Biological Effectiveness Monitoring for the Natomas Basin Habitat Conservation Plan Area

2013 ANNUAL SURVEY RESULTS

April 2014

the NATOMAS BASIN conservancy

Biological Effectiveness Monitoring for the Natomas Basin Habitat Conservation Plan Area 2013 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
Permit 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 length
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

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 Covered Species that could result from urban development and certain activities associated with implementation of the conservation activities required as mitigation.

The overall goal of the NBHCP is to minimize incidental take of Covered Species in the permit 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, with both wetland and upland components, that will support viable populations of Swainson's hawk, giant gartersnake, and other species covered under the Plan.

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

To achieve the goals of the Plan, TNBC has retained ICF International (ICF; formerly 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.

[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.

By the end of 2012, 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 Natomas Basin is a low-lying area of the Sacramento Valley in the northern portion of Sacramento County and the southern portion of Sutter County (Figure 1-1). The 54,206-acre (21,666-hectare) NBHCP Area (also referred to as the *permit 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 permit area contains incorporated and unincorporated areas under the jurisdictions of the City of Sacramento, Sacramento County, and Sutter County. The southern portion of the Basin is mostly urbanized, but most of the remainder is still agricultural.

1.1.2 Setting

The Natomas Basin is within the historical floodplain of the Sacramento and American Rivers. Prior to agricultural conversion, the Basin consisted of wetlands, narrow streams with associated riparian vegetation, shallow lakes, and grasslands on the higher terraces along the Basin's eastern edge. During the late 1800s and early 1900s, most of the Basin was converted to agriculture. Most native habitats were removed, and channelized water delivery and drainage systems replaced the natural stream corridors.

The central and northern portions are the lowest areas of the Basin. With deep clay soils, the flat and largely treeless terrain is characterized primarily by rice farming (Figure 1-3). Very few trees or other vegetation types are present, with the exception of areas along the Natomas Cross Canal on the Basin's northern boundary. This area supports a mature riparian forest and wetland complex throughout its length (Figure 1-3).

Situated primarily on alluvial soils, the southern and western portions of the Basin are characterized by a mixture of row, grain, and hay crops. Throughout this area, small remnant stands of valley oak woodland and remnant patches of riparian woodland, such as those along Fisherman's Lake, persist in an otherwise entirely agricultural area (Figure 1-4). The Sacramento River, on the Basin's western edge, supports mature cottonwood-dominated riparian forest. The southern portion of the Basin has largely been converted to urbanized uses, primarily residential development (Figure 1-5).

The eastern edge is on a terrace slightly higher than the rest of the Basin. This area, consisting primarily of loam and clay-loam soils and gently rolling topography, is characterized by annual grasslands and both dry and irrigated pastures. It is bordered on the east by Steelhead Creek (formerly known as the Natomas Main Drainage Canal and the East Main Drainage Canal), a channelized drainage that supports 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 permit area in order to evaluate the effectiveness of the NBHCP in terms of sustaining populations of Covered Species in the Basin.
- Evaluate the effectiveness of the design and management of reserves.
- 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 10(a)(1)(B) permit.

1.2.2 Covered Species

The NBHCP covers a total of 22 species. These 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; the preponderance of the monitoring effort is devoted to these two species. Accordingly, 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 Species,* 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 Implementing Agreement require that monitoring be conducted in accordance with conditions of the 10(a)(1)(B) permit from USFWS and the 2081 permit from DFG. Accordingly, 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 constitutes the baseline and foundation for all the monitoring efforts. Land cover mapping is conducted both Basin-wide and on reserves. The mapping efforts on reserves 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 extent that will continue through the permit term.

Floristic surveys were initiated in 2004. These surveys are conducted on reserves to monitor the vegetative composition of the reserves, to assess changes in vegetation over time, and to note any occurrence of covered plant species.

Noxious weed surveys were also initiated in 2004. These surveys are conducted on reserves to monitor the presence and extent of populations of such species. The presence of noxious weed populations can affect the ability of 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. However, to address issues associated with the low capture probabilities typically encountered with giant gartersnake, the monitoring protocol was modified in 2011. Chapter 3, *Giant Gartersnake*, details 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 these 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. Surveys on reserve lands include surveys to evaluate the extent to which the NBHCP is meeting its objectives for Other Covered Species. Surveys for Other Covered Species on non-reserve lands are conducted to assess changes in populations over time and to evaluate the extent to which reserve lands are meeting the objective of providing habitat for viable populations of Other Covered Species. The methodologies and results of these surveys are discussed in detail in Chapter 5, *Other Covered Wildlife Species*.

1.3 Summary of the 2013 Biological Effectiveness Monitoring Program Results

Changes in the major land cover types from 2012 to 2013 were relatively minor. Habitats that support giant gartersnake (ricelands and wetlands) increased slightly due to greater rice production, while habitats that support foraging Swainson's hawk decreased slightly.

Disturbance associated with construction of the Sacramento Area Flood Control Agency's (SAFCA's) Natomas Levee Improvement Program (NLIP) has been a potentially significant factor affecting populations of covered species over the last 2 years but was relatively minor in 2013 due to the cessation of construction activities. The establishment of native grasslands on disturbed and bare sites between Elverta Road and Riego Road along the sides of the new setback levee contributed to an increase in grasslands habitats in 2013. However, although construction of the fresh emergent marsh habitats in the Fisherman's Lake Reserve area were completed in 2012, vegetation had not established to the point where these marshes constituted habitat for covered species.

Estimates of abundance of giant gartersnake from the five abundance monitoring sites using closed population models (i.e., models that assume no change in the population from emigration, immigration, birth, or death over the period the sample is taken) decreased from 2012 to 2013 at all sites except Sills. For the first time since monitoring began, open population models (i.e., models that allow for emigration, immigration, birth, and death) could be used to estimate demographic rates. The population growth rates showed a decrease at all sites over the period 2011–2013 except Lucich South (and Natomas Farms, which had too few captures to fit an open population model). The recruitment rates were up at two sites and down at two sites. The occupancy monitoring models indicated a strong positive effect of emergent vegetation on the probability of a site being occupied by giant gartersnake.

The number of Swainson's hawk pairs in the Basin decreased slightly in 2013 from the record high number of pairs observed in 2012. However, all measures of reproductive success declined to the lowest levels recorded since comprehensive monitoring began.

The mean number of loggerhead shrike detections on reserves shows a slightly increasing trend over the monitoring period 2005–2013, while the mean number of detections during Basin-wide surveys shows a slightly decreasing trend. The numbers of white-faced ibis using the Basin has generally remained stable or increased slightly since this species first established a nesting colony within the Basin. Ibis nested on the Willey Wetland Preserve again in 2013. The proportion of surveys in which tricolored blackbirds are detected has decreased slightly on reserve lands over the monitoring period 2005–2013, and more steeply on Basin-wide surveys. Tricolored blackbirds did not nest in the Basin in 2013. The mean number of burrowing owls detected on reserves has been decreasing since 2009, when a record number of owls were observed on the Elsie and Tufts tracts. Burrowing owls had abandoned these sites by November 2012 and did not return until August 2013. Burrowing owls on non-reserve lands decreased slightly from the record highs observed in 2012. A large western pond turtle was documented using the Frazer tract for the first time in 2013.

1.4 References

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

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

ICF Jones & Stokes. 2009. *Natomas Basin Habitat Conservation Plan Area Biological Effectiveness Monitoring Program*. October. (ICF J&S 00164.07.) Sacramento, CA. Prepared for The Natomas Basin Conservancy.

Table 1-1. Reserve Lands Acquired under the NBHCP as of December 2013[a]

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[c]**

Source: The Natomas Basin Conservancy 2013.

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

[c] 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	*Gratiaola heterosepala*
Sacramento Orcutt grass	*Orcuttia viscida*
Slender Orcutt grass	*Orcuttia tenuis*
Legenere	*Legenere limosa*

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

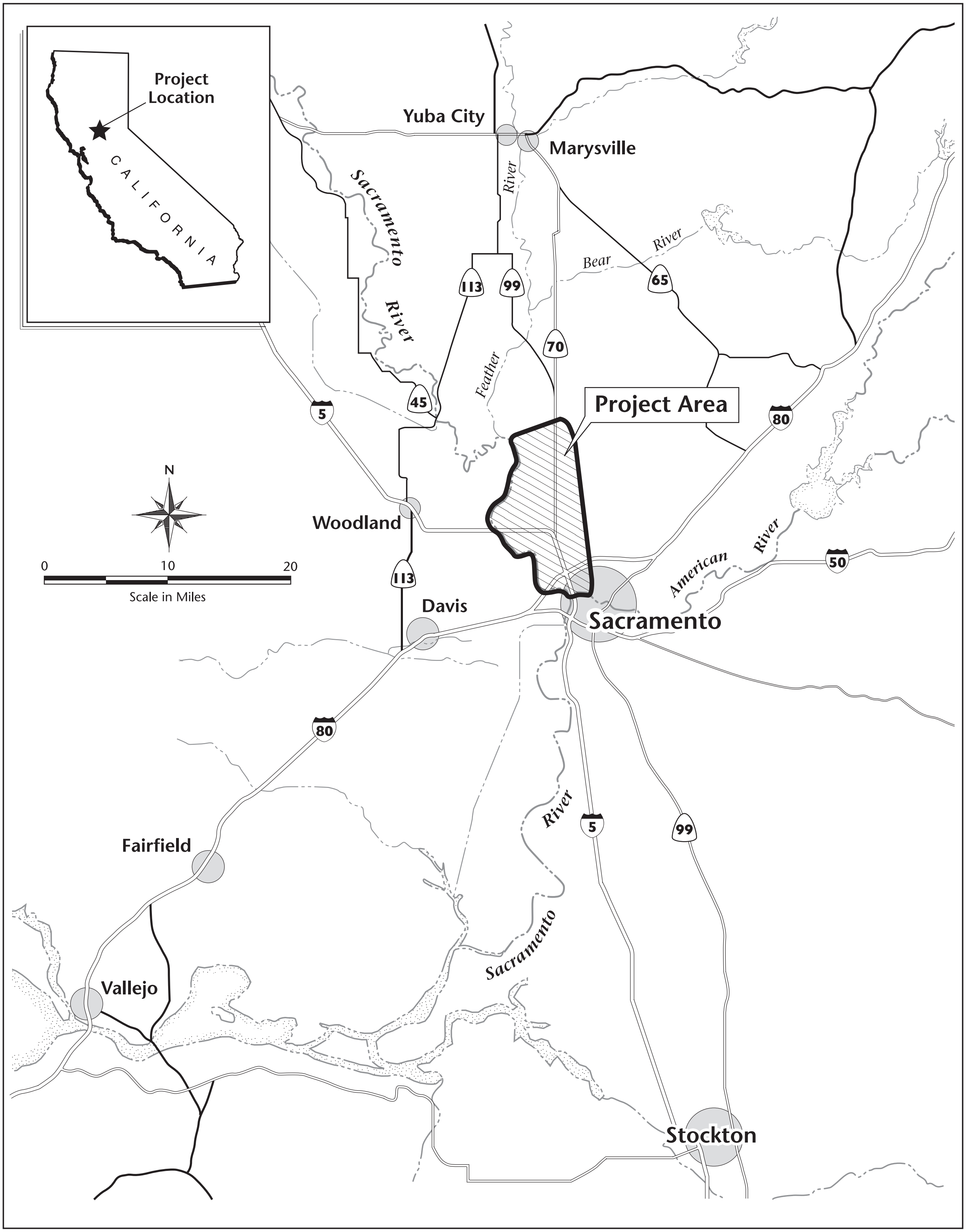

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Figure 1-1
Natomas Basin
Regional Location Map

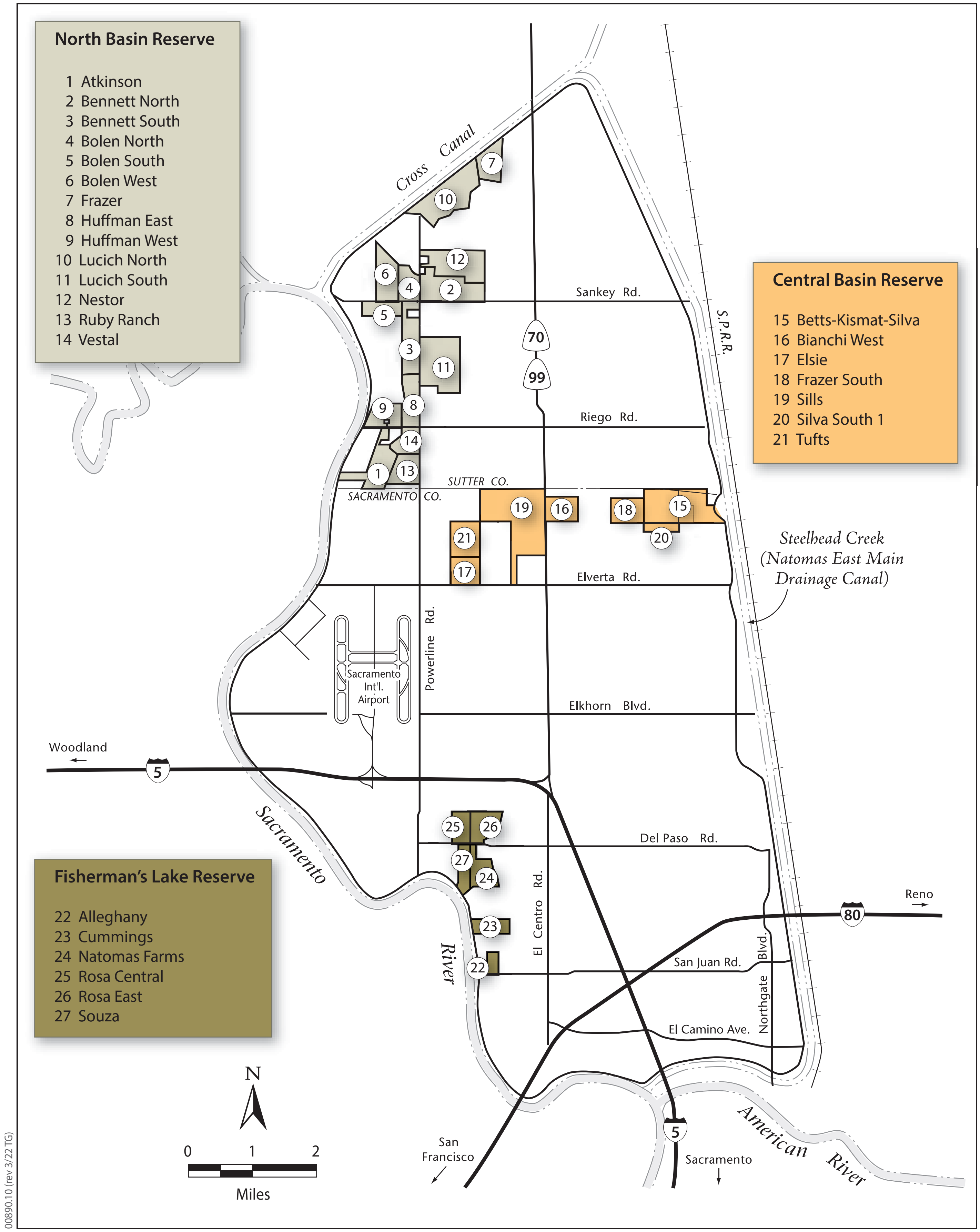

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Figure 1-2
Natomas Basin

Typical habitat of the central and northern Natomas Basin

Natomas Cross Canal

Figure 1-3
Central and Northern Basin Habitats

Fisherman's Lake

Mature riparian forest along the Sacramento River

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Figure 1-4
Riparian Habitats in the Natomas Basin

Typical habitat of the west and south Natomas Basin

Residential development in the south basin

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Figure 1-5
Southern and Western Basin Habitats

Typical habitat of the east basin

Steelhead Creek (formerly the Natomas East Main Drain Canal)

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 assess the progress of the NBHCP toward meeting the Plan's goals and objectives for Covered Species *and their habitats* [emphasis added]. One aspect of the biological effectiveness monitoring program that touches on all Covered Species is the mapping of land cover and habitat types and monitoring changes in those types over time. Two general types of land cover and habitat monitoring are conducted to meet the goals and objectives of the NBHCP: monitoring on reserve lands and monitoring off reserves (*Basin-wide monitoring*).

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 field verification of each land cover polygon originally mapped in 2004 when the comprehensive monitoring program was first established and annually documenting any changes that occur.

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 established 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

Baseline conditions were initially documented in 2004. To accomplish this, geographic information system (GIS) specialists created a base map of the permit area using true-color digital ortho-rectified aerial photography of Sacramento and Sutter Counties purchased from AirPhotoUSA. The aerial photographs of Sacramento County were taken in April 2004 at a resolution of 1 foot (i.e., each cell represents an area on the ground approximately 1 square foot); the aerial photographs of Sutter County were taken in spring 2004 at a resolution of 2 feet (i.e., 4 square feet). Updated ortho-imagery of both counties with a resolution of 1 foot was obtained in 2008 and 2012.

Botanists experienced with aerial photograph interpretation and vegetation signatures of the southern Sacramento Valley mapped land cover types on screen using ESRI's ArcGIS 10.0 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 photo from Google Earth (2012) was used to verify the land cover type.

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 conducted March through July 2013 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 to 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* (University of California–Berkeley 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 (2004) 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 on Lists A, B, and Red Alert of the California Invasive Plant Council's (Cal-IPC's) Pest Plant List, a categorized list of pest plants of ecological concern in California (California Invasive Plant Council 1999, 2012). 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 photographs 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 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 2013 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 major categories of land cover type providing 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 species covered by the NBHCP that are listed under either the California or federal Endangered Species Act (CESA or ESA). Active rice fields and the irrigation and drainage ditches that supply them are primary 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 types since 2004; these are summarized below.

- Active rice fields continue to dominate the landscape, increasing from approximately 31% of the Basin in 2012 to 35.1% of the Basin in 2013.
- Managed marsh/wetlands remained relatively stable and constitute approximately 2.1% of the Basin.
- Upland agricultural lands constitute 22.3% of the Basin, a decrease from 2012 of 1,923 acres. This change can be accounted for by the turnover of fallow land to active agriculture.
- Fallow lands constitute approximately 4.0% of the Basin, decreasing 122 acres from 2012.
- Grassland habitats now constitute approximately 8.9% of the Basin, an increase of 394 acres attributable primarily to the creation of native grasslands along the new setback levee as mitigation for the NLIP.

For the past 3 years, the most significant change in land cover continued to be the construction of the SAFCA NLIP, which includes improvements to the levee system that protects the Basin. The project involves 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 and 2012 as developed (the levee itself) or disturbed/bare (the borrow sites and construction areas). Although physical construction has been completed south to the vicinity of Powerline Road, the borrow sites on reserve lands—which have been converted to emergent wetlands—were not sufficiently developed to provide habitat for covered species during 2013. However, successful implementation of the revegetation program along portions of the project area resulted in several changes in land cover types. Notable changes include an increase of 394 acres of grassland (created), a 103-acre increase in open water, a 15-acre increase in valley oak woodland, a 12-acre increase in seasonal wetland, and a decrease of 468 acres of developed lands, the latter as a result of construction areas being successfully vegetated.

A moratorium on development has been in place since December 2008 due to concerns about the level of flood protection in the Basin, which resulted in the implementation of the SAFCA NLIP mentioned above.

Natural vegetation, composed of tree- and shrub-dominated vegetation such as valley oak woodland, riparian woodland, and riparian scrub, constitutes an extremely small proportion of the Basin—slightly more than 1% of the land area (831 acres in 2013); this proportion increased slightly from 2010 to 2013 due to the planting of valley oak woodlands as part of the SAFCA NLIP. 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 acreages of each land cover type mapped on reserves from 2004 to 2013 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.

Approximately 30 acres of mitigation lands were acquired in 2012, but were not counted until 2013 because the acquisition occurred after the giant gartersnake active season and Swainson's hawk breeding season. This land is part of BKS and referred to as the Silva South 1 tract; it is the first new acquisition of conservation lands by TNBC since 2006, when the total extent of reserve lands peaked at 4,154 acres.[1] Subsequently in 2009 SAFCA acquired approximately 30 acres of the Atkinson and Huffman West tracts in the North Basin Reserve, and in 2012 SAFCA acquired approximately 41 acres of the Natomas Farms tract in the Fisherman's Lake Reserve for use in construction of the NLIP. The new acquisition of Silva South 1 has brought the reserve land acreage up to approximately 4,104 acres.

The proportion of reserve lands in rice increased slightly in 2013 as a result of regular crop rotations. The total acreage[2] of wetlands on reserves remained consistent in 2013. The acreage of reserve lands in upland agriculture increased by 145 acres in 2013, primarily due to conversion of fallow lands. The majority of significant changes in land cover type from 2010 to 2013 resulted from changes in agricultural crops. Fallow fields were converted to rice, and rice fields were fallowed on several tracts. Completion of construction/maintenance activities along several water delivery channels on reserves resulted in minor changes in open water (increase), nonnative annual grassland (decrease), and disturbed bare (decrease) land cover types.

The acreages of each mapped land cover type for 2004–2013 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 2013, reserve lands accounted for 12% of the ricelands, 5.3% of upland agricultural habitats, and 54% of the managed marsh/wetlands in the Basin.

On the BKS and Bennett South tracts in the Central and North Basin Reserves, respectively, the planted riparian shrubs are continuing to mature into relatively dense riparian scrub; this land cover type has been mapped as such since 2004. Two elderberry mitigation sites were established in the Fisherman's Lake Reserve in 2005: one on the Cummings tract and one on the Natomas Farms tract. Each site was originally planted with several blue elderberry shrubs and associated riparian species: valley oak, Oregon ash, coyote bush, California rose, and box elder. Plant survival was high in 2006, exceeding the 2-year performance standard. Although several of the plantings on the Natomas Farms site died, surviving plants are now thriving. Plantings on the Cummings tract have thrived, and all elderberry shrubs now have stems more than 1 inch in diameter, the minimum size necessary to provide habitat for valley elderberry longhorn beetle.

2.3.3 Noxious Weeds Surveys

Noxious weed occurrences recorded from 2004 to 2013 are summarized in Table 2-6. A total of 18 new weed populations were documented in 2013: 7 bull thistle, 10 yellow star-thistle, and 1 Italian thistle. Bennett North, Bolen South, Vestal, BKS, Cummings, Rosa, and Sousa all had new occurrences of bull thistle. Atkinson, Huffman West, Lucich North, Lucich South, Vestal, Elsie, and

[1] Not all acres are fully committed to NBHCP mitigation. TNBC holds more acres than are currently required for mitigation obligations.

[2] This number includes 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 created marsh land cover category; when they are larger than the minimum mapping unit, they are mapped as the land cover type that characterizes them.

Sills all had new occurrences of yellow star-thistle. Alleghany had one new occurrence of Italian thistle. 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.

A total of 25 noxious weed occurrences documented in 2012 were not found in 2013, as listed below.

- 10 occurrences of perennial pepperweed on the BKS, Cummings, and Rosa tracts.
- 7 occurrences of bull thistle on the Alleghany, Bennett South, Bolen North, Bolen West, Huffman East, and Lucich South tracts.
- 4 occurrences of Himalayan blackberry on the Alleghany, Natomas Farms, and Rosa tracts.
- 2 occurrences of yellow star-thistle on the Bennett South and Frazer tracts.
- 1 occurrence of Harding grass on the Bianchi West tract.
- 1 occurrence of pampas grass on the Cummings 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 program appears 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 and small smutgrass 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 3 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 2013. Fresh water 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. Based on thorough surveys within potentially suitable habitat and historical survey records, this result was expected. The cumulative list of plant species recorded on each tract through the 2013 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, azola, and water fern and channel invasion by cattails. 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 carried out 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 of 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 conducted in 2013.

Vegetation management to prevent the spread of water primrose and perennial pepperweed have been very effective and although infestations of azola and water fern still occur in some areas, 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 from 2009 to 2013 were due primarily to the fallowing of rice lands in 2006 and subsequent return to rice over the last 3 years and to the implementation of the NLIP, which resulted in an increase in grasslands.

In 2013, the total area of ricelands increased substantially while managed marsh remained stable; together they constitute the primary habitats for giant gartersnake in the Basin. Although there were changes in the relative proportions of upland agriculture, fallow lands, and grasslands, the result was a relatively minor decrease in the total acreage of suitable Swainson's hawk foraging habitat in 2013.

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 over 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 most important agricultural habitat types for Covered Species in the Basin. In 2013, active ricelands on reserves constituted 12% of the Basin-wide total, down slightly from 13% in 2012. Upland agriculture on reserve lands accounted for approximately 5.3% of the upland agriculture in the Basin in 2013, an increase from 3.6% in 2012.

2.4.3 Floristic Surveys

A cumulative total (2004–2013) of 383 plant species from 71 families has been recorded on reserve lands. Nonnative species account for more than half (55%) of this list. 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 widespread plants common 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, 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 reducing levels of infestation and preventing further spread.

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 is on the A (Severe) list from the California Invasive Plant Inventory Database; it is rapidly forming dense stands along rivers and creeks in the Sacramento region (California Invasive Plant Inventory Database 2010). Red sesbania was not found within any of the TNBC reserves in 2013, despite the presence of a large population within Steelhead Creek that extends along most of the eastern border of the Basin. Monitoring 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 California Invasive Plant Council watchlist. According to the Cal-IPC weed alert, smutgrass has been found invading irrigated pastures of the Sacramento Valley. The plant reproduces exceptionally well, with one smutgrass plant having the potential to produce 45,000 seeds per year. The seeds become sticky and gelatinous when moistened, facilitating distribution (Cal-IPC 2010). 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 appear to be successfully reducing the level of infestation of perennial pepperweed and preventing the continued expansion of 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, 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 SSMPs to include successful management strategies.

