			17	52	11	360
American bittern				1		1		2		1		1			2	1		1				1							11
Great blue heron	4	27	22	12	2	11	21	17	1	37	35	11	7	6	51	14	5	14	17	9		6	9	10		13	31	16	408
Great egret	86	30	40	31	1	25	31	30	4	127	95	77	11	30	100	36	12	9	62	20		7	13	20		11	12	2	922
Snowy egret		2	2							19	1			1	144	13		4	4	1		4	4			64	27	1	291
Cattle egret														2															2
Green heron															1							3	1			2		2	9
Black-crowned night-heron	2		23				11	7		10	32	1		3	635	3	1	1	2				1				1	1	734
White-faced ibis		2				60	41			26	227	624		54	667	84		12	90	6									1893
Turkey vulture	3		9		1		1	1		4					1				1					1			1	1	24
Osprey																											1		1
White-tailed kite	8														9							2		7					26
Bald eagle					1																								1

Appendix C-2. Continued

	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve					SAFCA			
Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	Betts Kismat Silva	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany 50	Cummings	Natomas Farms	Rosa Central	Souza	AKT	Sharma	Natomas Farms West	**Total**
Northern harrier	4	6	5	1	2	2	2	2		7	4	9		1	7	2	6	1	4	5		2	5	4		1			82
Cooper's hawk	4	1			2		1				1				3				2				1		1				16
Red-shouldered hawk	1	1	1			1			1	1	2			3	2							1	2				1		17
Swainson's hawk					2										1		1					1		4					9
Red-tailed hawk	22	10	8	1	5	4	6	3	3	15	19	4	1	4	36	4	2	13	10	3	2	5	1	4		1	2		188
American kestrel	10	1			2	1	4	5	8	2	2	2	2	1	8			5				8	1	10	7	2	1	2	84
Peregrine falcon	1																												1
Prairie falcon													2																2
Virginia rail															1														1
Sora							1								1				1								2	1	6
Common moorhen		6								12					32								3			45	25	39	162
American coot		257	21	270			137			473	706	650			2105	520		564	1			44	1	4		46	58	32	5889
Killdeer	20	86	36	18	10	10	16	4	2	54	31	64	9	3	137	27		29	24	2	3	10	16			9	1	3	624
Black-necked stilt										8					83	3													94
American avocet						1									19														20
Greater yellowlegs		56	37	12		25		8		189	14	82			64	3		3	1	28			1						523
Long-billed curlew		1		1	175			20			15				1	79		50						13					355
Western sandpiper											40	20			5														65
Least sandpiper						30					57	102			42	16		24	40	20									331
Dunlin			150			60				60	80																		350
Long-billed dowitcher			30							245	210	600			980					12									2077
Wilson's snipe											2						1						1					2	6
Ring-billed gull		1		25				46			20	34			30	16													172
California gull									1	2	1				25			1	1								3		34
Rock pigeon																1											10		11
Eurasian collared-dove					2										39														41
Mourning dove	95	3	14	4	16	21			9	6	1	1	21	3	215	1		6			41	93	11	4	25	18	10	57	675
Great horned owl	3	1	4								1				5						1								15
Burrowing owl																	2		1	1									4
Short-eared owl												5																	5
Anna's hummingbird			1												1						2	2	3						9
Belted kingfisher	1		1				2		2	4	3		1		3					1		2	8	6			11	4	49
Nuttall's woodpecker	28																				2	6	1	1	1				39
Northern flicker	21														2						4	6	2	9	1				45
Western wood-pewee	7																												7
Black phoebe	19	6	8		12	2	20	2	3	32	5	2	4	4	56			2	2		8	24	13	15	7	8	8	3	265
Say's phoebe														1					1		2	2		4	3		1		14
Western kingbird	30	1	2		23	1	2		18	9	2		1		13							3	1	18	6	6	3	2	141