2.7 References

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Table 2-1. Basin-Wide Extent (acres) of Mapped Land Cover Types, 2004–2013

Land Cover Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Rice	23,240	22,321	14,792	14,590	14,224	15,014	15,023	15,287[a]	16,956	19,001
Fallow	823	1,625	10,101	10,033	10,076	5,869	2,912	2,323	2,282	2,160
Alfalfa	610	931	1,401	1,189	1,519	2,194	1,302	2,417	2,023	1,303
Irrigated grassland	776	452	374	451	373	378	345	746	750	757
Grass hay	158	178	153	2,212	2,367	2,769	6,724	5,423	6,504	6,250
Wheat	215	1,824	2,375	1,104	804	3,919	695	585	413	440
Milo	88	0	328	211	161	0	0	0	0	155
Tomatoes	93	50	145	112	113	8	10	0	0	0
Sunflower	0	709	572	0	251	166	804	714	362	821
Safflower	0	886	532	244	426	162	214	278	322	0
Other row and grain crops	6,312	2,537	582	2,396	2,279	2,096	3,770	4,937	3,645	2,370
Orchard	173	184	184	184	99	99	94	53	50[b]	50
Fresh emergent marsh (created)	538	575	575	676	897	897	897	897	897	897
Fresh emergent marsh	138	138	154	154	155	155	155	154	154	154
Seasonal wetland	105	105	105	108	105	105	110	103	103	115
Grassland (created)	42	49	71	68	74	74	80	74	75	469[c]
Nonnative annual grassland	7,475	7,389	6,786	5,192	4,988	5,016	4,032	3,670	3,652	3,609
Ruderal	330	329	406	409	399	704	747	864	766	754
Valley oak woodland	157	191	195	192	192	194	209	240	242	257
Riparian woodland	331	348	346	357	357	354	359	357	398	398
Riparian scrub	120	117	117	114	133	133	133	133	133	133
Nonriparian woodland	98	52	50	51	51	51	29	28	43	43
Open water	297	352	340	340	337	337	360	381	387	490
Developed—low density	1,383	1,565	1,639	1,706	1,949	1,961	1,977	2,114	2,202	2,307
Developed—high density	9,234	9,859	10,764	11,533	11,304	11,260	10,910	10,770[a]	10,604	10,529
Disturbed/bare	1,470	1,440	1,127	578	573	291	2,321	1,659	1,243	744
Total	**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 photos 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).

Table 2-2. Basin-Wide Summary of Major Habitat Types, 2004–2013

	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
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
Rice	23,240	42.9	22,321	41.2	14,782	27.3	14,590	26.9	14,224	26.2	15,017	27.7	15,023	27.7	15,287[b]	28.2[b]	16,956	31.3	19,001	35.1
Managed marsh/ wetlands	781	1.4	818	1.5	834	1.5	938	1.7	1,157	2.1	1,157	2.1	1,162	2.1	1,153	2.1	1,153	2.1	1,165	2.1
Upland agriculture	8,252	15.2	7,567	14.0	6,462	11.9	7,919	14.6	8,293	15.5	11,692	21.6	13,863	25.6	15,100	27.9	14,019	25.9	12,096	22.3
Grassland	7,847	14.5	7,767	14.3	7,263	13.4	5,669	10.5	5,461	10.1	5,794	10.7	4,853	9.0	4,608	8.5	4,493	8.3	4,832	8.9[c]
Fallow	823	1.5	1,625	3.0	10,101	18.6	10,033	18.5	10,076	18.5	5,869	10.8	2,912	5.4	2,323	4.3	2,282	4.2	2,160	4.0
Developed	12,087	22.3	12,864	23.7	13,531	25.0	13,817	25.5	13,826	25.5	13,512	24.9	15,208	28.1	14,543[b]	26.8[b]	14,049	25.9	13,581	25.1
Other	1,176	2.2	1,245	2.3	1,233	2.3	1,239	2.3	1,169	2.2	1,168	2.2	1,184	2.2	1,192	2.2	1,254	2.3	1,371	2.5
Total	**54,206**	**100.0**	**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 (SAFCA).

Table 2-3. On-Reserve Extent (acres) of Mapped Land Cover Types, 2004–2013

Land Cover Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Rice	1,728	1,671	1,529	1,715	1,849	2,136	2,059	1,930	2,200	2,273
Fallow	117	820	593	727	373	375	450	668	348	177
Alfalfa	68	106	106	150	150	204	127	126	259	204
Irrigated grassland	96	0	96	0	0	4	5	0	0	0
Grass hay	142	19	19	81	160	157	144	57	84	147
Wheat	130	207	497	77	79	132	187	58	58	58
Milo	80	0	0	49	0	0	0	0	0	155
Tomatoes	55	0	0	55	55	0	0	0	0	0
Sunflower	0	0	0	0	0	0	104	116	84	56
Safflower	0	0	0	0	0	104	0	68	11	0
Other row crops	0	10	157	279	472	26	32	27	6	27
Fresh emergent marsh (created)[a]	524	561	561	627	627	627	627	627	627	627
Fresh emergent marsh	2	2	2	0	0	0	0	0	0	0
Seasonal wetland	6	6	6	4	4	4	4	3	3	4
Grassland (created)	133	47	76	76	72	72	72	71	72	72
Nonnative annual grassland	263	318	225	254	254	254	254	254	228	226
Ruderal	38	38	33	29	29	29	28	25	25	25
Valley oak woodland	5	6	7	7	7	7	7	7	7	7
Riparian woodland	11	13	13	12	12	12	12	12	12	12
Riparian scrub	5	5	5	5	5	5	5	5	5	5
Nonriparian woodland	1	1	1	1	1	1	1	1	1	1
Open water	0	0	0	0	0	0	0	0	0	20[c]
Developed—low density	5	5	5	5	5	5	5	5	5	5
Developed—high density	0	0	0	0	0	0	0	0	0	0
Disturbed/bare	0	0	0	0	0	0	0	63[b]	47	11
Total	**3,409**	**3,835**	**3,931**	**4,154**	**4,154**	**4,154**	**4,124**[b]	**4,124**	**4,082**[b]	**4,112**[d]

[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 (SAFCA) Natomas Levee Improvement Project (NLIP).

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

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

Table 2-4. On-Reserve Summary of Major Habitat Types, 2004–2013

	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
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
Rice	1,728	50.8	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
Managed marsh/ wetlands[a]	532	15.6	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
Upland agriculture	571	16.8	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
Grassland	434	12.7	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
Fallow	117	3.4	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
Developed	5	0.1	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
Other	22	0.6	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
Total	**3,409**	**100.0**	**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**	**100.0**	**4,112**[c]	**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.

Table 2-5. On-Reserve Extent of Major Habitat Types as a Proportion of Each Habitat Type in the Basin, 2004–2013

	2004			2005			2006			2007			2008			2009			2010			2011			2012			2013		
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
Rice	1,728	23,240	7.4	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
Managed marsh/ wetlands[a]	532	781	68.1	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
Upland agriculture	571	8,251	6.9	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
Grassland	434	7,847	5.5	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
Fallow	117	823	14.2	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
Developed	5	12,087	0	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
Other	22	1,176	1.9	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
Total[f]	3,404	54,206	6.2	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

[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, 2004–2013

		Number and Degree of Occurrences[a]									
Reserve	Noxious Weed Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
North Basin Reserve											
Atkinson	Edible fig	1, T	1, T	1, T	1, T	1, T	1, T	1, T	1, T	1,T	1T
	Perennial pepperweed	3, M-H	3, M-H	3, M-H	1, M	1, M	1, M	–	–	–	–
	Himalayan blackberry	1, H	1, H	1, H	3, M-H	3, M	3, M-H	3, M	3, M	2, M	2, M
	Yellow star-thistle	–	–	–	–	–	2, L-M	2, L	1, L	2, L	3, L
Bennett North	Yellow star-thistle	2, L	1, L	1, L	1, L	–	–	1, L	2, M	1, L	1, T
	Bull thistle	–	–	–	–	–	–	1, L	–	1, L	2, T
Bennett South	Bull thistle	1, L	–	–	–	–	–	–	–	2, L	–
	Yellow star-thistle	1, L-M	2, L-M	2, L-M	2, M	1, M	3, L	2, L-M	1, L-M	1, L	–
Bolen North	Perennial pepperweed	–	1, M	1,L	–	–	–	–	–	–	–
	Himalayan blackberry	–	1, T	1,T	–	–	–	–	–	–	–
	Bull thistle	–	–	–	–	–	–	3, L	2, L	2, L	1, 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
Bolen West	Bull thistle	–	–	–	–	–	–	1, M	–	1, L	–
Frazer	Yellow star-thistle	1, H	1, H	2, L-H	4, M-L	4, M-L	5, M-L	4, M	1,L	3, L	2, T
Huffman East	Yellow star-thistle	1, L-H	7, L-H	7, L-M	–	–	3, L	2, M-L	3, M-L	1, L	1, L
	Himalayan blackberry	1,M	1, M	1, M	–	–	–	1, M	1, M	–	–
	Bull thistle	–	–	–	2, T	3, T	3,T	–	–	1,L	–
Huffman West	Yellow star-thistle	Present	–	–	–	–	–	1, L	1, L	2, L	3, T
	Sweet fennel	–	2, T	2, T	–	–	1, T	–	–	–	–
	Himalayan blackberry	–	–	–	1, H	1, H	1, M	2, M	–	–	–
Lucich North	Yellow star-thistle	Present	10, L-H	10, L-H	5, L-M	2, L	4, L-M	3, L	–	1, L	4, L
	Perennial pepperweed	Present	3, H	3, H	1, T	1, T	1, T	1, T	–	–	–
	Bull thistle	1, T	–	–	4, T-H	4, T-H	3, T-H	2, T	–	1, T	1, T
	Pennyroyal	–	–	–	–	–	–	–	1,M	1, M	1, M
Lucich South	Yellow star-thistle	1	3, M	3, M	9, T-H	4, T-H	4, T-M	3, L	1, L	1, T	2, T
	Bull thistle	–	1, T	–	1, H	2, L-M	2, L-M	2, L-M	3, L-M	2, L	1, T
	Italian thistle	–	–	–	1, L	1, L	1, L	1, L	1, L	–	–
Nestor	Bull thistle	–	–	–	–	–	–	–	1, L	–	–
Ruby Ranch	Yellow star-thistle	1, T	1, T	1, T	–	–	1, L	–	1, L	–	1, T

Reserve	Noxious Weed Species	Number and Degree of Occurrences[a]									
		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	Italian thistle	–	–	–	1, H	1, H	1, M	–	–	–	–
Vestal	Yellow star-thistle	–	–	3,T	–	–	–	3, L-M	2, L-M	2, L	3, T
	Himalayan blackberry	–	–	–	1, M	1, M	1, M	–	–	–	–
	Bull thistle	–	–	–	–	–	–	2, L	3, L	1, L	2, T
	Edible fig	–	–	–	1, L	1, L	1, L	1, L	1, L	1, L	1, L
Central Basin Reserve											
Betts-Kismat-Silva	Bull thistle	1, T	–	–	–	–	2, T	1, T	–	–	1, T
	Yellow star-thistle	L-M	L-H	L-H	7, T-H	5, T-L	5, T-L	–	–	–	–
	Perennial pepperweed	T	T	T	1, H	1, L	2, T-L	–	–	5, T-M	–
	Giant reed	L	L	L	L	–	–	–	–	–	–
	Italian thistle	1, T	1, T	–	–	–	–	–	–	–	–
	Pennyroyal	L-M	L-M	L-M	–	–	–	2, 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
	Tree-of-heaven	1, M	1, M	1, M	–	1, H	1, H	–	–	–	–
	Himalayan blackberry	D	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
	Small smutgrass	–	–	–	–	–	–	1,T	–	–	–
Bianchi West	Harding grass	–	–	–	–	–	–	3, L	2, L	2, L	1, L
	Yellow star-thistle	–	–	–	–	–	–	1, M	2, L	1, L	1, T
Elsie	Yellow star-thistle	–	–	–	–	–	–	–	2, T	1, M	2, T
Frazer South	–	–	–	–	–	–	–	–	–	–	–
Sills	Yellow star-thistle	Present	–	–	1, M	1, M	2, L	1, L	2, L	1, M	2, T
Tufts	Yellow star-thistle	–	1, M	1,M	–	–	–	–	–	–	–
Fisherman's Lake Reserve											
Alleghany	Sweet fennel	1, T	1, T	1, T	–	–	–	–	–	–	–
	Edible fig	1, T	1, T	1, T	–	–	–	–	–	–	–
	Himalayan blackberry	1, D	1, D	1, D	2, M-H	2, L-M	2, L-M	3, L-M	2, M	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
	Italian thistle	–	–	–	2, L	2, T-L	1, L	–	–	–	1, T
	Yellow star-thistle	–	–	–	–	–	–	1, L	1, L	2, L	2, T

Reserve	Noxious Weed Species	Number and Degree of Occurrences[a]									
		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Cummings	Himalayan blackberry	1, M	1, M	1, M	1, M	1, M	1, M	1, M	1, M	–	–
	Sweet fennel	1, T	1, T	1, T	–	–	1, T	–	–	–	–
	Perennial pepperweed	1, L-M	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
Natomas Farms	Sweet fennel	1, L	1, L	1, L	–	1, T	1, T	1, T	–	–	–
	Himalayan blackberry	1, M	1, M	1, L	1, L	1, L	1, L	1, L	–	2, L	1, L
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
	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
	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
Souza	English ivy	1, D	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

[a] Occurrences reflect the number of occurrences on each tract followed by the level of infestation, as shown below:
T = Trace (rare): less than 1% cover.
L = Low (occasional plants): 1–5% cover.
M = Moderate (scattered plants): 5–25% cover.
H = High (fairly dense): 25–75% cover.
D = Dense (dominant): more than 75% cover.

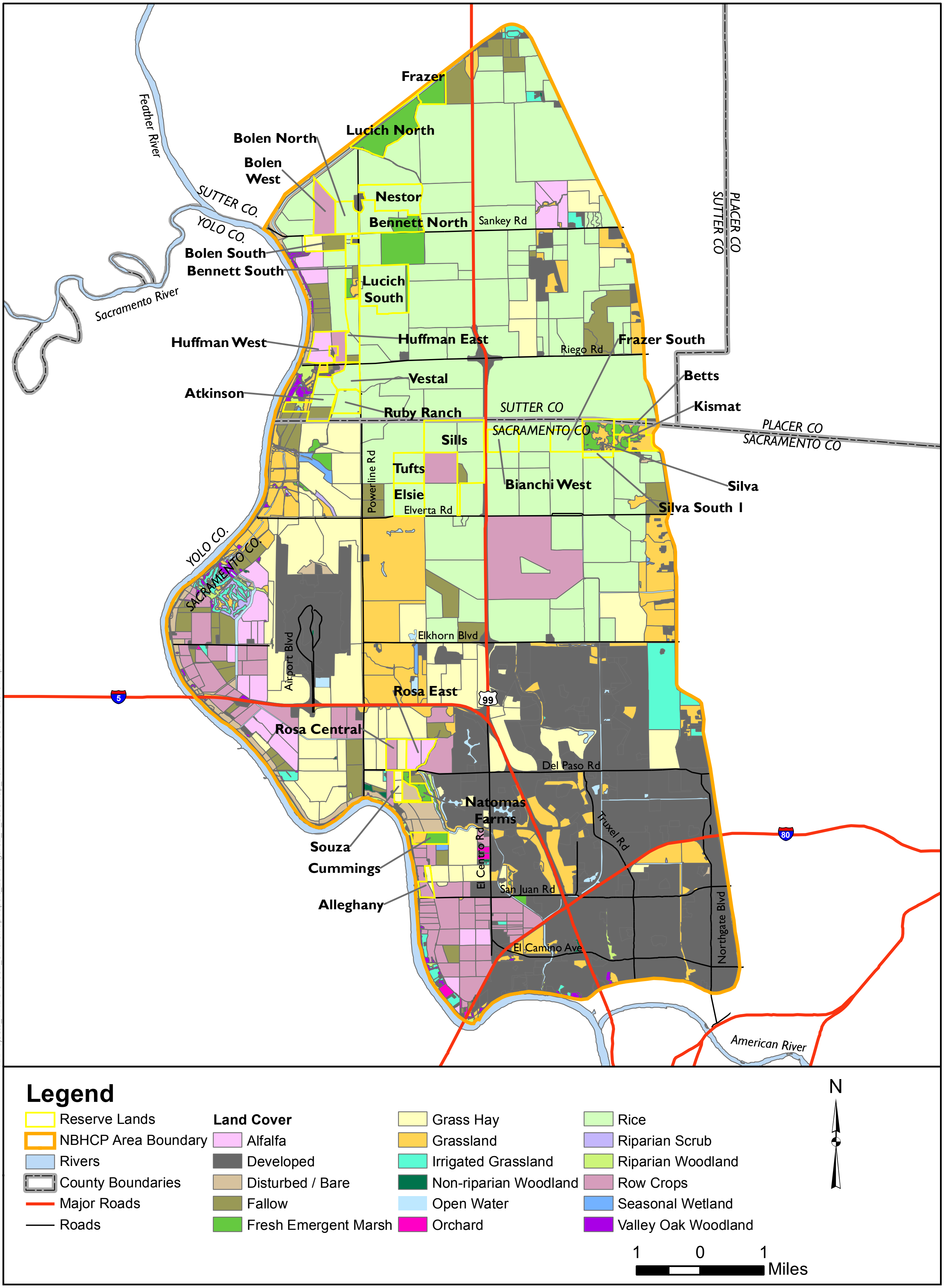

Figure 2-1
Distribution of Land Cover Types in the Natomas Basin, 2013

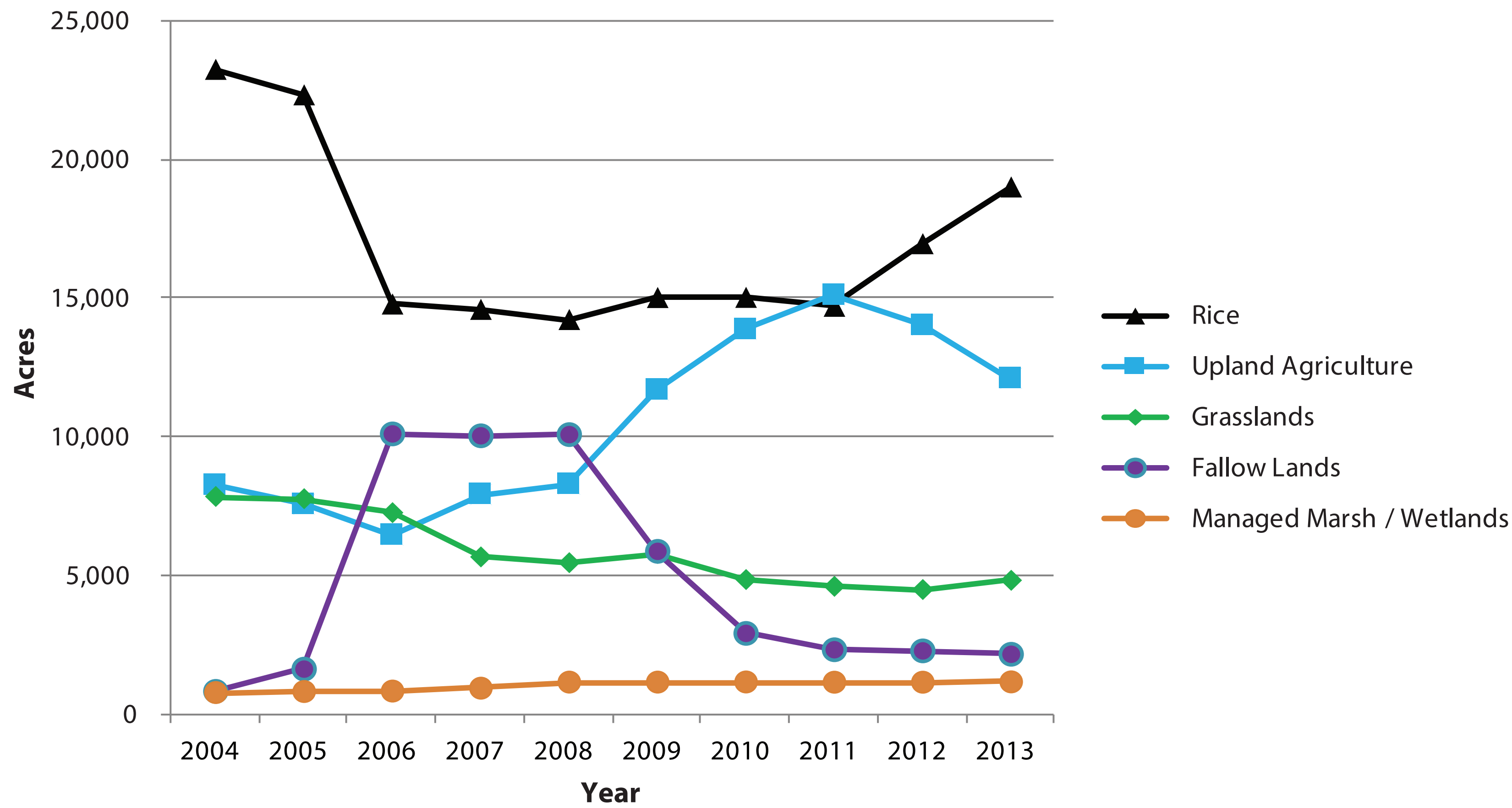

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Figure 2-2
Changes in Acreage of Major Habitat Types, 2004–2013

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 gartersnakes 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 the sierra gartersnake (*Thamnophis couchii*). Because giant gartersnake is morphologically distinguishable from and allopatric with its most closely related species, the aquatic gartersnake (*Thamnophis atratus*) and the 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 the American bullfrog (*Lithobates catesbeianus*) and tadpoles and adults of the 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 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 males might be metabolically costly, causing decreased body condition for male snakes 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 [CI] = 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 millimeter (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 (95% CI = 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 refugia. 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.

Historically, the 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 and the natural cycle of seasonal valley flooding by high Sierra snowmelt has been limited and the waters 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 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

Historically, the lands of the Natomas Basin were 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 mix 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 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. Traps were modified to contain one-way valves constructed from cable ties placed in the small opening of the funnels. 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.

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. For demographic monitoring sites, transects were placed close to one another to maximize sampling effort over a relatively small area, thereby increasing capture probabilities. Traps were checked daily.

Environmental conditions relevant to giant gartersnake behavior were monitored daily at each 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 or canals and ditches) necessitated the opening of traps temporarily or relocation of transects to a suitable nearby location within the selected site.

UTM coordinates of all trap locations were recorded and vegetation and habitat surveys at points along and adjacent to each transect were recorded. 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 1-meter radius of each trap. For each trap location, a point to the left (odd-numbered traps) or right (even-numbered traps) of the transect was selected at a randomly-selected perpendicular distance of 1–5 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 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 (>60 g), implanted with a passive integrated transponder (PIT) tag. Cartridge-style pre-sterilized needles with pre-loaded PIT tags were used, and the injection site on the snake was swabbed with alcohol prior to tag insertion. The tag was injected intracoelomically 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 Demography

Field Methods

Demography of giant gartersnake was monitored at the following five TNBC reserves selected for their 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 22, 2013) until approximately July 14, 2013.

With the exception of the BKS site, transects were 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. In 2013, transects at BKS could not be located at the previously used sites due to habitat maintenance activities; therefore, trap transects were moved to an adjacent wetland on the preserve. Sampling at Sills was delayed until June 7 because of water delivery associated with planting of rice.

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). 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).

Closed population models (closed models are models that assume no emigration from or immigration into the population of interest over the period of the sample) were used to estimate abundance at each demographic monitoring site. For each site, we attempted to fit up to nine models that included different combinations of variables likely to influence capture probabilities; data were too sparse for some models at all sites. We first evaluated individual models for identifiability of all parameters, given the observed capture histories, then fit a full model containing all identifiable parameters. All continuous variables were standardized to improve behavior of the Markov chain Monte Carlo (MCMC) algorithm and to allow direct comparison of model coefficients. Posterior[1] probability was calculated for each subset of the full model using indicator variables on model parameters (Kuo and Mallick 1998; Royle and Dorazio 2008). Because only one individual was captured at Natomas Farms, only the null model of constant capture probability was used, and analysis was limited to using informative priors based upon the posterior distribution of capture

[1] In Bayesian analyses, the posterior probability is the probability of a random event or uncertain proposition given the data at hand. It requires specification of a *prior* probability distribution. 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, which is a probability distribution that will have no effect on the outcome of the analysis.

probability for the null model from 2011 (p = *Beta*[1.313,34.313]). Using these informative priors allowed estimation of abundance under the rather strict assumption that capture probability in 2013 was expected *a priori* to be the same as in 2011. Without making this assumption, however, no estimate of abundance could be obtained. For all abundance sites and models, the capture histories of trapped individuals were augmented with 100–500 all-zero capture histories. The number of pseudo-individuals was deemed adequate by the posterior density for abundance falling far below the number of augmented individuals. Uninformative priors were used for all parameters of all models except as indicated above for Natomas Farms: *Beta(1,1)* for probabilities, *N(0,1.648)* for regression coefficients, *U(0,10)* for standard deviations, and *Bin(1,0.5)* for indicator variables. For all sites except Natomas Farms, posterior inference regarding abundance was based upon averaging across all models in the model set (Burnham and Anderson 2002; Anderson 2008).

Each closed population model was run on 5 independent chains of 10,000 iterations after a burn-in of 10,000; each chain was thinned by a factor of five. Each model was analyzed by calling JAGS 3.3.0 (Plummer 2012a) from R 3.0.2 (R Core Team 2013) using the package rjags (Plummer 2012b). Posterior distributions were summarized with the posterior median and 95% symmetrical credible interval (2.5% and 97.5% quantiles of the posterior distribution).

In addition to the closed population models, Jolly-Seber models (Williams et al. 2002) for open populations[2] were also fit to data from the 3 years of sampling using the new monitoring protocol (i.e., 2011–2013) for each demographic monitoring site (except Natomas Farms, for which no among-year recaptures were obtained). We chose to use a Jolly-Seber model, rather than a Cormack-Jolly-Seber model, because we were interested in changes in abundance in addition to survival. Because of sparse data, only a relatively simple model was fit with recruitment and daily capture probabilities that varied annually and constant annual survival. To make the best use of capture data, which included multiple captures of individuals within a season of sampling, a binomial model was used for the observation process that assumes that daily capture probabilities are equal for each individual on each day within a sampling season (Royle and Dorazio 2008). Annual variation in recruitment was a necessary component of the model using the selected data augmentation approach. We report annual apparent survival, which is a combination of survival and emigration, and the instantaneous per capita, or exponential, growth rate (r), which was chosen because of its interpretability (it is symmetric about zero, rather than asymmetric about one as for the geometric growth rate (λ) usually used for populations that reproduce in discrete time). Probabilities are provided for benchmarks of population change (10% increase, 10% decrease, and stability (less than 10% change in either direction). 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 *Beta(1,1)* 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 5 independent chains of 10,000 iterations after a burn-in of 5,000 iterations; each chain was thinned by a factor of 5. Each model was analyzed by

[2] 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. Immigration and birth are treated together and termed *recruitment* (the proportion of a population that is “new” from the previous year) while emigration and death are treated together and termed *apparent survival* (the proportion of the population that remained within the population of interest, or 1-[emigration + death]).

calling OpenBUGS (Lunn et al. 2009) from R 3.0.2 (R Core Team 2013) using the package R2OpenBUGS (Sturtz et al. 2005). Posterior distributions were summarized with the posterior median and 95% symmetrical credible interval (2.5% and 97.5% quantiles of the posterior distribution).

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 3.2.3, *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. The binomial model assumes sampling with replacement (Skalski et al. 2005); accordingly, counts of captures rather than individuals were used for analysis. Bayesian methods were used to describe the mean SVL and mass of giant gartersnakes from all sampling locations within the Basin and at each demographic monitoring site. 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). Sexual size dimorphism in SVL and mass was examined throughout the Natomas 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). Sexual size dimorphism was not examined at individual sites because of the great uncertainty in estimating means with small sample sizes. 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 3.2.2 (Lunn et al. 2009) from R 3.0.2 (R Core Team 2013) using the R package R2OpenBUGS (Sturtz et al. 2005). Posterior distributions were summarized with the posterior median and 95% symmetrical credible interval.

3.2.3 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 the dates of June 30 and September 30, 2013. 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 in previous years 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). 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. The detection component of each of these models was based upon previous research (Halstead et al. 2011b) and consisted of effects of water temperature, date, and unexplained site heterogeneity. Two versions of the detection model were fit with each occurrence model.

- One with uninformative priors that assumed no prior information exists on the effects of covariates on the probability of detecting giant gartersnake.
- One that used information from previous U.S. Geological Survey studies (2003–2009) to inform the detection probability component of the model (Table 3-1).

Priors for the occupancy component of each model were chosen to be uninformative (Table 3-1). All continuous variables were standardized to improve behavior of the 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 3.2.2 (Lunn et al. 2009) from R 3.0.2 (R Core Team 2013) using the package R2OpenBUGS (Sturtz et al. 2005). Posterior distributions were summarized with the posterior median and 95% symmetrical credible interval.

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. Because only 3 years of data were available, a simple model of constant initial probability of occurrence, constant colonization and extinction probabilities, and constant within-year daily detection probabilities (which were allowed to vary between years) was fit. All probabilities were given $U(0,1)$ priors. The dynamic occupancy model was run on 3 independent chains of 10,000 iterations each after a burn-in of 1,000; each chain was thinned by a factor of 3. Each model was analyzed by calling OpenBUGS 3.2.2 (Lunn et al. 2009) from R 3.0.2 (R Core Team 2013) using the package R2OpenBUGS (Sturtz et al. 2005). Posterior distributions were summarized with the posterior median and 95% symmetrical credible interval (2.5% and 97.5% quantiles of the posterior distribution).

3.2.4 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, 145 individual giant gartersnakes were captured 203 times by trap on TNBC reserves over the course of nearly 59,000 trap days in 2013 (Table 3-2). Catch per unit effort across the Basin was 0.0035 in 2013, which was greater than 2012 (0.0028) and 2011 (0.0031).

3.3.1 Demography

Estimates of Abundance Using Closed Population Models

At Natomas Farms, one individual male was captured one time. In 2011 and 2012, only one individual was captured each year, both females. Because the data were so sparse, only a model with constant capture probability with informative priors based upon the daily capture probability for 2011 at Natomas Farms was fit. This model indicated an abundance of 6 (1–87) individuals (Figure 3-2), with an estimated daily capture probability of 0.004 (<0.001–0.035) at Natomas Farms.

At BKS, 68 individuals were captured 101 times in traps. The estimated model-averaged abundance at BKS was 138 (106–191) individuals (Figure 3-3). A positive effect of water temperature on capture probability and a positive ephemeral behavioral response to capture were strongly supported at BKS (Table 3-3; Figure 3-4).

At Sills, 15 individuals were captured 23 times in traps. The estimated model-averaged abundance at Sills was 41 (21–97) individuals (Figure 3-5). Considerable model selection uncertainty existed at Sills (Table 3-4). A positive ephemeral behavioral response was strongly supported, and females had greater capture probabilities than males (Table 3-4; Figure 3-6).

At Lucich North, 32 individuals were captured 44 times in traps. The estimated model-averaged abundance at Lucich North was 70 (47–123) individuals (Figure 3-7). The null model had the greatest posterior probability (0.235), though considerable model selection uncertainty existed at Lucich North (Table 3-5). The model with an effect of water temperature on capture probability was 0.159, and the model with an ephemeral behavioral response on capture probability had some support as well (probability = 0.149; Table 3-5).

At Lucich South, 17 individuals were captured 17 times in traps. The estimated model-averaged abundance at Lucich South was 120 (40–444) individuals (Figure 3-8), with a model-averaged capture probability of 0.002 (<0.001–0.006). As for Lucich North, the null model had the greatest posterior probability, but the model with a behavioral response also received considerable support (probability = 0.229; Table 3-6).

Annual estimates of abundance at each of the five demographic monitoring sites over the last 3 years based upon annual closed population models are summarized in Table 3-7.

Estimates of Abundance and Demographic Rates Using Jolly-Seber Open Population Models

The open population model for BKS produced annual abundance estimates in hundreds of individuals (Figure 3-9). Estimates of the average per capita recruitment probability were 0.80 (0.36–1.50) from 2011 to 2012 and 0.72 (0.41–1.14) from 2012 to 2013. Over the 3-year period, annual apparent survival probability was 0.12 (0.13–0.22). The estimates of the instantaneous per capita population growth rate were -0.06 (-0.70–0.51) from 2011 to 2012 and -0.20 (-0.64–0.22) from 2012 to 2013. The probability that abundance decreased by more than 10% annually was 0.568, which was higher than the probability that the population increased by more than 10% annually (0.043) or the probability that the population was stable (less than 10% annual change) (0.390).

The open population model for Sills produced estimates of annual abundance in the tens of individuals (Figure 3-10). Unlike BKS, Sills exhibited a slight increase in per capita recruitment, from 0.67 (0.34–1.22) in the interval 2011–2012 to 0.81 (0.40–1.55) in the interval 2012–2013. The estimate of apparent survival over the 3-year period was 0.096 (0.023–0.249). The estimates of the instantaneous per capita population growth rate were -0.28 (-0.83–0.27) from 2011 to 2012 and -0.10 (-0.69–0.51) from 2012 to 2013. The probability that abundance decreased by more than 10% annually was 0.725, which was higher than the probability that abundance increased by more than 10% annually (0.031) or the probability that the population was stable (less than 10% annual change) (0.245).

The open population model for Lucich North produced estimates of annual abundance near 100 individuals (Figure 3-11). The average per capita recruitment probability was 0.59 (0.12–1.64) from 2011 to 2012, and increased slightly to 0.91 (0.44–1.81) from 2012 to 2013. The estimate of apparent survival probability over the 3-year period was 0.126 (0.037–0.283). The estimates of the instantaneous per capita population growth rate were -0.33 (-1.27–0.58) from 2011 to 2012 and 0.03 (-0.57–0.67) from 2012 to 2013. The probability that abundance decreased by more than 10% annually was 0.574, which was higher than the probability that abundance increased by more than 10% annually (0.175) or the probability that the population was stable (less than 10% annual change) (0.250).

The open population model for Lucich South produced estimates of annual abundance in the hundreds of individuals (Figure 3-12). The average per capita recruitment probability was 0.62 (0.02–3.27) in the interval 2011–2012, which then dropped to 0.30 (0.01–1.96) in the interval 2012–2013, though posterior credible intervals almost completely overlapped. The estimate of apparent survival probability over the 3-year period was 0.75 (0.31–0.99), which was higher at Lucich South than at any other demographic monitoring site. The estimates of the instantaneous per capita population growth rate were 0.28 (-0.60–1.39) from 2011 to 2012 and 0.08 (-0.81–1.01) from 2012 to 2013. The probability that abundance increased by more than 10% annually was 0.672, which was higher than the probability that abundance decreased by more than 10% annually (0.133) and the probability that the population was stable (less than 10% annual change) (0.195).

The lack of among-year recaptures at Natomas Farms precluded the use of open population models for this location from 2011 to 2013.

Size Distribution and Sex Ratio

The overall sex ratio in the Basin was 0.809 (0.614–1.061) males per female. Sex ratios were not statistically biased at any demographic monitoring sites (Table 3-8). Basin-wide SVL was best approximated by a normal distribution (ΔBIC = 14; posterior probability = 0.999; Table 3-9), but Basin-wide mass was best approximated by a lognormal distribution (ΔBIC = 101; posterior probability > 0.999; Table 3-10). Distributions of SVL and mass at individual monitoring sites followed patterns similar to Basin-wide distributions (Tables 3-8 and 3-10). Basin-wide mean SVL was 548 mm (522–574 mm), and Basin-wide mean mass was 81.1 g (70.1–94.0 g; Table 3-11). Mean female SVL was 110 mm (61–158 mm) greater than mean male SVL, and mean female mass was 49.0 g (24.5–76.5 g) greater than male mass (Figure 3-13).

3.3.2 Distribution of Giant Gartersnake on Reserve Lands

Giant gartersnakes were detected at 9 of 17 occupancy sites in 2013. Using uninformative priors, it was estimated that approximately 68% (95% CI = 27–96%) of wetland sites with average habitat profiles were occupied by giant gartersnake. Inference using informative priors was similar, indicating that approximately 65% (26–94%) of reserve sites were occupied (Figure 3-14). Of the sites monitored, 10 (9–15) were estimated to be occupied based upon uninformative priors; 10 (9–13) were estimated to be occupied based upon informative priors (Figure 3-14).

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 gartersnakes, the null model of no effect was slightly better than the model with an effect of reserve area (probability of effect of reserve area = 0.444 with uninformative priors; 0.422 with informative priors). Reserve areas therefore had similar probabilities of occurrence for giant gartersnakes. Based upon uninformative priors, the probability of occurrence in the North Basin Reserve was 0.684 (0.267–0.956), the probability of occurrence in the Central Basin Reserve was 0.669 (0.200–0.961), and the probability of occurrence in the Fisherman's Lake Reserve was 0.840 (0.327–0.997). Informative priors had little effect on these estimates, which were 0.654 (0.256–0.939) in the North Basin Reserve, 0.638 (0.189–0.942) in the Central Basin Reserve, and 0.820 (0.318–0.996) in the Fisherman's Lake Reserve.

Regardless of the prior probabilities used for the detection component of the occupancy model, a strong positive effect of emergent vegetation on the probability of occurrence existed (Table 3-12). The probability that emergent vegetation had an effect on the probability of occurrence was 0.97. Based upon uninformative priors, a 16% increase in the percent cover of emergent vegetation increases the odds of occurrence by 10.8 (1.0–104.9) times (Table 3-13). With informative priors, the same increase in percent cover of emergent vegetation increases the odds of occurrence by 11.8 (1.0–112.8) times (Table 3-13; Figure 3-15). The effects of other variables on the probability of occurrence weren't as pronounced. The odds of a negative effect of floating vegetation and rice on the probability of occurrence were 2.8 and 1.3 times higher than the odds of a positive effect on the probability of occurrence using uninformative priors, and 3.0 and 1.4 times higher using informative priors, respectively (Table 3-13). 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 much greater precision when prior information on the detection process was accounted for (Figure 3-16).

The dynamic occupancy model indicated evidence for a decrease in the probability of occurrence of giant gartersnake on TNBC reserves over time. The probability of occurrence decreased from 0.71 (0.47–0.93) in 2011 to 0.62 (0.44–0.80) in 2012 to 0.59 (0.36–0.84) in 2013 (Figure 3-17). The probability that occupied sites in 2011 remained occupied in 2012 was 0.76 (0.52–0.96), and decreased slightly to 0.70 (0.38–0.96) from 2012 to 2013. The probability that an unoccupied site would be colonized increased slightly from 0.27 (0.02–0.72) in the interval 2011 to 2012 to 0.41 (0.06–0.85) in the interval 2012 to 2013.

The number of sites where occupancy trapping occurred since the new protocol was implemented that were estimated to be occupied was estimated as 22 (16–28), 19 (17–22) and 18 (13–25) in 2011, 2012 and 2013, respectively (Figure 3-18). The exponential growth rate of occupancy from 2011 to 2012 was -0.13 (-0.41–0.16) and -0.05 (-0.43–0.30) from 2012 to 2013. The probability that the number of sites occupied decreased by more than 10% annually was 0.447, which was higher than the probability that the number of sites increased by more than 10% annually (0.045), but lower than the probability that occupancy rates were stable (less than 10% annual change) (0.508).

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, the highest quality giant gartersnake habitat, constituted more than 15%[3] (631 acres) of the area of reserve properties, but just over 2% (1,165 acres) of non-reserve lands. Rice agriculture, which along with its supporting infrastructure of canals provides the only remaining suitable giant gartersnake habitat in the Basin, comprised slightly more than 55% (2,273 acres) of the area of reserve properties compared to 35% (19,001 acres) of the non-reserve lands. Overall, nearly 2,904 acres (71%) of the total acres of TNBC reserve lands was potential giant gartersnake habitat, while only 37% (20,166 acres) of the total 50,094 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 area cover approximately 419 acres. Seventy-two of these acres (17%) were created marsh in 2013. No rice existed in the Fisherman's Lake reserve area tracts in 2013. Recently constructed wetlands comprised much of the landscape immediately southeast of the Natomas Farms tract and between the Natomas Farms and Cummings tracts, although these wetlands are not yet developed enough to provide suitable giant gartersnake habitat.

Tracts in the Central Basin reserve area cover approximately 1,343 acres. One-hundred forty-one of these acres (10.5%) were created marsh in 2013. A total of 978 acres (72.9%) of rice existed in the Central Basin reserve area in 2013. Overall, 1,119 (83%) of the total acreage of the Central Basin

[3] 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.

reserve area was potential giant gartersnake habitat in 2013, though, 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 area cover approximately 2,351 acres. A total of 417 of these acres (18%) were created marsh in 2013, and 1,294 acres (55%) of rice existed in the North Basin reserve area in 2013. Overall, 1,711 (73%) of the total acreage of the North Basin reserve area was potential giant gartersnake habitat in 2013. Of the 14 tracts in the North Basin reserve area, 3 (Bolen West, Bolen South, and Huffman West) did not contain habitat suitable for giant gartersnake. Six tracts (Atkinson, 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 3-19). In particular, although surface water connects the Fisherman's Lake area with other reserve areas, the northern end of the northernmost suitable Fisherman's Lake tract (Natomas Farms), is 7.6 kilometers (by canal) south of the nearest suitable Central Basin 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 I-5 exacerbate the great distance between reserves of the Central Basin and those of Fisherman's Lake. Given the distance and intervening habitat conditions, it is unlikely that the reserves of Fisherman's Lake are demographically connected to other reserves. Within the Fisherman's Lake area, the two suitable tracts, Natomas Farms and Cummings, are connected by approximately 0.9 kilometers of canal habitats that comprise Fisherman's Lake. Construction of mitigation wetlands by SAFCA should provide even greater continuity of habitat within the Fisherman's Lake area as the marshes mature.

In contrast to the Fisherman's Lake tracts, the tracts of the Central Basin are in close proximity to those of the North Basin. The eastern edge of Ruby Ranch in the North Basin is only 2.6 kilometers (by canal) to the Sills and Tufts tracts of the Central Basin. Within the Central Basin, tracts are nearly contiguous, with the exception of a 0.8-kilometer gap between Bianchi West and Frazer South. 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 Highway 99, which lies between Bianchi West and Sills. Although this highway is a formidable barrier, a female giant gartersnake initially marked in 2010 at Bianchi West (east of Highway 99) was captured at Sills (west of Highway 99) three times in 2011. This individual almost certainly crossed through the 132-meter long single box culvert under Highway 99, providing strong evidence for genetic (and possibly even demographic) connectivity across Highway 99 in the Natomas Basin (Halstead et al. 2013b).

Since 2012, the Elverta Road and Riego Road Interchange Projects, conducted by Caltrans, have been ongoing in the Natomas Basin (Caltrans 2012). Canals that bordered Highway 99 and each road near the intersection have been 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 is expected to be completed in late 2014 (Caltrans 2012). With the diverted canals and ongoing construction, the potential for disturbance is high. It is unknown whether connectivity or snake movement across the Highway 99 corridor is being affected.

Like the Central Basin, the reserves of the North Basin are well connected. No major highways fragment North Basin reserves, and the only discontinuity between reserves containing suitable habitat is 2 kilometers between Lucich North and Bennett North. This gap occurs along the North Drain, which is suitable giant gartersnake habitat. It is highly likely that all reserves in the North Basin are genetically connected, and nearly all tracts are demographically connected with at least one other tract as well. Resumption of rice agriculture or creation of marshes at Nestor would further enhance the connectivity of the North Basin reserves.

Overall, it is very likely that all North Basin and Central Basin reserves are genetically connected, and that these reserves are also demographically connected to at least one other reserve. 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. The situation is far more dire on the Fisherman's Lake Reserve. 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. It is hoped that the creation 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 hundreds of individuals. Abundance decreased across all demographic monitoring sites except Sills in 2013, although this decrease was not statistically significant, as evidenced by the considerable overlap in credible intervals[4] for all sites over time. Abundance was lowest in the Fisherman's Lake area, where only one individual was captured once during demographic monitoring—this is similar to the capture histories observed at this site over the last 2 years. Because no recaptures occurred at Natomas Farms, considerable uncertainty exists regarding the estimate of abundance at this site. The mode of the posterior distribution, which is equivalent to the most likely single estimate of abundance, was 1, and the probability that abundance in the sampled area was less than 10 was 0.614.

Lucich South, while having considerably more captures (17 individuals) than Natomas Farms, had no recaptures in 2013 at the demographic monitoring site, which results in considerable uncertainty regarding abundance. Abundance was estimated to be 120 at Lucich South, drastically less than the estimate of nearly 400 in 2012, although estimates of abundance were very imprecise in every year.

The remaining demographic monitoring sites had higher capture probabilities resulting in more precise estimates of abundance. Abundance at Sills, which is the only demographic monitoring site composed entirely of rice and its associated canals, was less than at BKS in 2013, but was not statistically different from the other demographic monitoring sites, all of which have a managed marsh component.

Abundance at Lucich North was estimated to be approximately 70 individuals, which was about half the median estimate of BKS, and similar to the estimate from 2012.

BKS had slightly, although not significantly, lower abundance in 2013 than 2012. This comparison is difficult to interpret, however, as the location of traps was moved to accommodate marsh maintenance at Pond Q. Nonetheless, abundance was estimated to be greater at BKS than at Sills and Natomas Farms. Finally, 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.

Capture probabilities varied among sites, but 95% credible intervals for capture probability overlapped among all sites. BKS and Sills had the highest (and similar) initial capture probabilities in 2013, but the positive behavioral response to capture at Sills was much more pronounced than that at BKS. The capture probability at BKS was higher than in past years and also higher than capture probabilities at other wetland units. The explanation for this may be related to habitat maintenance activities that occurred at one of the demographic monitoring trap transects at BKS. The wetland unit in which one of the trap transects is usually placed (Pond Q) was drained for maintenance,

[4] *Credible intervals* are the Bayesian equivalent of confidence intervals in traditional frequentist statistics.

requiring the relocation of this transect to an adjacent wetland unit. One of the other two demographic monitoring trap transects also occurs in an adjacent wetland unit, and the other transect occurs in the canal just west of Pond Q. Giant gartersnakes that regularly use Pond Q likely were displaced and moved to the adjacent wetland units and canals, potentially increasing capture probabilities at those sites. Further evidence of displacement comes from an occupancy site located in the northeast corner of the Betts tract in which eight individuals were captured—one while traps were being set—where no individuals were captured in 2012 during the 21-day period.

Subsequent to the completion of maintenance activities and the refilling of Pond Q, one individual was captured during 21 days of occupancy monitoring at the site.

Demographic Rates

The completion of 3 years of monitoring under the revised sampling protocol at demographic monitoring sites allowed the estimation of demographic parameters of great interest to resource managers for the first time since comprehensive monitoring began in 2004. In particular, apparent survival, per capita recruitment, and population growth rates of giant gartersnakes were estimated at four of the five demographic monitoring sites.

Apparent survival for all sites except Lucich South was low, with all sites having posterior distributions entirely below 0.3. At Lucich South, however, apparent survival was estimated to be significantly higher, although it was estimated imprecisely. Lucich South was the only site at which an individual captured in 2011 was also captured in 2013, which is the proximate reason that apparent survival was estimated to be much higher at Lucich South. Several factors can contribute to a lack of recaptures of individuals captured in previous years. Low annual survival rates is one obvious explanation. However, because many large snakes were captured—and the expected annual survival rate of adult females in the Sacramento Valley is 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.

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. We suspect that the low apparent survival rates at the demographic monitoring sites are primarily caused by temporary emigration, and will analytically address this as more data accumulate 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 were estimated relatively imprecisely, but were generally below replacement levels. At all sites during all intervals, however, the posterior distribution of per capita recruitment included values that exceeded one. Like survival, recruitment comes in two forms: births of individuals to resident females, and immigration of individuals from outside the sampled area. We suspect that both sources contribute to recruitment at the demographic monitoring sites in the Natomas Basin.

Taken together, the low apparent survival and per capita recruitment rates resulted in populations that were estimated to be declining at three of the four demographic monitoring sites where estimates using open population Jolly-Seber models were obtainable. At BKS, a 10% decline in abundance from 2011 to 2013 was 29 times more likely to have occurred than a 10% increase in abundance, although this result is suspect due to the confounding caused by relocation of one of the demographic monitoring trap lines necessitated by habitat maintenance activities. At Lucich North over the same time period, the odds of a 10% decline in abundance were six times greater than the odds of a 10% increase in abundance. Sills was even less likely to be increasing in abundance, with a 10% decline 82 times more likely than a 10% increase in abundance. Lucich South, however, was 13 times more likely to have increased in abundance by 10% than to have decreased in abundance by 10% from 2011 to 2013. It should be noted, however, that Lucich South also had the greatest uncertainty in abundance caused by capture probabilities that were an order of magnitude lower than at other sites.

Although population growth rates at most sites were negative, it is premature to relate these trends to habitat characteristics or management practices. Many factors other than management practices can affect giant gartersnakes, and we suspect that such widespread declines (if they indeed occurred) were likely caused by regional, rather than site-specific, variables. We particularly caution against concluding that Lucich South is in some way "better" than the other demographic monitoring sites. This site had extremely low capture probabilities and great uncertainty in estimates of apparent survival, recruitment, and abundance. Indeed, while capture probabilities were generally increasing or stable from 2011 through 2013 at other sites (thus increasing the precision of estimates of demographic parameters at these sites), they were decreasing at Lucich South over the same period, potentially inflating abundance estimates. As longer-term data is collected, the potential of the revised study design will be realized, and changes in survival and recruitment (and ultimately, abundance) will be better able to be related to climatic, habitat, and management variables.