Appendix C-2. Continued

	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve					SAFCA			
Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	Betts Kismat Silva	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany 50	Cummings	Natomas Farms	Rosa Central	Souza	AKT	Sharma	Natomas Farms West	**Total**
Loggerhead shrike	4										1													4					9
Western scrub-jay	56				3																23	14	1		1				98
Yellow-billed magpie					2										3						9			2					16
American crow	52		6		4			66	74		7		6	9	4		9					26	12	486	10	3	3		777
Common raven			2												4														6
Horned lark									40			25							14	43									122
Tree swallow	50		2		8		2	2	6	30	4			3	121		7		6	10			1	10			2	1	265
Cliff swallow				3	50	6	42	16		19	26	5			200						5	50	53	70		356	128	12	1041
Barn swallow	1	12	4	4		1	36		8	18			8		68					1		27	3	8		9	5	1	214
Oak titmouse	6													1							1	5							13
Bushtit	18																					20		10	15				63
White-breasted nuthatch																						1							1
House wren	24																				3	10		1					38
Marsh wren		38	22				50	1		76	29				220							1	12			91	115	83	738
Ruby-crowned kinglet	3																				2	4							9
Western bluebird	35				1		2		3				1									2		2		2			48
Hermit thrush																						1							1
American robin	10								9					1	2						10	6		9					47
Northern mockingbird	23	2		2					3				3		19						6	3	14	31	4	3	4		117
European starling	109				68				410				50	10	257				75		49	125	10	152	4	28			1347
American pipit	2	74	63	90	21	72	44	45	71	139	186	64	32	92	69	115	22	54	107	61	23	13	7	56	5	47	26	35	1635
Cedar waxwing	21																							8					29
Yellow-rumped warbler	7				3										25						17	26	26	11		6	7	7	135
Common yellowthroat	1																					3	4				1		9
Wilson's warbler																						1							1
MacGillivray's warbler	1																												1
Spotted towhee	20																				1	5		1					27
California towhee	8														1						2	2	1		1				15
Lark sparrow	23								70					12						2	2				1				110
Savannah sparrow	221	278	180	199	83	180	57	118	112	33	280	229	89	50	140	83	216	72	335	135	12	21	29	102	3	11	7	23	3298
Fox sparrow	1				1																			1					3
Song sparrow	1	2	25				10		1	33	9				43							17	9			10	1		161
White-crowned sparrow	85	72	167		49		28			95	49				224			90			20	86	45	102	90	31	14		1247
Golden-crowned sparrow	76				12										20						5	8	11	40					172
Dark-eyed junco					12									8	2						14	34							70
Red-winged blackbird	467	1074	2095	271	47	32	742	2420	883	2740	7095	174	283	322	7440	50	38	744	81	42	133	828	244	15	27	323	22	93	28725
Tricolored blackbird								1	5	70	10	50			51			20					25			1			233
Western meadowlark	162	366	166	205	10	56	195	59	262	127	100	94	33	4	372	56	32	24	131		2	19	23	79	9	52	8	28	2674

Appendix C-2. Continued

	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve					SAFCA			
Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	Betts Kismat Silva	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany 50	Cummings	Natomas Farms	Rosa Central	Souza	AKT	Sharma	Natomas Farms West	**Total**
Yellow-headed blackbird		2							5	20	7				14			35											83
Brewer's blackbird	109	149	500	82	50	25		398	299	58	1122	426	293	89	242	30	200	18	173	30	21	31		27					4372
Great-tailed grackle										3					51	1													55
Brown-headed cowbird	21	12	42		2		11	50	4	18	27		33	10	148		1	22			1	7	5	1		3	1		419
Bullock's oriole	8													1										2					11
House finch	174	13	37	90	33	15	68	2	14	304	56	4	33	52	101			34	25		33	166	48	40	70	24	15	12	1463
Lesser goldfinch	6										12											3	1						22
American goldfinch																					1	89	1	8			12		111
House sparrow	4	1									1		2		38														46
Total	2421	3245	4091	1856	730	648	2525	5108	2335	9311	11267	3663	1114	780	17636	4309	561	1881	1242	434	481	1971	769	1565	293	1449	1047	605	83337