Size Distribution and Sex Ratio

The sex ratio of giant gartersnakes on TNBC reserves was not distinguishable from one male per female, and should not limit the reproductive potential of the species. Nevertheless, 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 Natomas Basin Conservancy 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

Just as in previous years, the occupancy analysis for 2013 indicated that the giant gartersnake is expected to occur in most wetland or rice units on reserve lands. Evidence existed for a strong positive effect of emergent vegetation on the probability of occurrence of giant gartersnake. This is likely because emergent vegetation provides the habitat complexity that provides cover from predators and concentrations of small prey fish and tadpoles. Emergent vegetation is also likely the critical component of giant gartersnake's historic habitat—tule marsh. There was also evidence of a negative effect of floating vegetation on the probability of occurrence of giant gartersnake. Floating vegetation, which in the Natomas Basin is predominantly mosquito fern (*Azolla* spp.), duckweed (*Lemna* spp.), and algae, likely changes many aspects of the physical and biological environment by preventing light from penetrating through the water's surface. The lack of light may reduce underwater photosynthesis, reducing dissolved oxygen content. Low dissolved oxygen could be further exacerbated by decomposition of plant matter. Decreased light and oxygen might result in decreased prey abundance, but prey communities might be depauperate beneath floating vegetation for other reasons as well. In 2013, some evidence also existed indicating a higher probability of occurrence of giant gartersnake in marsh relative to rice, although the effect was smaller than that of floating vegetation. Although the giant gartersnake likely uses rice habitat to traverse fields or even to hunt, rice and its associated canals do not provide the habitat complexity for cover and concentrated prey items like what is seen with emergent vegetation in marshes. Additional research is 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 reserves occupied was most likely stable or decreasing. Occupied sites had a relatively high probability of remaining occupied, but the estimates of colonization probabilities were imprecise. 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 an apparent decrease in the proportion of sites occupied is increased detection probabilities in 2013 and 2012 relative to 2011. Because greater detection probabilities decrease the uncertainty about the status of sites at which no snakes are detected, the possibility exists that increased precision in 2013 resulted in an apparent decrease in the proportion of sites occupied, just as in 2012. Additional years of sampling will allow for the fitting of more complex models that provide more robust conclusions regarding trends in the proportion of reserve wetlands and rice fields occupied by giant gartersnake, and the effects of habitat and management variables on extirpation probabilities.

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. Sills also had a greater probability of declining in abundance than the other demographic monitoring sites. 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) and restriction of giant gartersnake to structurally simple linear canals during the other 5 months of the active season 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). 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 likely 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 an "as absolutely necessary" basis.

Another important component of giant gartersnake habitat is refuge from predators and, perhaps more importantly, 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*) 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.

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) that increases the probability of occurrence of giant gartersnakes.
- 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 gartersnakes prefer tules to other aquatic vegetation such as cattails or water primrose, which are used but not positively selected by giant gartersnakes. (U.S. Geological Survey, unpublished data)
- Continue to control mosquitofern (*Azolla* spp.) and other floating vegetation where possible. The probability of occurrence of giant gartersnake is lower in areas with greater floating vegetation cover and giant gartersnakes tend to avoid mosquitofern (U.S. Geological Survey, unpublished data). Mosquitofern likely alters the vegetative and prey communities and water characteristics.
- Maintain herbaceous terrestrial bankside vegetation to provide cover for giant gartersnake when in terrestrial habitats.
- To the extent possible, avoid rapid changes in water levels during giant gartersnake's inactive season (October through March) to avoid disturbance to hibernating individuals, and try to restrict changes in water levels to the minimum number of fluctuations possible.
- Maintain as many muskrat (*Ondatra zibethicus*) burrows, crayfish burrows, and California ground squirrel (*Otospermophilus beecheyi*) and other small mammal burrows as feasible to provide giant gartersnakes abundant summer refugia and winter hibernacula. 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 by mid-October 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.
- Continue implementation of the revised sampling protocols for occupancy and demographic surveys, as they have shown to be effective in evaluating the effects of management practices,

and will allow explicit examination of the effects of management practices on demographic rates as data accumulate.

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Table 3-1. Prior Probabilities for Parameters of Single-Season Occupancy Models for Giant Gartersnake on Natomas Basin Conservancy Reserve Properties, 2013

			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
		$\beta_{water}\beta_{fl.veg}$	*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, 2013

	Number of Giant Gartersnake					
Reserve/Tract	Individuals	Captures	Dates Trapped (2013)			Total Trap-Days
North Basin Reserve						
Atkinson	0	0	08/09–08/29			891
Bennett North (rice)	0	0	08/29–09/19			1,047
Bennett North (wetland)	0	0	09/06–09/18			600
Bennett South	2	2	08/17–08/26			450
Frazer North Southeast	1	1	07/16–08/05			1,049
Frazer North West	1	1	07/16–08/06			1,050
Huffman West	2	3	07/19–08/09			1,049
Lucich North Southwest	4	7	08/09–08/17			400
Lucich North	32	44	04/30–06/25			8,395
Lucich South	17	17	04/23–07/14			12,000
Lucich South (rice)	0	0	07/15–08/05			936
Ruby Ranch	0	0	08/26–09/16			947
Central Basin Reserve						
Bianchi West	0	0	08/05–08/26			950
BKS	68	101	05/07–06/24	08/05–08/09	08/26–09/16	7,998
Sills	15	23	06/07–07/13			5,050
Tufts	1	2	08/27–09/17			1,050
Fisherman's Lake Reserve						
Cummings	1	1	08/06–08/27	08/28–09/18		2,000
Natomas Farms	1	1	04/22–07/10			11,843
Rosa East	0	0	08/23–09/18			1,050
Total	**145**	**203**				**58,755**

Table 3-3. Posterior Model Probabilities for Abundance of Giant Gartersnake at the Western Edge of BKS, May–June 2013

Explanatory Variable					
Water Temperature	SVL	Sex	Behavioral Response	Temporal Heterogeneity	Posterior Probability[a]
1	0	0	1	0	0.570
1	1	0	1	0	0.138
1	0	1	1	0	0.082
1	0	0	0	0	0.081
0	0	0	0	0	0.004

[a] The posterior probability is the probability that the model is the best the "best" model. If all possible models were shown, the probabilities would sum to 1.

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 > 0.03125 (the prior probability for each model) and the null model are presented in the table.

Table 3-4. Posterior Model Probabilities for Abundance of Giant Gartersnake at Sills, June–July 2013

Explanatory Variable					
Water Temperature	SVL	Sex	Behavioral Response	Temporal Heterogeneity	Posterior Probability[a]
0	0	1	1	0	0.315
0	0	0	1	0	0.298
0	1	1	1	0	0.092
0	0	1	1	1	0.053
0	1	0	1	0	0.052
0	0	0	1	1	0.050
1	0	1	1	0	0.039
1	0	0	1	0	0.037
0	0	0	0	0	0.001

[a] The posterior probability is the probability that the model is the best the "best" model. If all possible models were shown, the probabilities would sum to 1.

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 > 0.03125 (the prior probability for each model) and the null model are presented in the table.

Table 3-5. Posterior Model Probabilities for Abundance of Giant Gartersnake at the Southern Edge of Lucich North, April–June 2013

Explanatory Variable					
Water Temperature	SVL	Sex	Behavioral Response	Temporal Heterogeneity	Posterior Probability[a]
0	0	0	0	0	0.235
1	0	0	0	0	0.159
0	0	0	1	0	0.149
1	0	0	1	0	0.097
0	0	1	0	0	0.077
1	0	1	0	0	0.054
0	0	1	1	0	0.048
1	0	1	1	0	0.034

[a] The posterior probability is the probability that the model is the best the "best" model. If all possible models were shown, the probabilities would sum to 1.

Notes:

1 = variable was included in the model.

0 = variable was left out of the model.

Models are presented in order of decreasing posterior probability.

Only those models with posterior probability > 0.03125 (the prior probability for each model) are presented in the table.

Table 3-6. Posterior Model Probabilities for Abundance of Giant Gartersnake at the Eastern Edge of Lucich South, April–June 2013

Explanatory Variable					
Water Temperature	SVL	Sex	Behavioral Response	Temporal Heterogeneity	Posterior Probability[a]
0	0	0	0	0	0.235
0	0	0	1	0	0.229
0	0	1	0	0	0.068
0	0	1	1	0	0.067
1	0	0	1	0	0.047
1	0	0	0	0	0.047
0	0	0	0	1	0.047
0	0	0	1	1	0.043
0	1	0	0	0	0.040
0	1	0	1	0	0.032

[a] The posterior probability is the probability that the model is the best the "best" model. If all possible models were shown, the probabilities would sum to 1.

Notes:

1 = variable was included in the model.

0 = variable was left out of the model.

Models are presented in order of decreasing posterior probability.

Only those models with posterior probability > 0.03125 (the prior probability for each model) are presented in the table.

Table 3-7. Estimated Abundance (Symmetric Posterior 95% Credible Intervals) of Giant Gartersnake at the Five Demographic Monitoring Sites, 2011–2013, Based upon Annual Closed Population Models

Site	2011	2012	2013
Natomas Farms	3 (1–24)	48 (1–388)	6 (1–87)
BKS	175 (101–318)	205 (125–348)	138 (106–191)
Lucich North	264 (68–673)	100 (58–183)	70 (47–123)
Lucich South	309 (70–854)	390 (88–945)	120 (40–444)
Sills	44 (28–75)	27 (18–42)	41 (21–97)

Table 3-8. Sex Ratios (Symmetric Posterior 95% Credible Intervals) of Giant Gartersnake at Demographic Monitoring Sites in the Natomas Basin, 2013

Site	Male:Female Sex Ratio
Natomas Basin	0.809 (0.614–1.061)
BKS	1.063 (0.716–1.583)
Lucich North	0.840 (0.464–1.497)
Lucich South	1.117 (0.444–2.854)
Sills	0.489 (0.194–1.118)

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 Giant Gartersnake in the Natomas Basin, 2013

Site	Model	Bayesian p-value	BIC	ΔBIC	Prior Probability	Posterior Probability[a]
Natomas Basin	Normal	0.517	1,999	0.0	0.5	0.999
	Log-normal	0.650	2,013	14.0	0.5	0.001
BKS	Normal	0.523	986	0.0	0.5	0.646
	Log-normal	0.591	987	1.2	0.5	0.354
Lucich North	Normal	0.534	426	0.0	0.5	0.998
	Log-normal	0.657	439	12.7	0.5	0.002
Lucich South	Log-normal	0.550	220	0.0	0.5	0.825
	Normal	0.511	224	3.1	0.5	0.175
Sills	Log-normal	0.554	187	0.0	0.5	0.810
	Normal	0.509	190	2.9	0.5	0.190

[a] The posterior probability is the probability that the model is the best the “best” model. If all possible models were shown, the probabilities would sum to 1.

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

Table 3-10. Model Selection Table for Mean Mass of Giant Gartersnake in the Natomas Basin, 2013

Site	Model	Bayesian p-value	BIC	ΔBIC	Prior Probability	Posterior Probability[a]
Natomas Basin	Log-normal	0.789	1,737	0.0	0.5	>>0.999
	Normal	0.517	1,838	101.0	0.5	<<0.001
BKS	Log-normal	0.875	850	0.0	0.5	>0.999
	Normal	0.525	906	56.0	0.5	<0.001
Lucich North	Log-normal	0.461	367	0.0	0.5	0.731
	Normal	0.533	369	2.0	0.5	0.269
Lucich South	Log-normal	0.492	199	0.0	0.5	0.999
	Normal	0.551	214	15.0	0.5	0.001
Sills	Log-normal	0.482	163	0.0	0.5	>0.999
	Normal	0.552	178	16.0	0.5	<0.001

[a] The posterior probability is the probability that the model is the best the "best" model. If all possible models were shown, the probabilities would sum to 1.

Note:

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

Table 3-11. Mean Snout–Vent Length and Mean Mass of Giant Gartersnake (Symmetric Posterior 95% Credible Intervals) throughout the Natomas Basin and at Demographic Monitoring Sites, 2013

Site	SVL (mm)	Mass (g)
Natomas Basin	548 (522–574)	81.1 (70.1–94.0)
BKS	551 (509–593)	78.8 (61.1–101.4)
Lucich North	514 (463–565)	79.4 (61.1–103.2)
Lucich South	580 (511–658)	101.5 (69.1–149.6)
Sills	510 (451–577)	69.8 (46.5–110.7)

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 Giant Gartersnake Based on Habitat on Natomas Basin Conservancy Reserves, 2011–2013

Explanatory Variable					Posterior Probability[a]	
Rice	Emergent Vegetation	Floating Vegetation	Open Water	Terrestrial Vegetation	Uninformative	Informative
0	1	0	0	0	0.106	0.112
1	1	0	0	0	0.086	0.089
0	1	0	0	1	0.078	0.082
0	1	1	0	0	0.080	0.081
1	1	0	0	1	0.068	0.070
1	1	1	0	0	0.066	0.068
0	1	0	1	0	0.061	0.060
0	1	1	1	0	0.053	0.055
0	1	1	0	1	0.052	0.053
1	1	0	1	0	0.049	0.051
1	1	1	0	1	0.047	0.049
1	1	1	1	0	0.046	0.046
0	1	0	1	1	0.042	0.044
1	1	0	1	1	0.037	0.037
0	1	1	1	1	0.035	0.037
1	1	1	1	1	0.031	0.033
0	0	0	0	0	0.006	0.003

[a] The posterior probability is the probability that the model is the best the “best” model. If all possible models were shown, the probabilities would sum to 1.

Notes:

1 = variable was included in the model.

0 = variable was left out of the model.

Only those models with posterior probability > 0.03125 (the prior probability for each model) are presented in the table.

Table 3-13. Model-Averaged Posterior Distributions for Parameters of Single-Season Occupancy Habitat Models for Giant Gartersnake on Natomas Basin Conservancy Reserve Properties, 2013

		Form of Priors on Detection Component of Model	
Model Component	Parameter	Uninformative	Informative
Detection	α_0	-2.038 (-3.422–-0.540)	-2.029 (-2.281–-1.778)
	α_{temp}	-0.270 (-0.818–0.262)	0.250 (0.151–0.350)
	α_{date}	-0.149 (-1.323–1.110)	-0.308 (-0.424–-0.192)
	σ_{site}	1.713 (0.670–3.778)	1.025 (0.840–1.234)
Occurrence	β_0	0.772 (-1.008–3.068)	0.639 (-1.067–2.731)
	β_{rice}	0.096 (-3.102–2.991)	-0.108 (-3.082–2.936)
	$\beta_{em.veg}$	2.392 (-0.560–4.656)	2.476 (0.284–4.729)
	$\beta_{fl.veg}$	-0.298 (-3.010–2.853)	-0.310 (-3.025–2.868)
	$\beta_{open.water}$	0.042 (-2.944–2.913)	0.026 (-2.962–2.897)
	$\beta_{terr.veg}$	0.280 (-2.873–2.965)	0.315 (-2.835–2.919)
	ψ_{avg}	0.684 (0.267–0.956)	0.654 (0.256–0.939)
	N_{occ}	10 (9–15)	10 (9–13)

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

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Figure 3-1
Giant Gartersnake

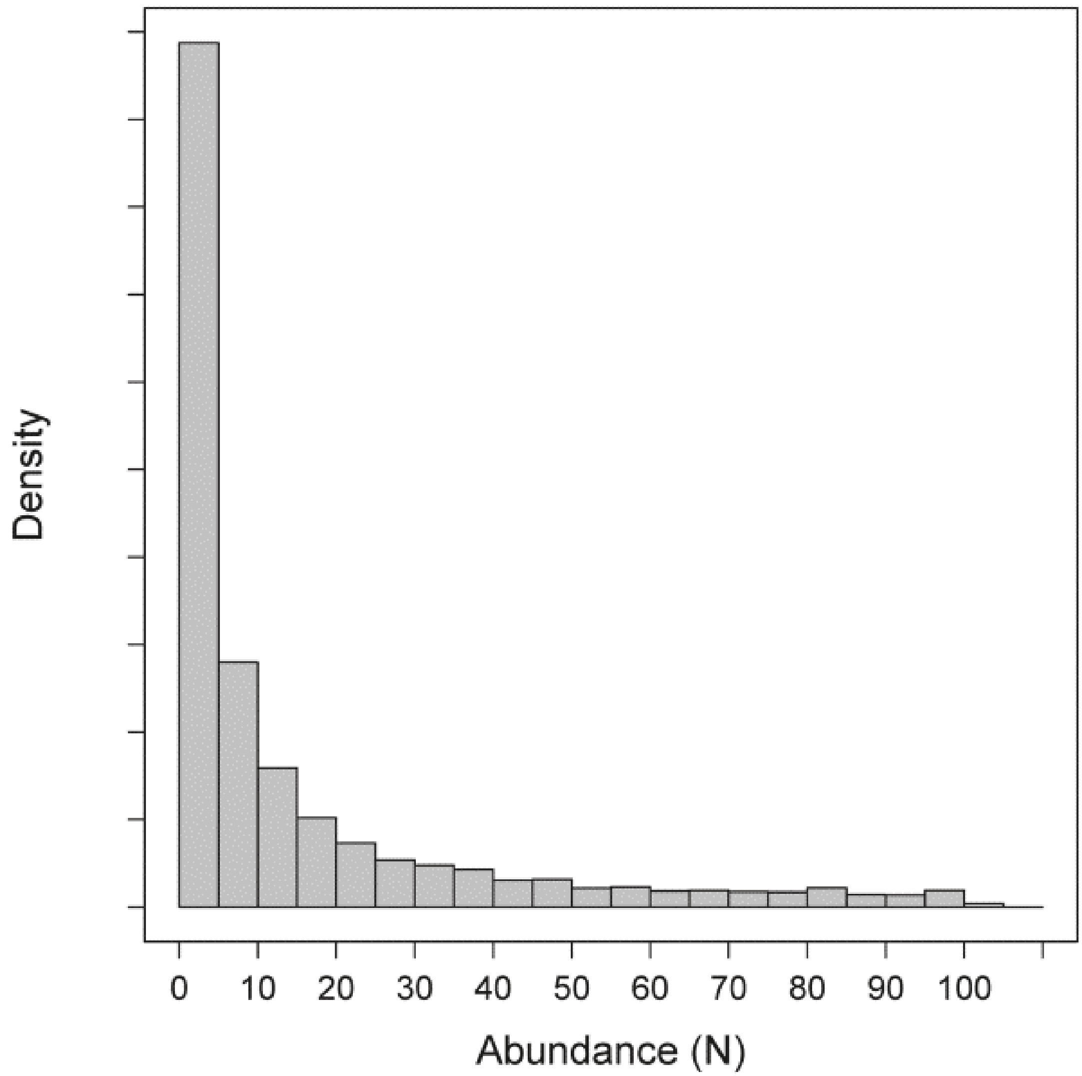

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Figure 3-2
Posterior Histogram of Giant Gartersnake Abundance at Natomas Farms, April–July 2013

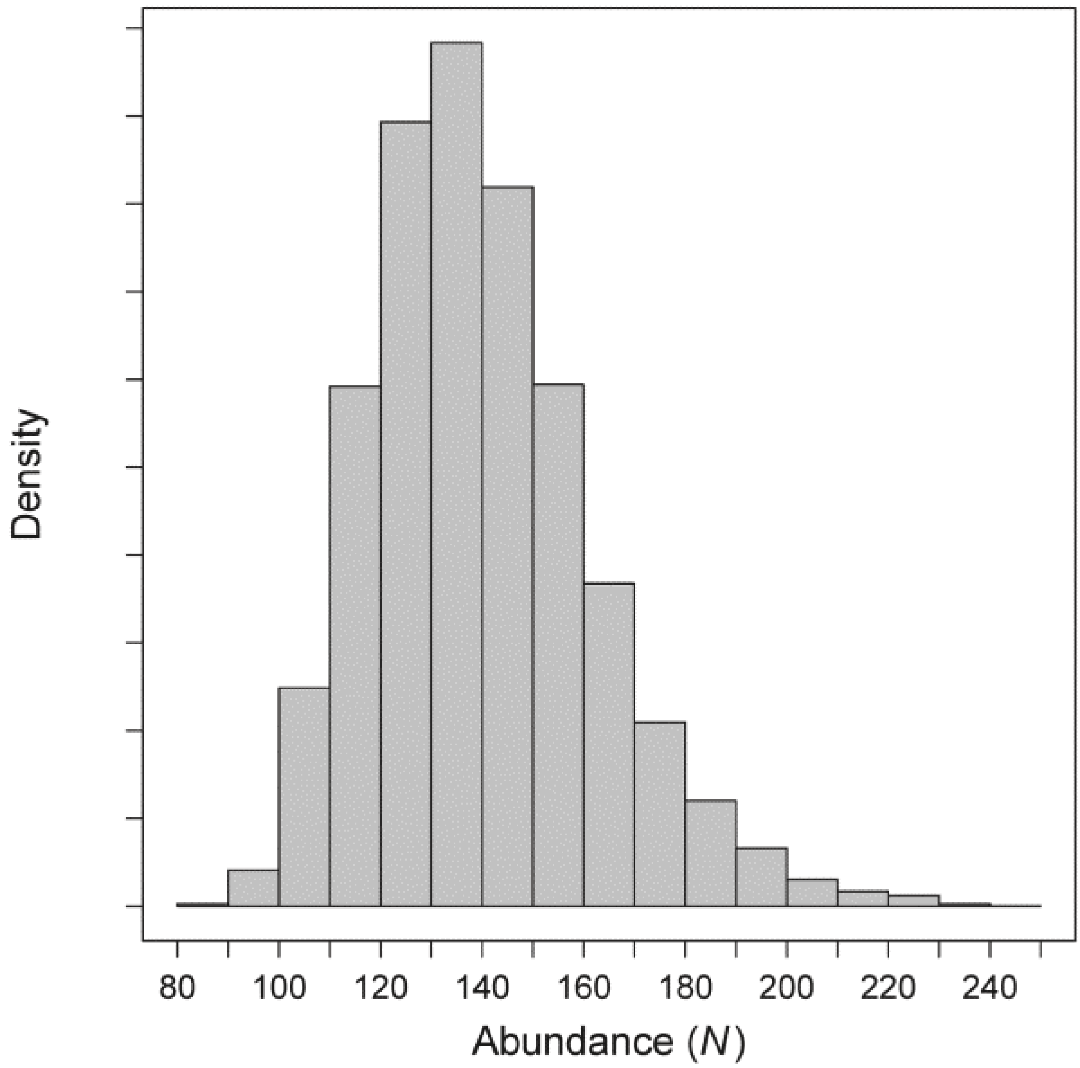

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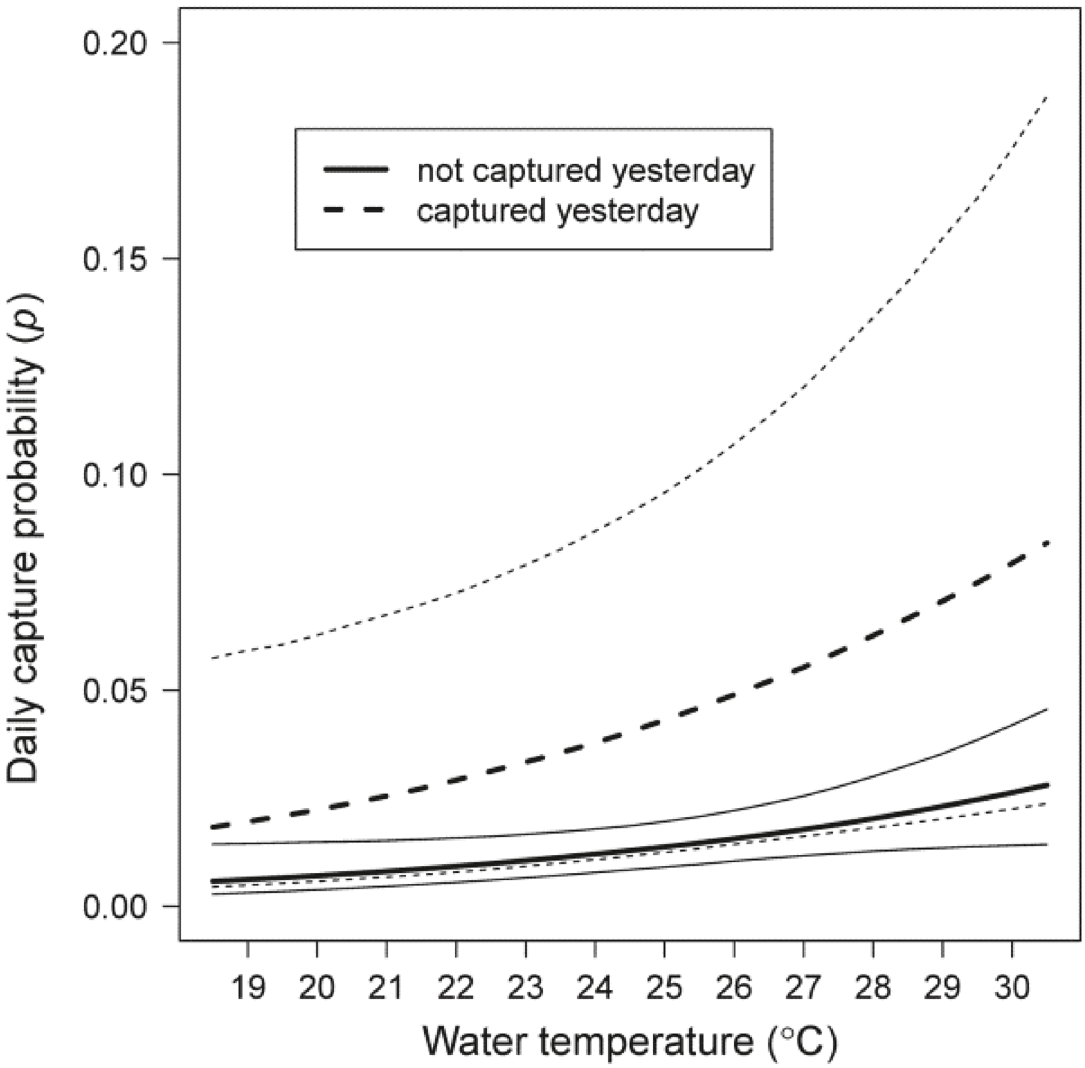
Figure 3-3
Posterior Histogram of Giant Gartersnake Abundance at BKS, May–June 2013



Solid lines represent individuals not captured the previous day; dashed lines represent individuals captured the previous day. The bold lines represent the posterior median effect; light lines represent symmetric 95% credible intervals.

Figure 3-4
Posterior Effect of Water Temperature on Daily Individual Capture Probability of Giant Gartersnake at the BKS, May–June 2013

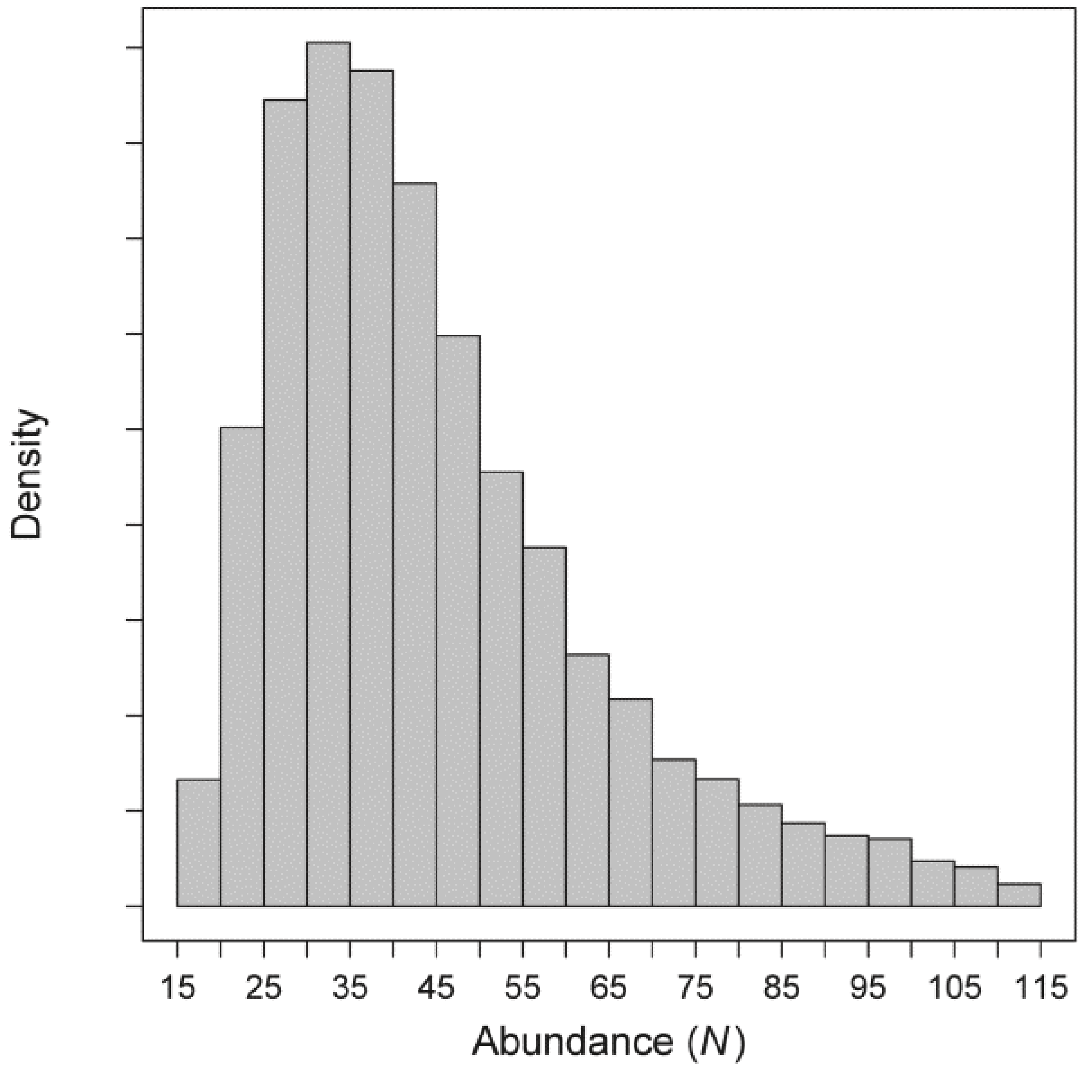
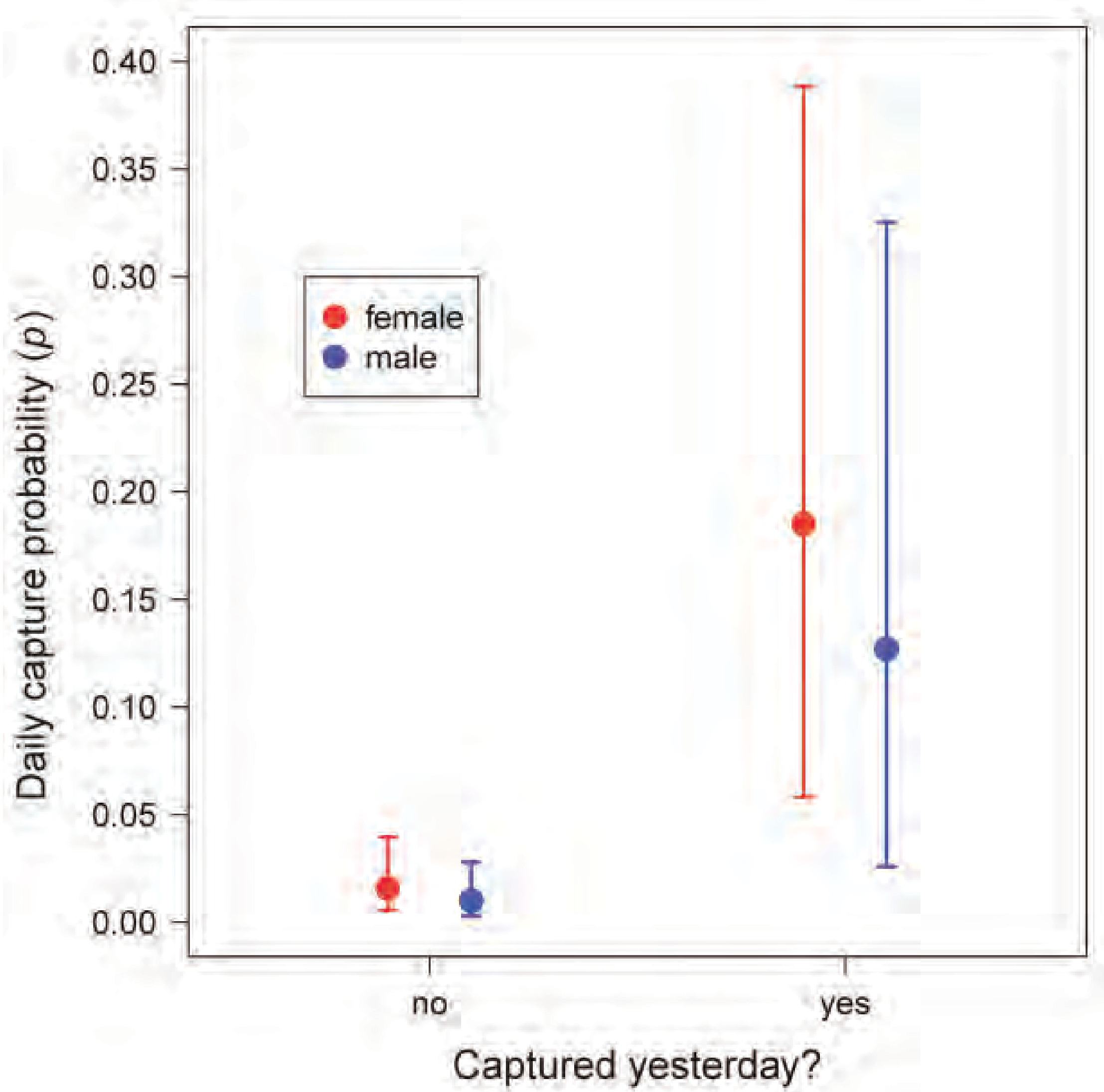


Figure 3-5
Posterior Histogram of Giant Gartersnake Abundance at Sills, June–July 2013



Error bars represent 95% credible intervals.

Figure 3-6
Posterior Median Daily Individual Capture Probabilities for Male (blue) and Female (red) Giant Gartersnakes at Sills, June–July 2013

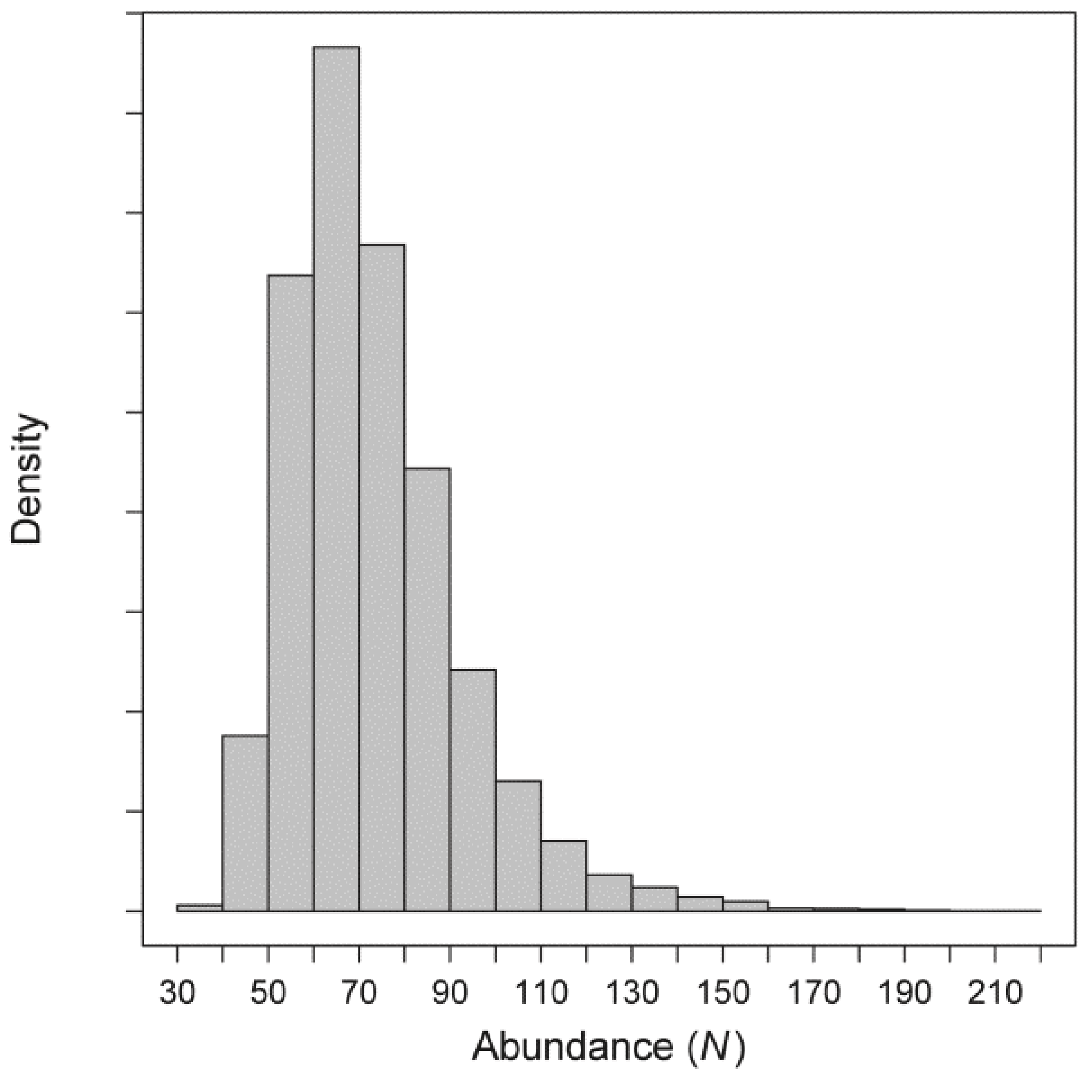


Figure 3-7
Posterior Histogram of Giant Gartersnake Abundance at Lucich North, April–June 2013

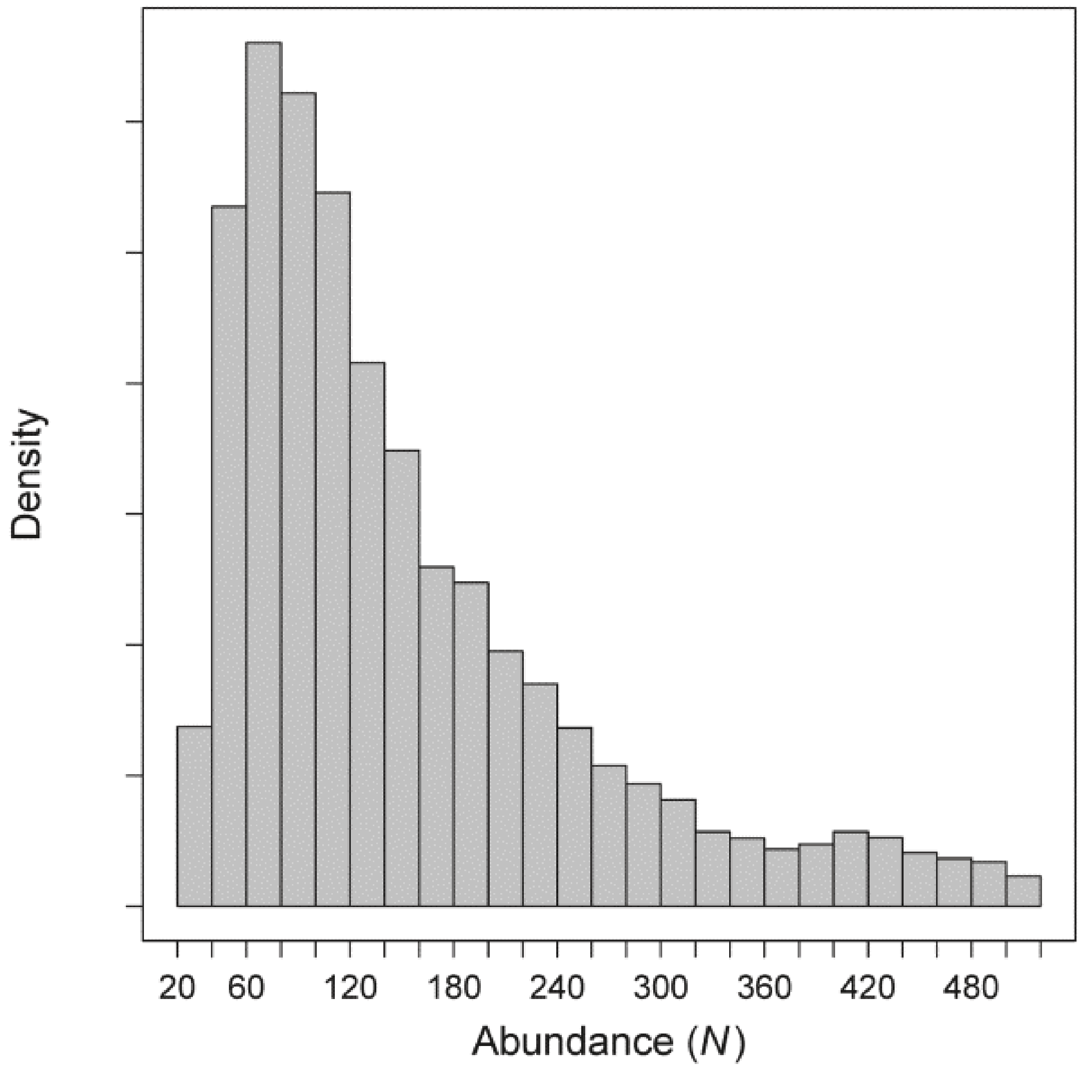


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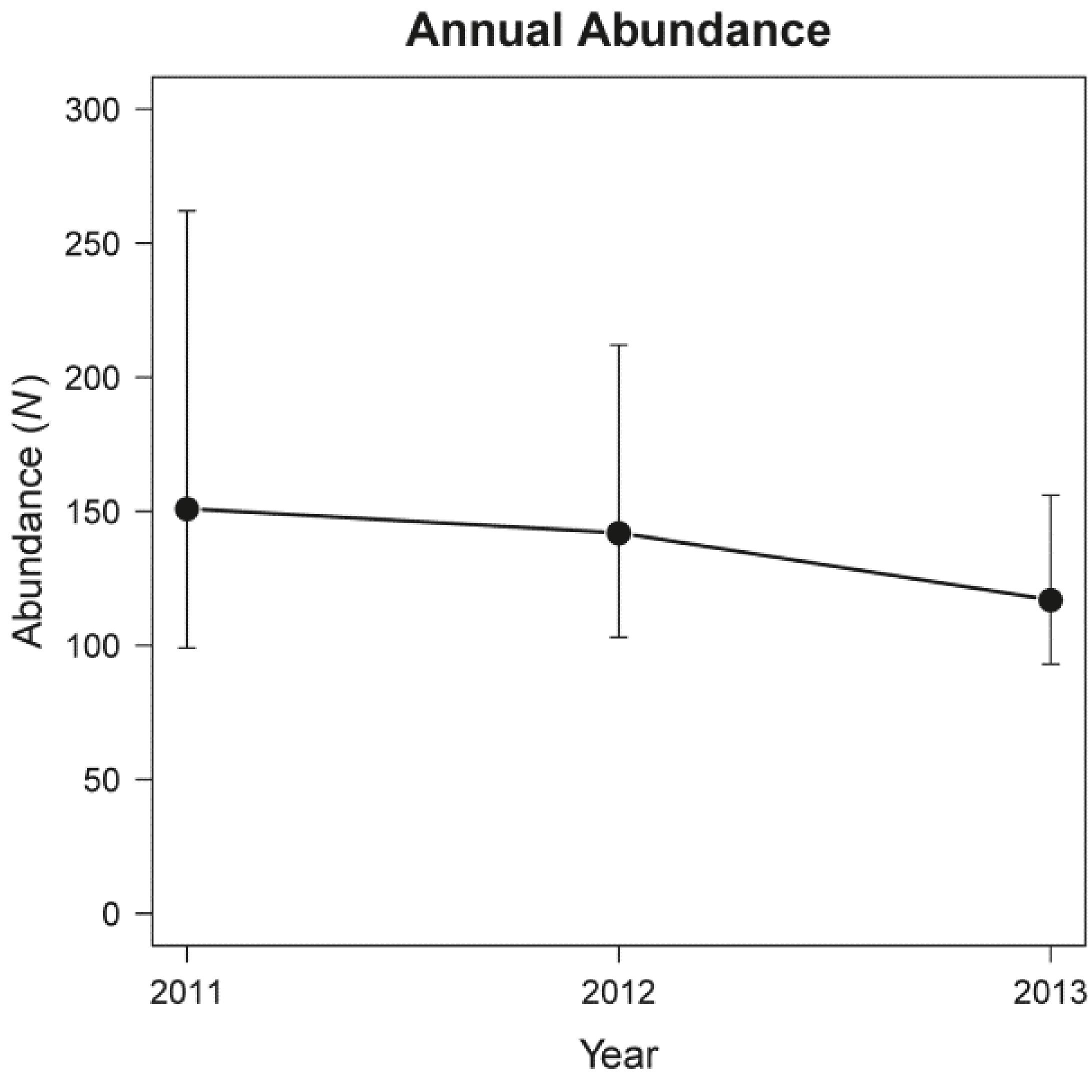
Figure 3-8
Posterior Histogram of Giant Gartersnake Abundance at Lucich South, April–July 2013



Error bars represent 95% credible intervals.

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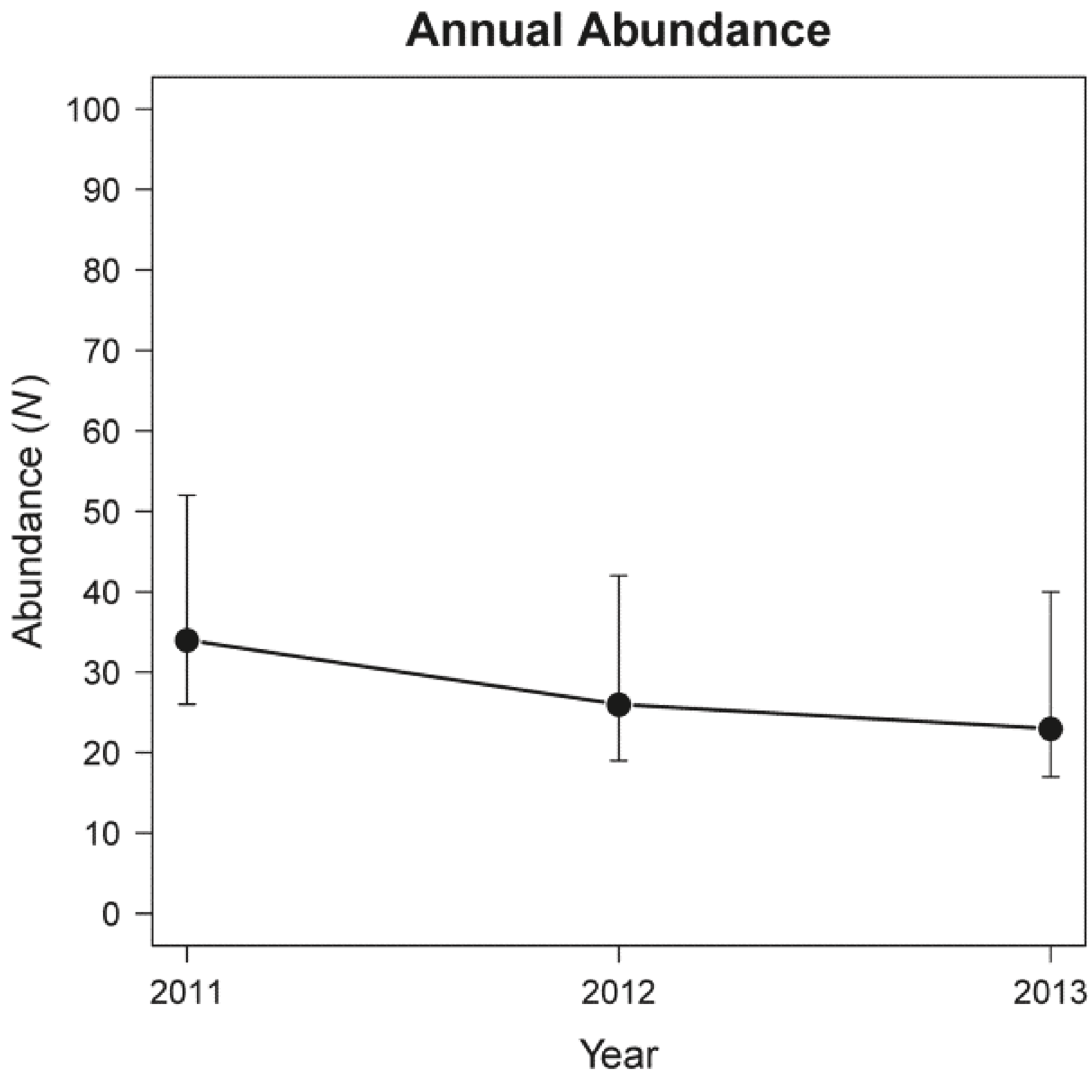
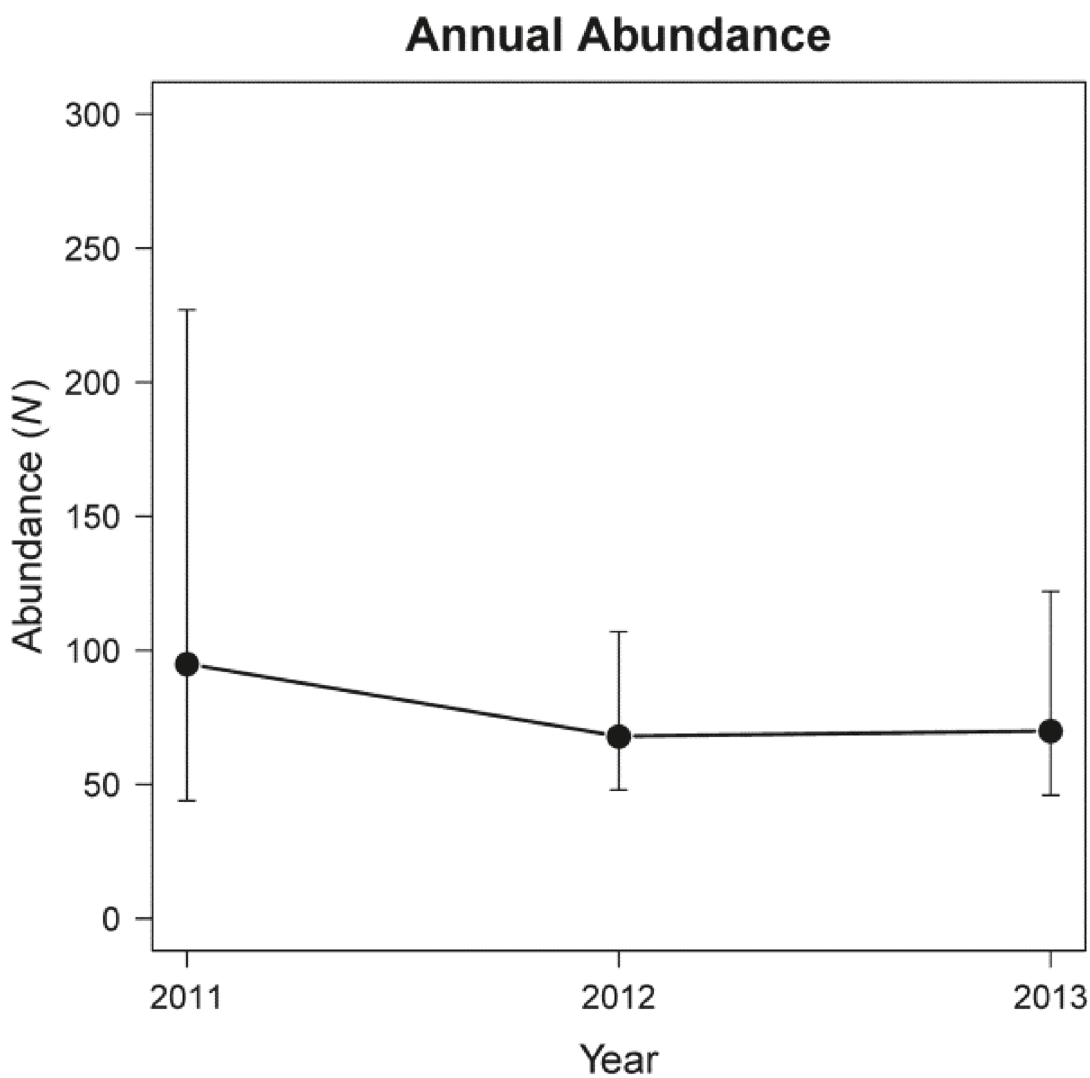
Figure 3-9
Posterior Median Annual Abundance of Giant Gartersnake at BKS, 2011–2013



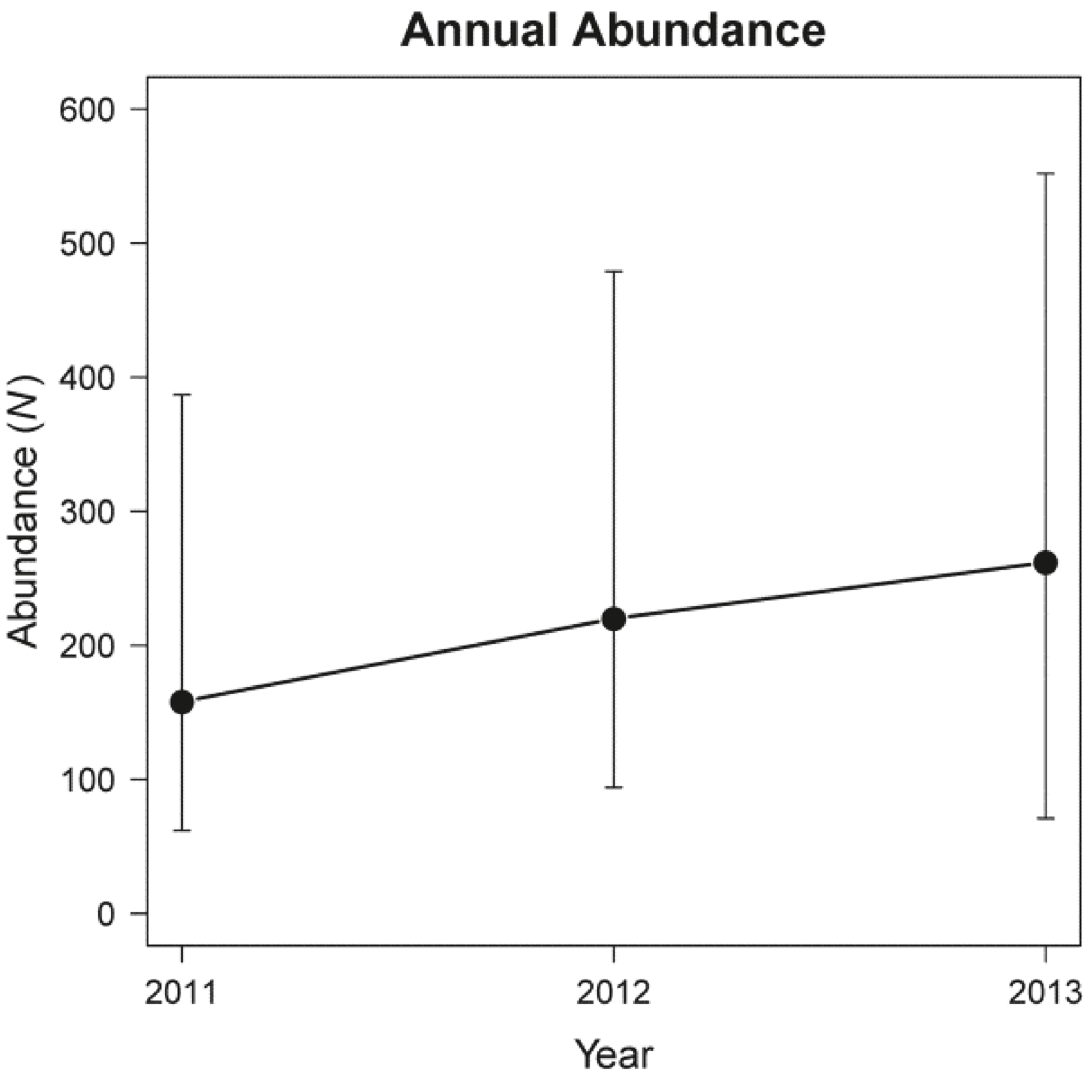
Error bars represent 95% credible intervals.

Figure 3-10
Posterior Median Annual Abundance of Giant Gartersnake at Sills, 2011–2013



Error bars represent 95% credible intervals.

Figure 3-11
Posterior Median Annual Abundance of Giant Gartersnake at Lucich North, 2011–2013



Error bars represent 95% credible intervals.

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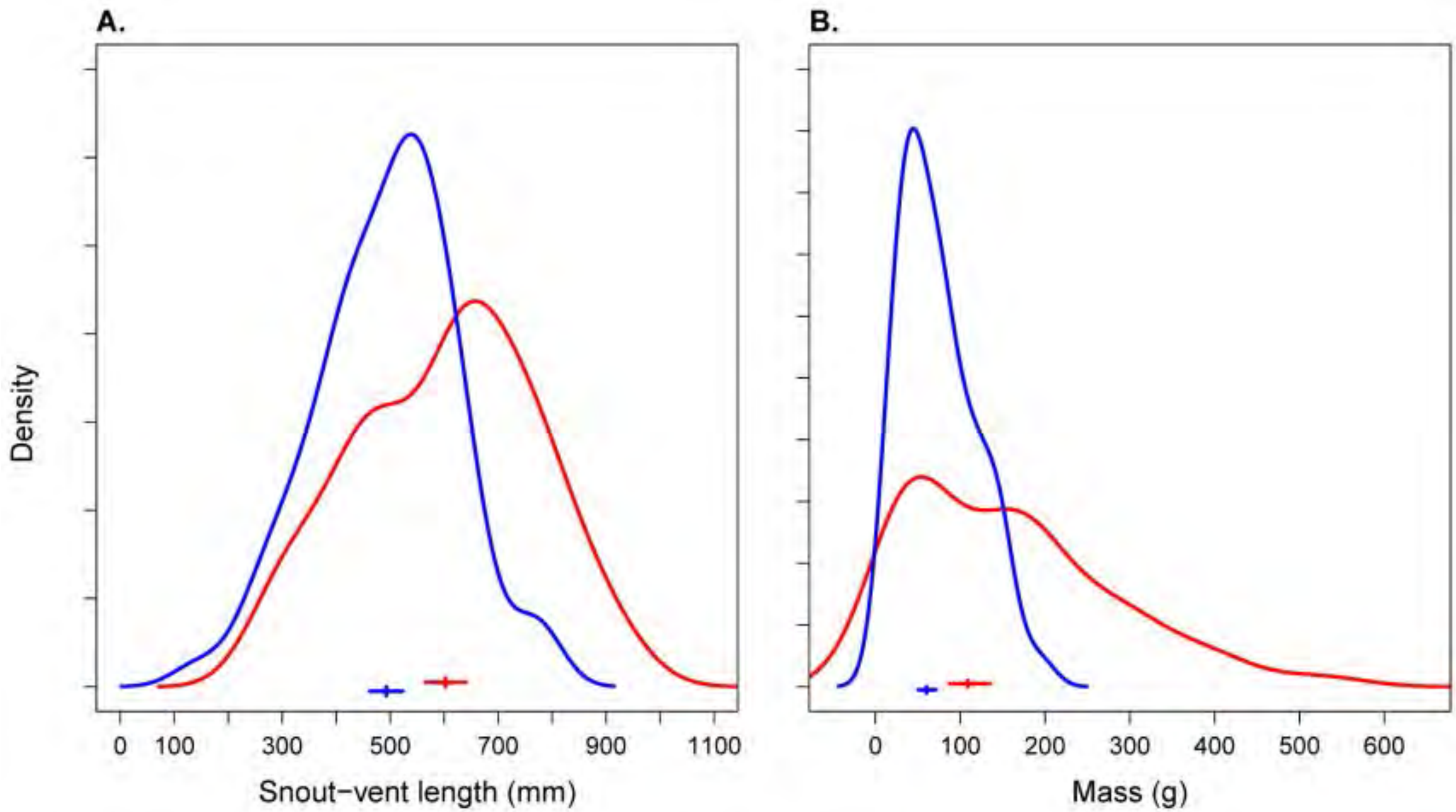
Figure 3-12
Posterior Median Annual Abundance of Giant Gartersnake at Lucich South, 2011–2013



Vertical line near the x-axis of each plot indicates the posterior mean size of males (blue) and females (red), and horizontal line indicates the 95% credible interval.

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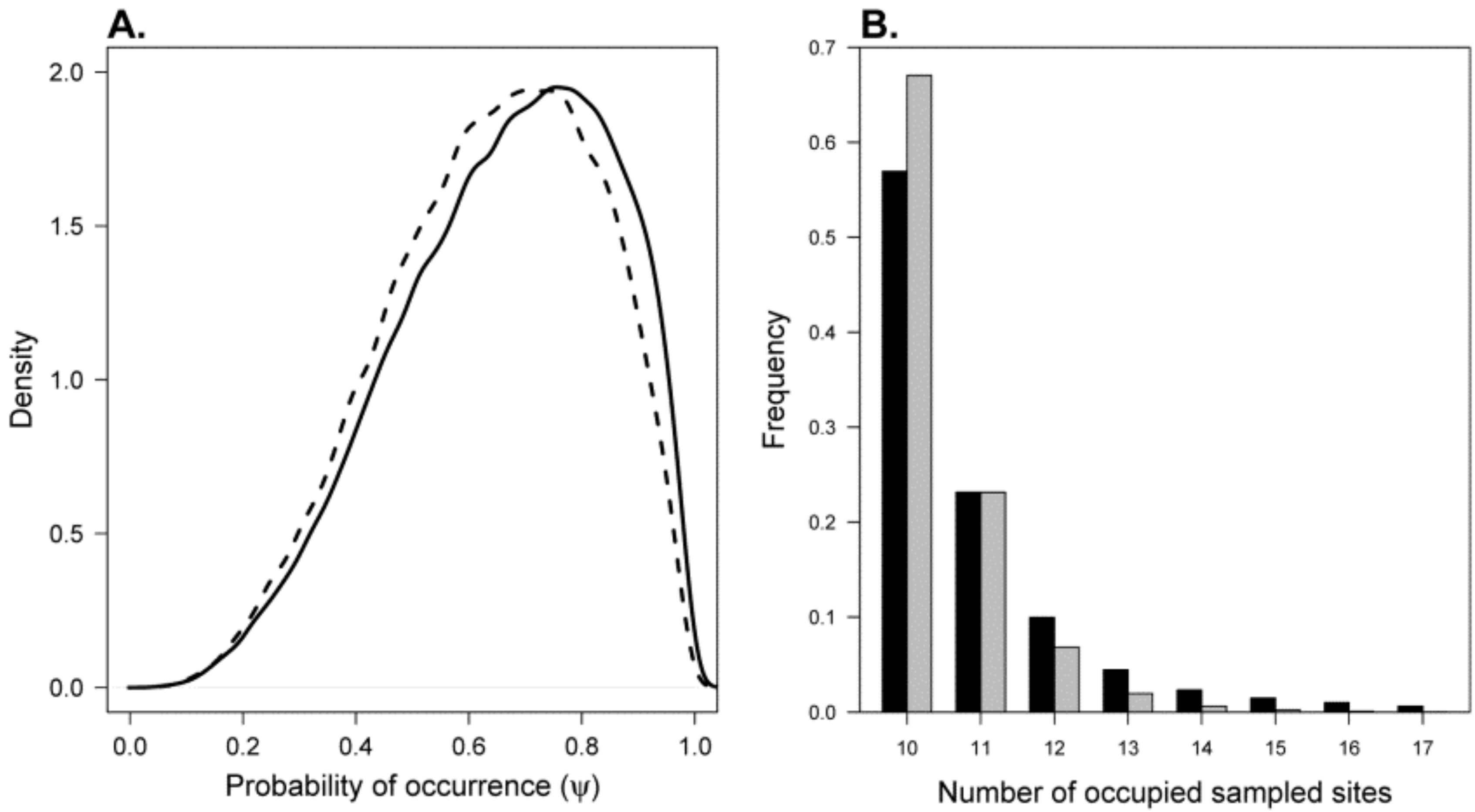
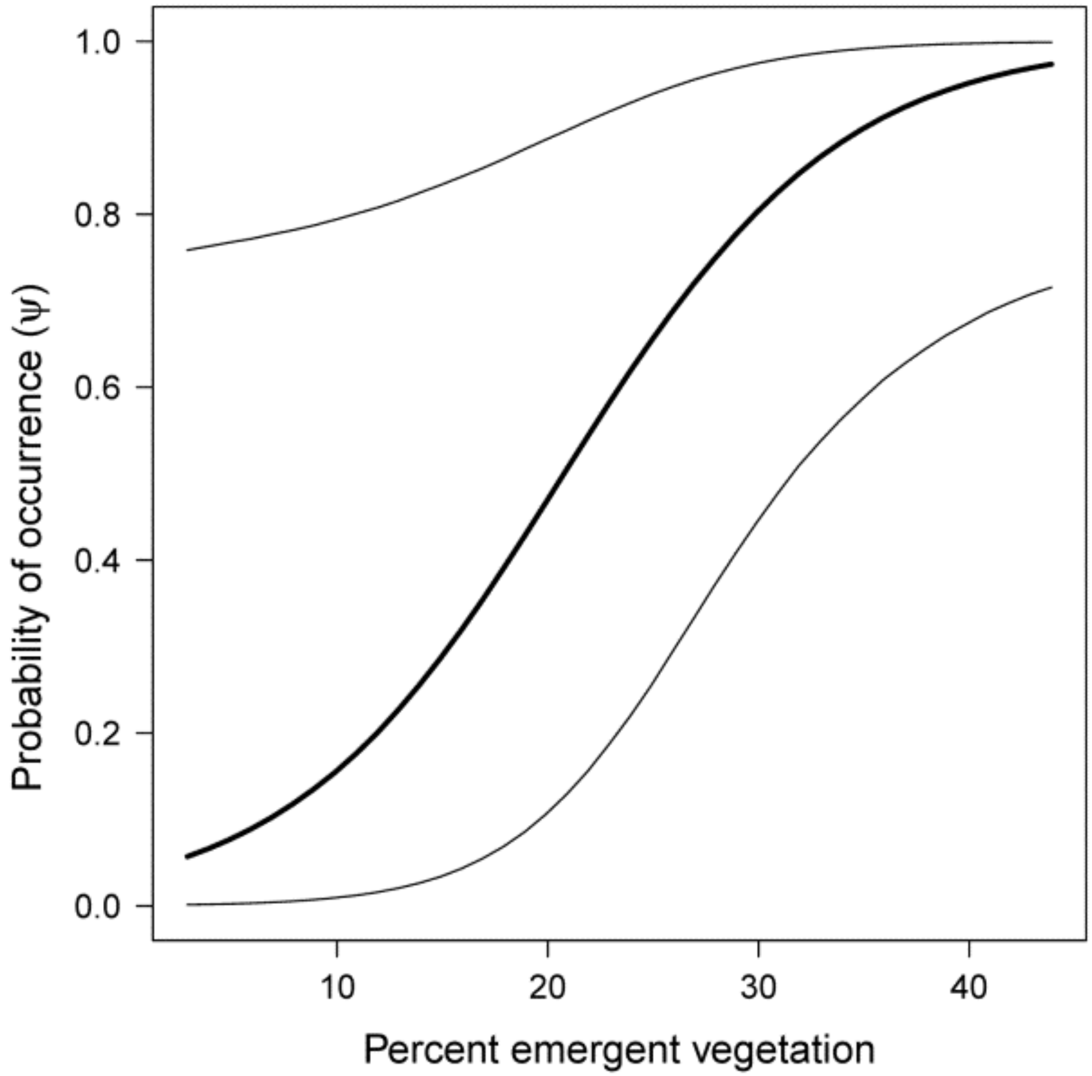
Figure 3-13
Distribution of Male (blue) and Female (red) Giant Gartersnake (A) Snout-Vent Length and (B) Mass in the Natomas Basin, 2013



Solid lines and black bars represent posterior distributions based upon uninformative priors; dashed lines and gray bars represent posterior distributions based upon informative priors. Individual wetland units were counted as separate sites; agricultural reserves were counted as a single site.

Figure 3-14
Posterior Distributions of (A) the Probability of Occurrence of Giant gartersnake on Natomas Basin Conservancy Reserves at Mean Values of Covariates in 2013 and (B) the Number of Sampled Reserve Sites Estimated to be Occupied by Giant Gartersnake in 2013



The bold line represents the median effect; light lines represent the symmetric 95% credible interval.

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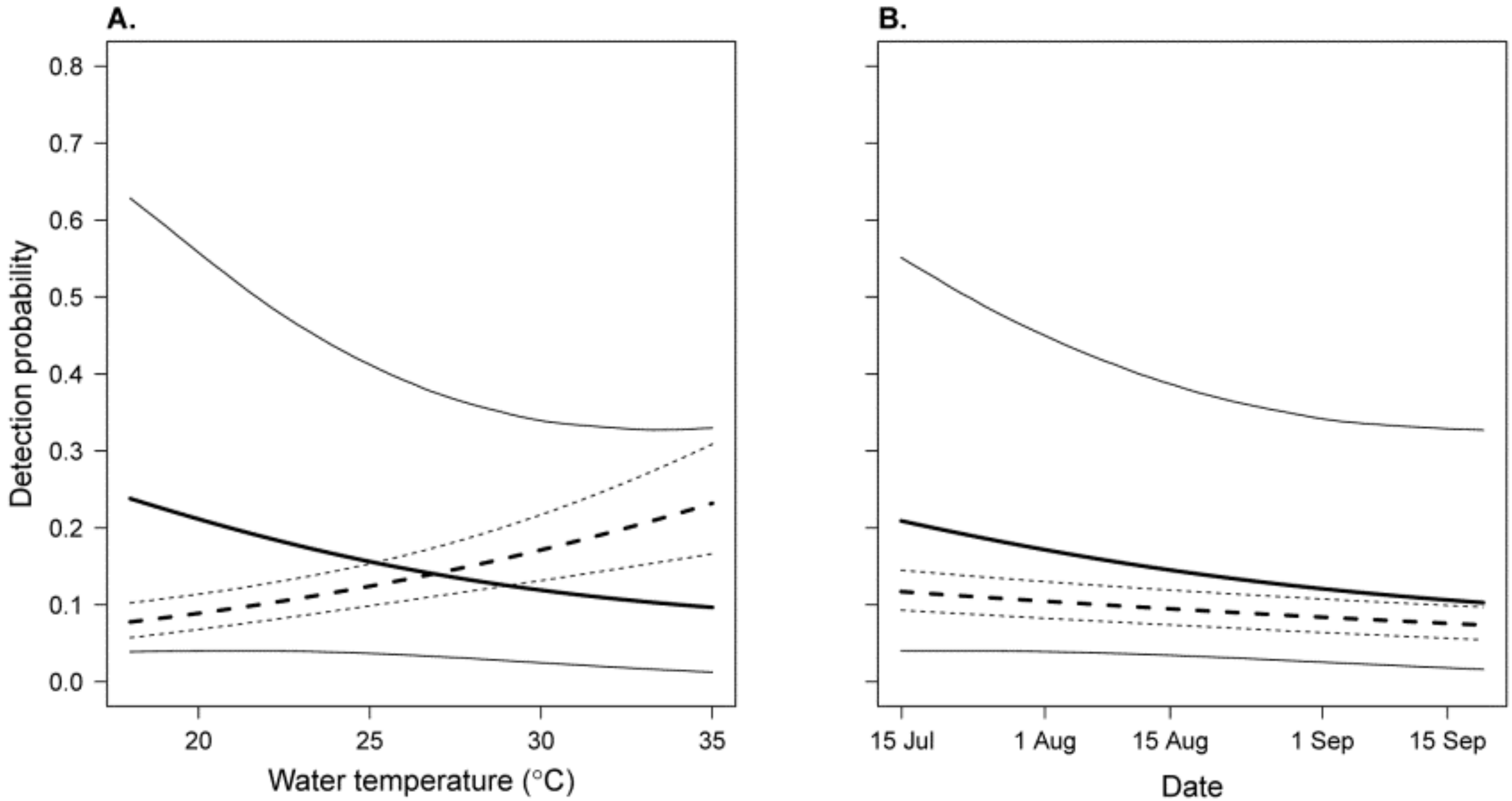
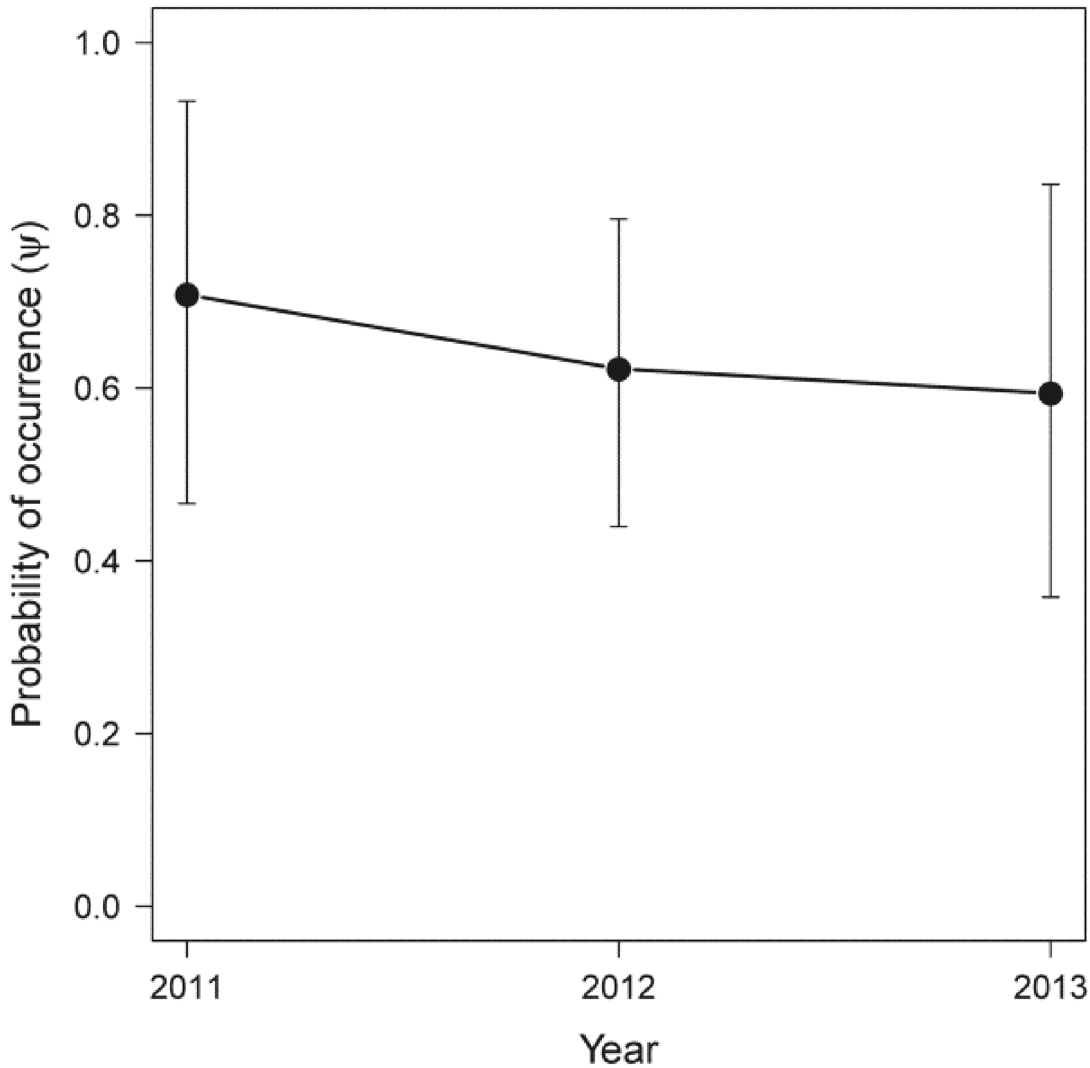
Figure 3-15
Posterior Effect of Emergent Vegetation on Probability of Occurrence of Giant Gartersnake on Natomas Basin Conservancy Reserves, 2013



Solid lines represent posterior distributions based upon uninformative priors; dashed lines represent posterior distributions based upon informative priors. The bold line represents the median effect; light lines represent the symmetric 95% credible interval. Individual wetland units were counted as separate sites; agricultural reserves were counted as a single site.

Figure 3-16
Posterior Effect of (A) Water Temperature and (B) Date on Detection Probability of Giant Gartersnake on Natomas Basin Conservancy Reserves in 2013



Error bars represent 95% credible intervals.

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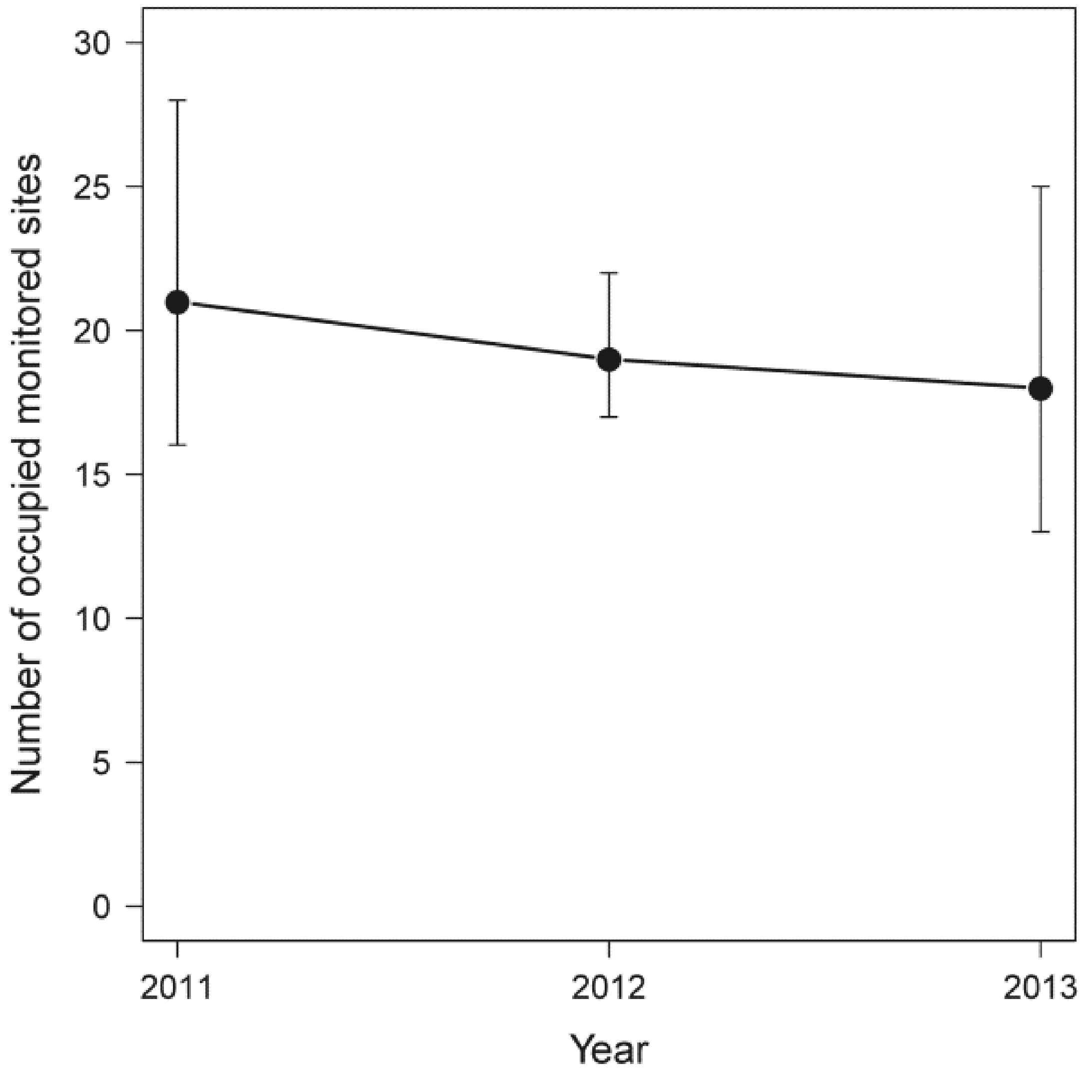
Figure 3-17
Posterior Median Probability of Occurrence of Giant Gartersnake on Natomas Basin Conservancy Reserves, 2011–2013



Error bars represent 95% credible intervals.

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Figure 3-18
Posterior Median Number of Sampled Reserve Sites Estimated to be Occupied by Giant Gartersnake on Natomas Basin Conservancy Reserves, 2011–2013

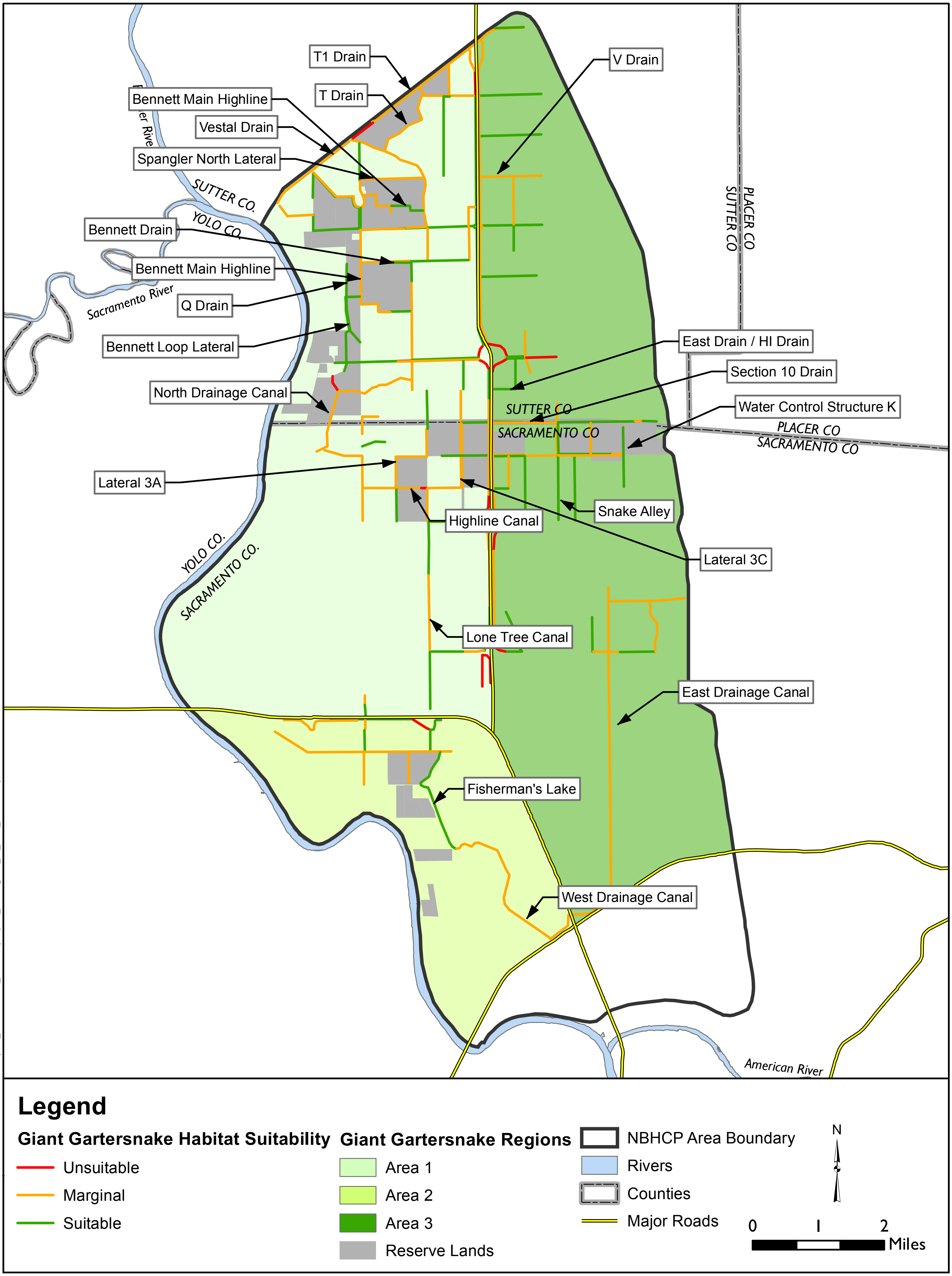

Figure 3-19
Giant Gartersnake Habitat Connectivity, 2013

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 and analyzes the results of surveys for Swainson's hawk in the Natomas Basin from 1999 to 2013.

It should be noted that the study area in the context of 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 birds 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; Bradbury 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).

Results of a 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 recent 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 habitat for Swainson's hawks continues to decline in the Central Valley because of flood control projects, 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 (to provide access to the ground) and high densities of prey (Bechard 1982; Estep 1989, 2008; 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. 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, with an average of 1.2–1.8 young per successful nest (Estep in preparation, Estep 2007) (Figure 4-4). 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 (Bradbury 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 GPS unit.

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 active 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 one in 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 nested primarily in the southern portion and along the far western and northern edges of the Basin in 2013. 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 nesting trees in this area.

A total of 132 Swainson's hawk nesting territories were monitored in 2013 (Table 4-1); among these is one new territory, NB-132. As in past years, each new territory could be an alternate nest site of other known territories. In instances where individual birds are marked (color banded) and can be identified, or where a new nest site occurs in the immediate vicinity of 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. Thus, although the number of territories increases each year, this increase does not necessarily reflect new breeding pairs within the study area.

Changes in the number of active Swainson's hawk nesting territories, the number of successful nests, and the number of young fledged from 2001 to 2013 are depicted in Figure 4-5. There has been an overall increase over time in the number of active territories documented during the course of the study. Although the number of active territories decreased by 13.8% from 2012 to 2013, the decrease was well within the normal range of annual variation. However, the number of successful nests and the total number of young fledged decreased to the lowest levels documented since 2001 (1999 and 2000 are excluded because only the Basin sides of the rivers were included in the survey in those years) (Table 4-2).

Changes in the number of young fledged per active territory, per occupied nest, and per successful nest are depicted in Figure 4-6. All measures of reproductive performance decreased to the lowest levels documented since monitoring began (Table 4-2). This resulted from a high number of pairs not nesting (highest recorded since monitoring began), high number of nest failures among pairs that did nest (second highest recorded since monitoring began), and the low number of young fledged among pairs that successfully nested (lowest recorded since monitoring began).

From 2012 to 2013, the number of active territories along the Sacramento River decreased from 31 to 25 (Table 4-2). While the number of active sites on the west side of the river did not change between 2012 and 2013, the number on the east side decreased by six. The number of nesting pairs along the Sacramento River has remained relatively stable since monitoring began despite continuing home construction, removal of trees, and increasing human disturbances, including disturbance associated with implementation of the NLIP project along the east side of the river. Interestingly, since 2007 variation in the total number of active territories along the river appear to be primarily due to changes in the number of active territories along the east side of the river, while the number of active territories along the west side have been relatively stable over the same period.

Only one new territory was documented in 2013, located at the southwestern corner of the Teal Bend Golf Course near the Sacramento River. The overall distribution of nesting Swainson's hawks remains consistent with all past monitoring years with the bulk of the nesting pairs occurring along the western side of the Basin, primarily along the Sacramento River and within approximately 1 mile of the river. This area continues to provide the highest value foraging habitat and the most abundant nesting habitat in the Basin.

No Swainson's hawk nest trees were removed in 2013. While many potential trees were removed during levee construction activities, restoration actions have successfully established new replacement trees near the toe of the new levee. These are expected to provide new potential nesting habitat in the future. 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).

4.3.2 Habitat Assessment

Table 4-3 lists the acreages of three general habitat categories (upland agriculture, fallow lands, and grasslands) that provided suitable Swainson's hawk foraging habitat Basin-wide from 2004 to 2013. Changes in the Basin-wide total acreage of these habitats over this time period are depicted in Figure 4-7. 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. By 2009, much of the fallowed rice acreage was put back into production, reducing the total fallowed acreage to its current 12% of the total foraging habitat acreage in the Basin. Also during the monitoring period, upland agriculture increased while grassland habitats decreased. While fluctuating year to year due to rice fallowing, land use changes, and other factors, the overall acreage of suitable foraging habitat has remained relatively stable since monitoring began. However, there has been a decrease each year since 2011, including a 7% decrease from 2011 to 2012 and an 8% decrease from 2012 to 2013. In 2013, Basin-wide acreage of upland agricultural and fallow land decreased by a combined total of 2,045 acres; however, grasslands increased by 341 acres due to NLIP grassland restoration activities. In 2013, the amount of suitable foraging habitat decreased approximately 20% (4,742 acres) from the historic high in 2008; however, the total acreage of suitable habitat in 2013 was still 11% above the historic low in 2004. The areal distribution of suitable Swainson's hawk foraging habitat is shown in Figure 4-3.

There is no correlation between the total acreage of suitable forging habitat in the Basin each year and the number of active territories ($r^2 = 0.03$, $p=0.65$). However, there is a positive correlation between the total acreage of upland agricultural crops each year and the total number of active territories ($r^2 = 0.56$, $p=0.01$). No measures of reproductive success were significantly correlated with any of the categories of Swainson's hawk suitable foraging habitat in the Basin.

In 2013, the overall amount of suitable Swainson's hawk foraging habitat on reserve lands remained relatively stable, decreasing from 2012 by only 28 acres due to regular crop rotations. Table 4-4 lists the extent and proportion of five categories of suitable Swainson's hawk foraging habitat on reserve lands in 2013. These categories include both cultivated and uncultivated lands. Suitable cultivated habitats comprise 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. While other habitat types are occasionally used for foraging, their value is generally considered to be less than that of the habitat types listed above.

The acreages and relative proportions of Swainson's hawk foraging habitat types on reserve lands has changed since 2011, but changes were most pronounced with alfalfa and fallow land cover types. The proportion of foraging habitat in higher value crop types (i.e., alfalfa) on reserve lands is nearly three times that observed on non-reserve lands (Table 4-5), despite the slight decrease in alfalfa on reserve lands between 2012 and 2013. The proportion of row, grain, and other hay crops on reserve lands increased by 18% from 2012 and narrowed the margin compared with the higher off-preserve proportion. The Basin-wide decrease in fallowed lands in 2013 occurred primarily on reserve lands resulting in a narrowing of the margin compared with the lower off-preserve proportion from 2012, but still exceeding the proportion of off-reserve lands (16% versus 11%).

The reserve system currently accounts for approximately 6.0% of the suitable Swainson's hawk foraging habitat in the Basin, slightly up from 2012 (5.6%). Consequently, the extent to which TNBC-managed land will help sustain the Swainson's hawk population in the Basin is not yet determined.

4.4 Discussion

The decline in the number of active nesting territories in the Basin from 2012 to 2013 was well within the range of variation documented over the last 13 years, which has ranged between 43 and 65 active territories (Table 4-2). However, reproductive performance of the Natomas Basin population in 2013 was the lowest on record since monitoring began. All components of reproductive success contributed to the decline in reproductive performance. While based mostly on anecdotal data, poor reproductive performance in 2013 appears similar to other Central Valley locales, and may be a regional phenomenon. While there is no obvious cause for this sharp decline, there has been speculation and some anecdotal evidence to support the hypothesis that it is related to food resources, particularly a possible decline in *Microtus* populations. The record number of territories that were active but did not nest suggests that hawks may have returned from wintering grounds in a poor condition insufficient to support reproduction. The high number of failed nesting attempts and low number of young produced per successful nest may also be a result of poor body condition at the onset of the breeding season or may be indicative of insufficient resources to support reproduction.

Both the number of young fledged per occupied nest and per successful nest are anomalous in that they are outside the range typically reported for the Central Valley population. If these declines resulted from a regional decline in food resources or other more broad ecological conditions, reproductive performance would be expected to rebound in subsequent years.

The generally increasing trend in the number of active Swainson's hawk nesting territories coincides to some extent with a general increase in the total acreage of upland agriculture in the Basin, but appears to be unrelated to the total amount of suitable Swainson's hawk foraging habitat. The number of active breeding territories has remained relatively stable since 2011 despite decreases in the total acreage of suitable habitat and the total acreage of upland agriculture in the Basin. This likely reflects the foraging behavior of Swainson's hawks and their extensive use of out-of-Basin habitats by birds nesting within the Basin.

The distribution of nest sites remained similar to past years, with the bulk of the nest sites along the perimeter drainages, primarily the Sacramento River and the Natomas Cross Canal. Most of the remaining sites are in the south Basin (south of Elkhorn Boulevard) and along the western edge of the Basin. While several nest sites in the south Basin continue to be at risk from urbanization, land use changes continue to be minimal, primarily due to the moratorium on new development that remains in effect until upgrades to the levee system are complete.

Relatively little levee construction or related activities occurred during the 2013 nesting season. Interestingly, despite the changes that have resulted from levee and canal construction activities, tree removal, restoration activities, and related disturbances that may have been responsible for nest failures in 2011 and 2012, the nesting distribution within the area affected by levee construction remains relatively stable. The restored grassland habitats in the area of the NLIP project provide moderate to high value foraging habitat, and the restored woodland habitats are expected to provide future nesting opportunities.

Historically, nest tree removal has contributed to the reduction in nesting territories in the south Basin. While planned and proposed urbanization has been on hold due to the levee-related restrictions from the U.S. Army Corps of Engineers, once the levee system is complete and development plans are allowed to continue, additional nesting pairs will likely be displaced. Foraging habitat within the Basin will also likely decline once development resumes. However, because the majority of nesting territories occur along or within 1 mile of perimeter drainages, an area that is less likely to be subject to future urbanization, and because hawks that nest in the Basin also use out-of-Basin foraging habitats, future development as currently proposed (and assuming no further loss of trees along the Sacramento River), may not have a substantial effect on the distribution or abundance of the species in the Basin.

Continuing loss of trees limits future nesting opportunities and the ability of the Swainson's hawk population to respond to habitat changes throughout the Basin. Sacramento County has continued to allow residential development on the river side of the Sacramento River levee, accelerating 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; 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, contributed to additional tree loss along the river. This loss of potential nesting trees and the increase in human disturbance along the river will likely result in additional territory abandonment and will 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). While 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 as nest sites. No active nest trees were removed by SCAS in 2013. SCAS has also recently implemented a wildlife hazard management plan (Sacramento County Airport System 2007) on airport lands to minimize potential bird-strike hazards. 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 maintaining existing Swainson's hawk population levels in the Basin.

While the NLIP, coordinated by the SAFCA, has completed the majority of major levee construction activities from the Natomas Cross Canal to Powerline Road, future landside levee construction, including the removal of trees, along the remaining portion of the Sacramento River and along Steelhead Creek could affect nesting activity in those areas. NLIP activities removed a substantial number of trees; however, no active nest trees were removed, and while construction activities were likely responsible for nest failures in 2011, successful nesting resumed in 2012 in areas where construction has been largely completed. It is anticipated that future levee construction will have similar impacts on the nesting population.

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. It is also measured on the basis of successful implementation of management recommendations designed to further benefit Swainson's hawk through targeted acquisition or specific land management activities.

As discussed above, the status of the Swainson's hawk population in the Basin remains stable. While 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 actions unforeseen by the NBHCP—such as the continuation of the NLIP south of Powerline Road, bird control actions by SCAS, continued disturbance and habitat removal along the east side of the Sacramento River, 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 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 SSMPs for details).

As discussed in Section 4.4, reserve lands managed for Swainson's hawk foraging habitat continue to provide a high proportion of high-value cover types (i.e., alfalfa). 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.

Continuing to acquire reserve lands within 1 mile of the Sacramento River is desirable because a large segment of the nesting population occurs along the river and because the value of foraging habitat along the river is greater than that in the Basin interior. Several reserve tracts are within this zone: Alleghany, Cummings, Souza, Natomas Farms, Rosa East, Rosa Central, Atkinson, Huffman West, Huffman East, Bennett South, and Bolen South. All these tracts include an upland component that provides suitable foraging habitat for Swainson's hawk.

Acquiring contiguous properties or properties with a high probability of being contiguous in the future is also desirable because greater contiguity enhances the suitability of Swainson's hawk foraging habitat. Contiguity has been and continues to be a key component in the decisionmaking process regarding reserve acquisition. The acquisition of the Rosa East and Rosa Central properties in 2005 successfully expanded and consolidated TNBC holdings in the Fisherman's Lake Reserve in the southwestern portion of the Basin. In 2006, TNBC exchanged the 242-acre Brennan tract for the Nestor and Bolen West tracts. These two properties comprise 388 acres and significantly contribute to achieving the reserve consolidation goals established in the NBHCP.

4.6 Recommendations

- Although TNBC has not been in a position to acquire new reserve lands for several years due to the current building moratorium and is currently ahead of NBHCP requirements for acquiring lands within 1-mile of the Sacramento River, 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 work with SAFCA to minimize the effects of levee improvements on TNBC reserves and other lands in the Basin. To the extent feasible, coordinate with SAFCA with regard to mitigation and compensation of impacts that may be compatible with TNBC goals, including tree replacement activities and management of additional lands that can provide reserve linkages and restoration 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 further 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.
- Explore the potential for creating hedgerows along field borders on reserve lands. Hedgerows provide additional wildlife value in agricultural landscapes and can provide refugia for rodent and other prey populations to more effectively re-inhabit seasonally cultivated agricultural lands.

4.7 References

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Table 4-1. Results of 2013 Swainson's Hawk Surveys, NBHCP Area

Nest Site Number	Status[a]	Number of Young	Nesting Habitat	Nest Tree Species[b]
NB-1	A-S	1	Urban	Eucalyptus
NB-2	I	0	Ornamental	Cottonwood
NB-3	NLE	0	Nesting habitat removed in 2003	None
NB-4	I	0	Riparian	Cottonwood
NB-5	I	0	Riparian	Willow
NB-6	I	0	Ornamental	Eucalyptus
NB-7	NLE	0	Nest trees removed in 2002	None
NB-8	A-F	0	Ornamental	Cottonwood
NB-9	I	0	Channelized riparian	Cottonwood
NB-10	I	0	Riparian	Cottonwood
NB-11	I	0	Riparian	Valley oak
NB-12	A-X	0	Riparian	Willow
NB-13	A-X	0	Riparian	Willow
NB-14	A-S	1	Ornamental	Eucalyptus
NB-15	NLE	0	Nesting habitat removed in 2002	None
NB-16	A-S	1	Oak grove	Valley oak
NB-17	NLE	0	Lone tree, removed in 1998	None
NB-18	I	0	Isolated tree	Cottonwood
NB-19	A-X	0	Tree along irrigation canal	Valley oak
NB-20	NLE	0	Nest tree removed in 2002	None
NB-21	A-X	0	Riparian	Cottonwood
NB-22	A-F	0	Tree along irrigation canal	Willow
NB-23	A-X	0	Riparian	Willow
NB-24	A-U	-	Riparian	Valley oak
NB-25	I	0	Riparian	Walnut
NB-26	NLE	0	Nesting habitat removed in 2002	None
NB-27	A-X	0	Riparian	Cottonwood
NB-28	A-X	0	Riparian	Cottonwood
NB-29	A-S	1	Riparian	Willow
NB-30	A-S	1	Riparian	Cottonwood
NB-31	I	0	Riparian	Valley oak
NB-32	I	0	Riparian	Cottonwood
NB-33	I	0	Riparian	Cottonwood
NB-34	I	0	Riparian	Cottonwood
NB-35	A-U	-	Riparian	Cottonwood
NB-36	I	0	Riparian	Cottonwood
NB-37	A-U	-	Riparian	Cottonwood
NB-38	I	0	Riparian	Cottonwood
NB-39	A-F	0	Riparian	Cottonwood
NB-40	A-X	0	Riparian	Cottonwood
NB-41	A-X	0	Riparian	Willow
NB-42	I	0	Riparian	Cottonwood
NB-43	A-X	0	Riparian	Cottonwood
NB-44	I	0	Riparian	Cottonwood
NB-45	I	0	Riparian	Cottonwood
NB-46	A-X	0	Riparian	Cottonwood

Nest Site Number	Status[a]	Number of Young	Nesting Habitat	Nest Tree Species[b]
NB-47	A-S	1	Riparian	Cottonwood
NB-48	I	0	Riparian	Cottonwood
NB-49	I	0	Riparian	Cottonwood
NB-50	I	0	Riparian	Sycamore
NB-51	I	0	Riparian	Cottonwood
NB-52	I	0	Riparian	Cottonwood
NB-53	I	0	Riparian	Cottonwood
NB-54	I	0	Riparian	Cottonwood
NB-55	I	0	Riparian	Cottonwood
NB-56	I	0	Riparian	Cottonwood
NB-57	I	0	Riparian	Valley oak
NB-58	I	0	Riparian	Cottonwood
NB-59	A-S	1	Riparian	Cottonwood
NB-60	I	0	Riparian	Cottonwood
NB-61	A-F	0	Riparian	Cottonwood
NB-62	I	0	Riparian	Cottonwood
NB-63	I	0	Isolated tree	Willow
NB-64	A-F	0	Riparian	Cottonwood
NB-65	A-F	0	Cottonwood grove	Cottonwood
NB-66	I	0	Riparian	Cottonwood
NB-67	I	0	Riparian	Valley oak
NB-68	A-F	0	Riparian	Cottonwood
NB-69	I	0	Ornamental	Willow
NB-70	I	0	Riparian	Valley oak
NB-71	I	0	Riparian	Cottonwood
NB-72	I	0	Riparian	Cottonwood
NB-73	I	0	Tree row	Ornamental conifer
NB-74	A-F	0	Roadside tree	Willow
NB-75	I	0	Riparian	Cottonwood
NB-76	NLE	0	Trees removed in 2004	None
NB-77	A-F	0	Riparian	Cottonwood
NB-78	A-X	0	Riparian	Cottonwood
NB-79	I	0	Riparian	Sycamore
NB-80	I	0	Riparian	Cottonwood
NB-81	I	0	Isolated tree	Cottonwood
NB-82	I	0	Riparian	Willow
NB-83	I	0	Riparian	Willow
NB-84	I	0	Riparian	Cottonwood
NB-85	I	0	Riparian	Cottonwood
NB-86	I	0	Riparian	Cottonwood
NB-87	A-F	0	Riparian	Cottonwood
NB-88	I	0	Riparian	Cottonwood
NB-89	I	0	Riparian	Valley oak
NB-90	I	0	Riparian	Willow
NB-91	I	0	Riparian	Cottonwood
NB-92	I	0	Riparian	Cottonwood

Nest Site Number	Status[a]	Number of Young	Nesting Habitat	Nest Tree Species[b]
NB-93	I	0	Riparian	Cottonwood
NB-94	A-F	0	Riparian	Cottonwood
NB-95	I	0	Riparian	Valley oak
NB-96	I	0	Riparian	Valley oak
NB-97	A-X	0	Tree row	Eucalyptus
NB-98	I	0	Tree row	Eucalyptus
NB-99	I	0	Urban	Ornamental pine
NB-100	I	0	Riparian	Walnut
NB-101	I	0	Riparian	Cottonwood
NB-102	I	0	Riparian	Cottonwood
NB-103	I	0	Riparian	Cottonwood
NB-104	A-F	0	Riparian	Cottonwood
NB-105	A-F	0	Riparian	Cottonwood
NB-106	I	0	Roadside	Valley oak
NB-107	A-F	0	Riparian	Cottonwood
NB-108	A-F	0	Ornamental (freeway rest stop)	Cottonwood
NB-109	A-F	0	Channelized riparian/tree row	Valley Oak
NB-110	I	0	Riparian	Willow
NB-111	A-F	0	Tree Row	Cottonwood
NB-112	A-F	0	Riparian	Valley oak
NB-113	A-F	0	Riparian	Valley oak
NB-114	A-F	0	Tree row	Valley oak
NB-115	I	0	Isolated tree	Valley oak
NB-116	A-F	0	Cottonwood grove	Cottonwood
NB-117	A-X	0	Riparian	Cottonwood
NB-118	I	0	Tree Row	Valley oak
NB-119	A-F	0	Channelized riparian/tree row	Cottonwood
NB-120	A-F	0	Channelized riparian/tree row	Valley oak
NB-121	A-S	1	Rural residential	Cottonwood
NB-122	I	0	Tree row	Valley oak
NB-123	A-S	1	Isolated tree	Valley Oak
NB-124	A-X	0	Riparian	Cottonwood
NB-125	A-F	0	Riparian	Cottonwood
NB-126	I	0	Riparian	Cottonwood
NB-127	A-S	1	Riparian	Cottonwood
NB-128	A-S	2	Riparian	Willow
NB-129	A-F	0	Roadside tree row	Willow
NB-130	I	0	Isolated tree	Locust
NB-131	A-F	0	Riparian	Cottonwood
NB-132	A-X	0	Riparian	Cottonwood

[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, 1999–2013

Year	Active Territories	Successful Nests	Failed Nests	Active but Not Nesting	Active with Unknown Outcome	Young Reared to Fledging	Young per Active Territory	Young per Occupied Nest[b]	Young per Successful Nest
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	1.05	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	1.41	1.57	1.63
2010	52	42	4	3	3	70	1.35	1.52	1.67
2011	62	23	27	6	6	30	0.48	0.60	1.30
2012	65	42	14	3	6	59	0.91	1.05	1.40
2013	56	11	26	16	3	12	0.21	0.32	1.09

[a] Years 1999 and 2000 do not include the Sacramento River territories.
[b] Occupied nest = number of successful nests + number of failed nests.

Table 4-3. Number of Active Territories on the Sacramento River, 2001–2013

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

Table 4-4. Swainson's Hawk Foraging Habitat in the NBHCP Area, 2004–2013 (acres)

Habitat Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Upland agriculture	8,251	7,566	6,462	7,919	8,293	11,692	13,863	15,100	14,019	12,096
Fallow lands	823	1,625	10,101	10,033	10,076	5,869	2,912	2,323	2,282	2,160
Grasslands[a]	7,847	7,766	7,263	5,669	5,461	5,794	4,853	4,608	4,491	4,832
Total	**16,921**	**16,957**	**23,826**	**23,621**	**23,830**	**23,355**	**21,628**	**22,031**	**20,792**	**19,088**

[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, 2013

	Alfalfa	Row, Grain, and Other Hay Crops[a]	Irrigated Pasture	Grasslands[b]	Fallow	Total
On-reserve acreage (acres)	204	443	0	323	177	1,147
On-reserve percentage of cover type (%)	17.8	38.6	0	28.2	15.4	100
Off-reserve acreage (acres)	1,099	10,350	0	4,509	1,983	17,941
Off-reserve percentage of cover type (%)	6.1	57.7	0	25.1	11.1	100
Total	**1,303**	**10,793**	**0**	**4,832**	**2,160**	**19,088**

[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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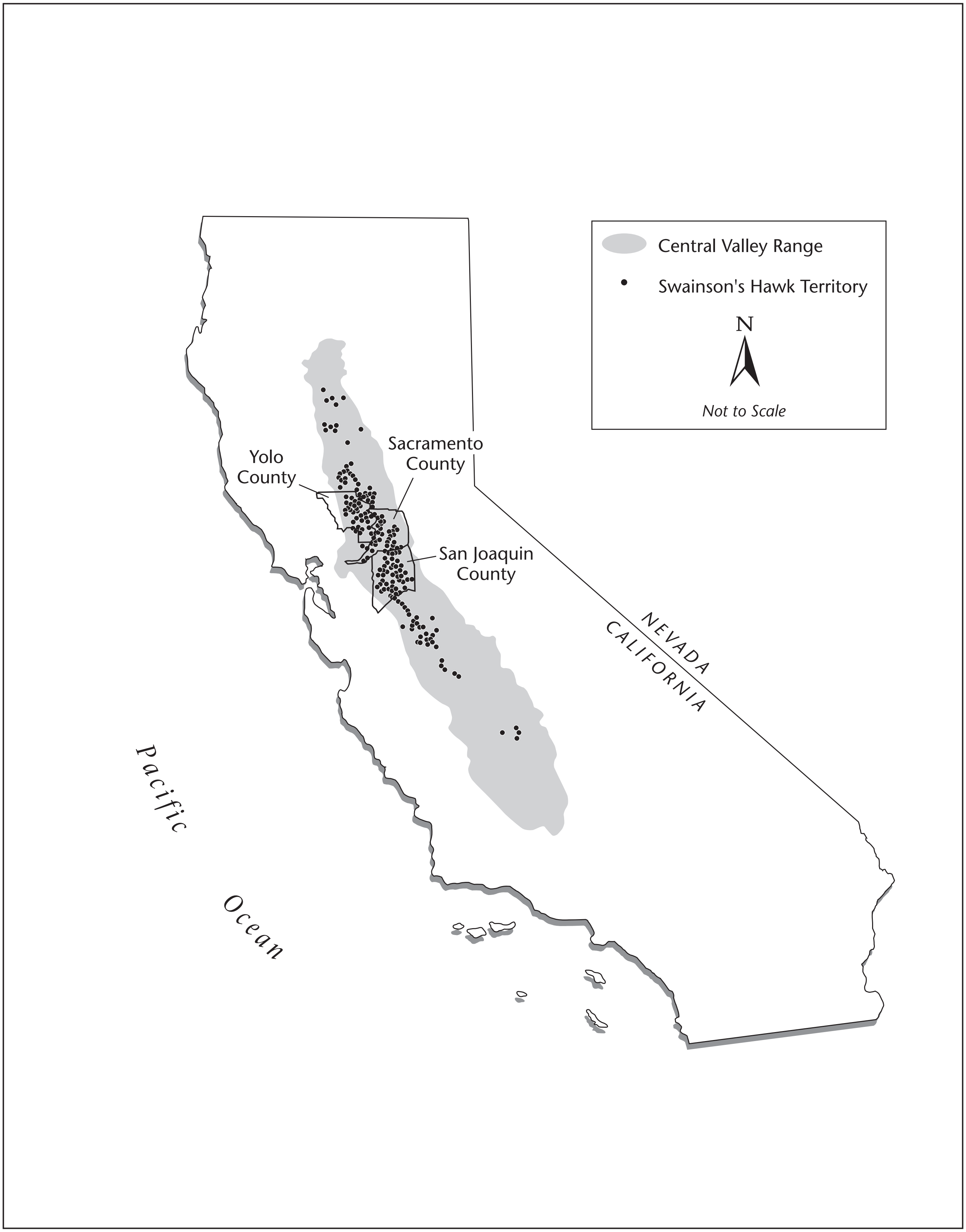
Figure 4-1
Adult Swainson's Hawk



00890.10 NBC 2011 Report (03-12)SS

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

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

Typical Swainson's hawk nest

Figure 4-3
Swainson's Hawk Nesting Habitat

Swainson's hawk nest with eggs

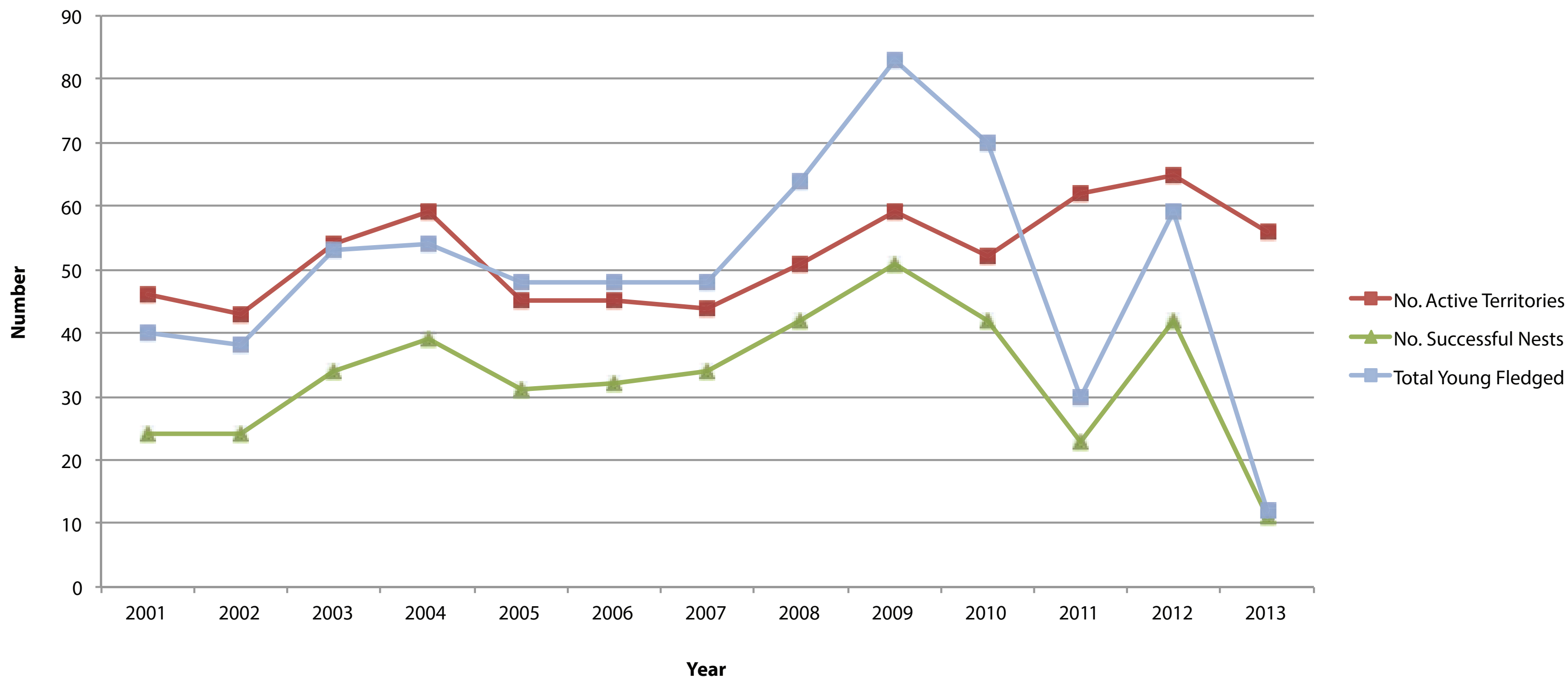
Nestling Swainson's hawks

Nearly fledged Swainson's hawks

00890.10 NBC 2011 Report (03-12)SS

ICF INTERNATIONAL

Figure 4-4
Swainson's Hawks in the Nest



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ICF INTERNATIONAL

Figure 4-5
Active Swainson's Hawk Territories, 2001–2013

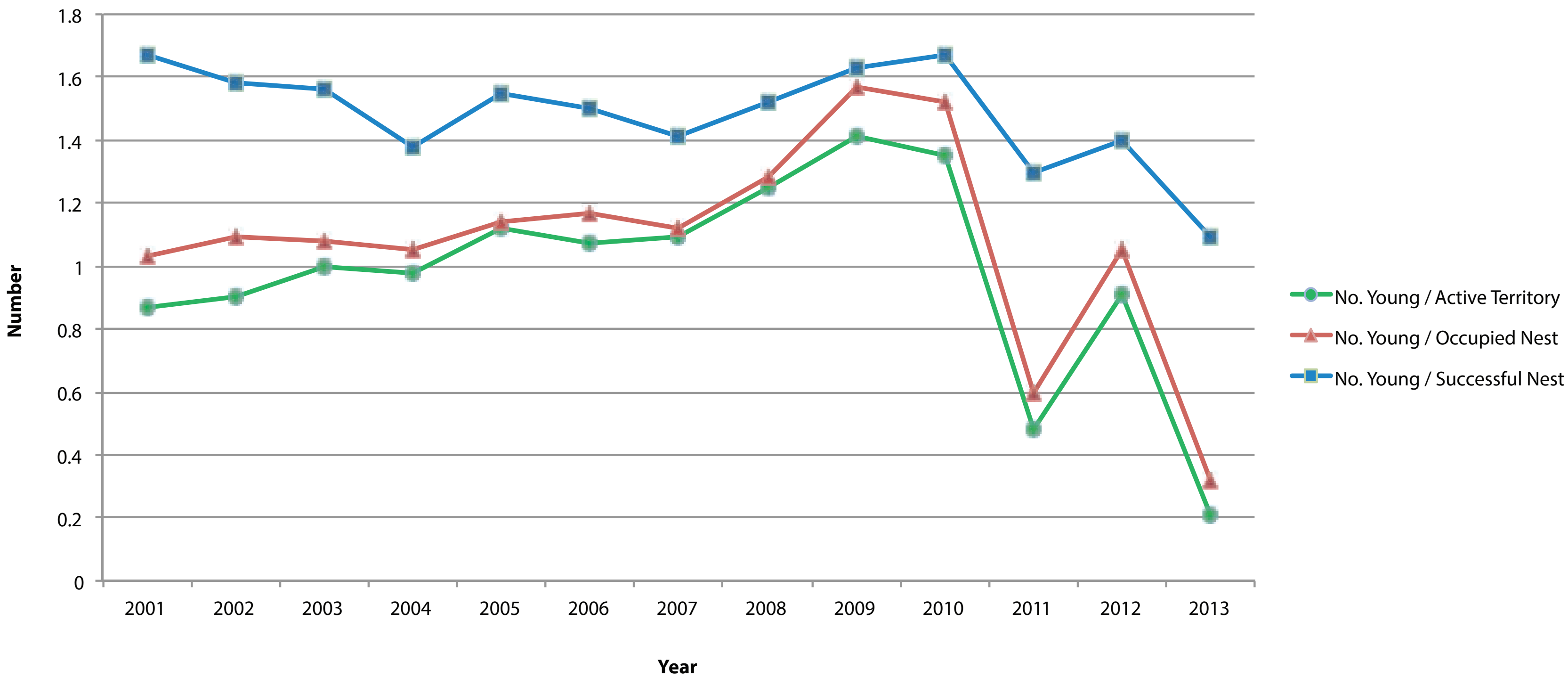

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Figure 4-6
Swainson's Hawk Reproductive Success, 2001–2013

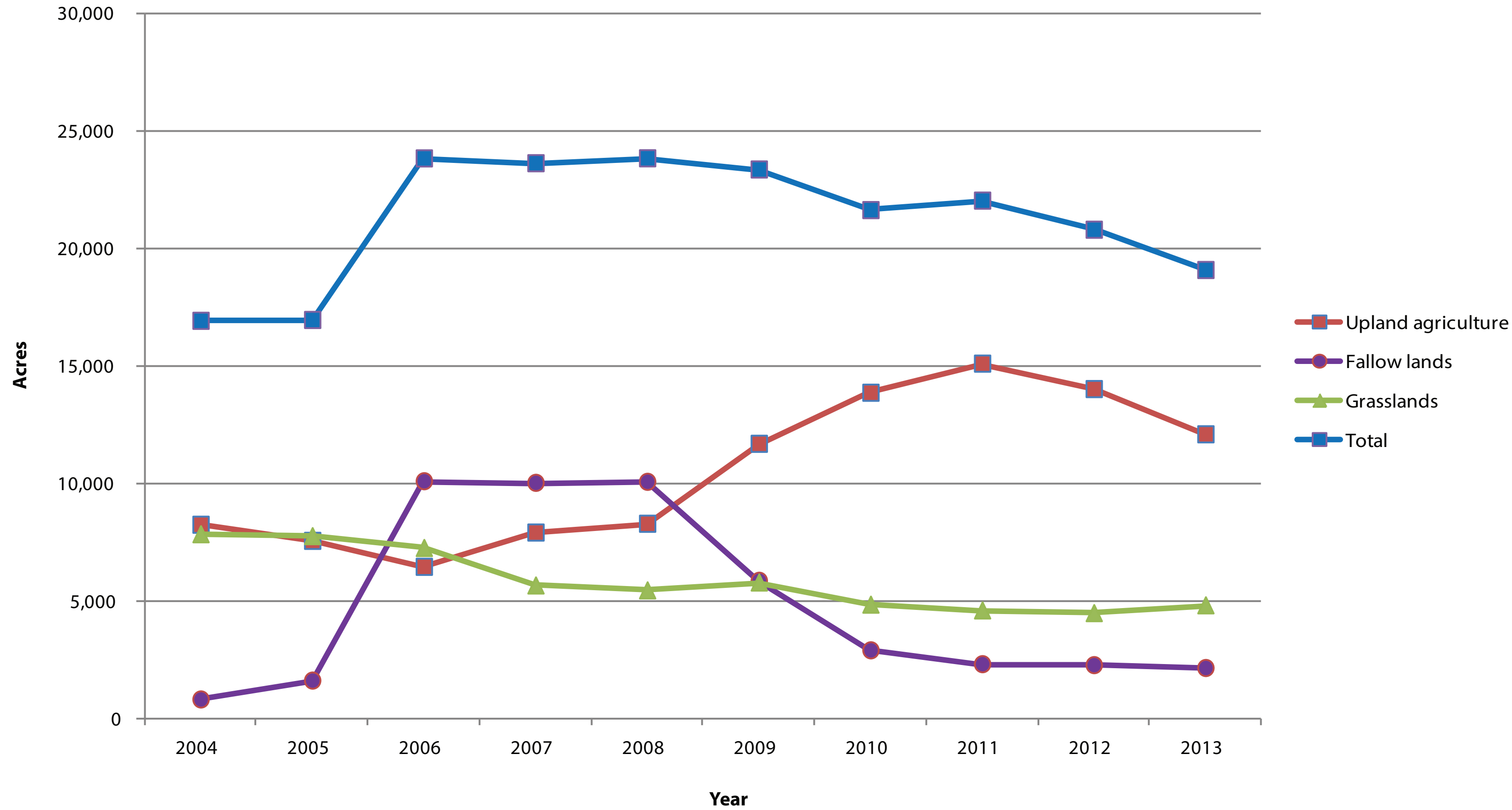

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Figure 4-7
Changes in the Abundance of Swainson's Hawk Foraging Habitat by Category, 2004–2013

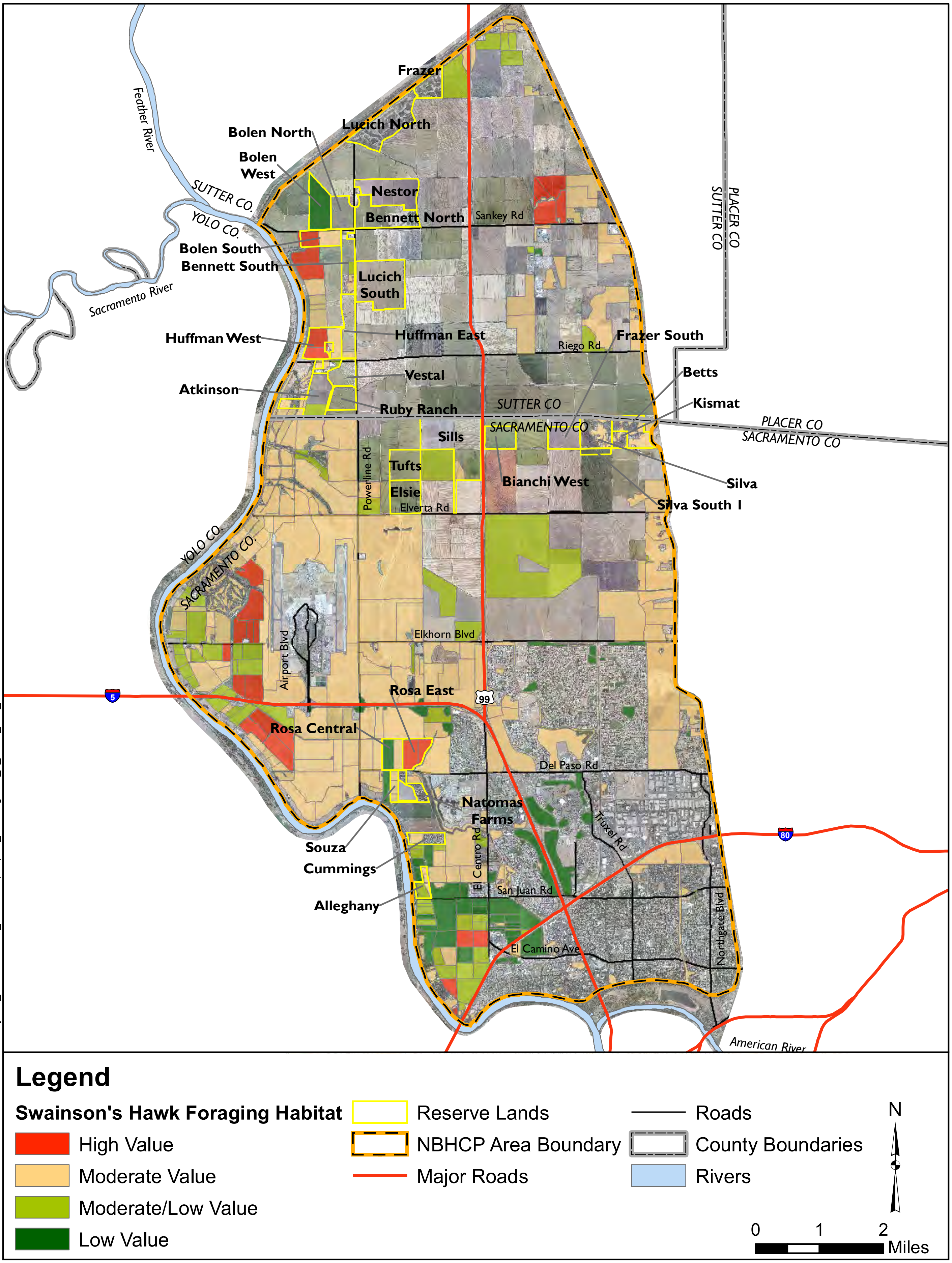

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Figure 4-8
Suitable Swainson's Hawk
Foraging Habitat in the Natomas Basin, 2013

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 assess the progress of the NBHCP toward meeting the Plan's goals and objectives for Covered Species and their habitats. Two general types of monitoring were conducted to meet the goals and objectives of the HCP: monitoring on-reserve lands and Basin-wide monitoring (i.e., off-reserve lands).

5.1.2 Goals and Objectives

Monitoring populations of Other Covered Species is accomplished using a variety of techniques, including generalized avian surveys on reserves, to evaluate the extent to which the NBHCP is meeting its biological goals and objectives. The objectives of monitoring efforts on reserves are listed below.

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

Basin-wide 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.

Secondary objectives of monitoring off reserves include providing information to guide future acquisition of reserve lands and providing information on Covered Species' use of, or presence within, corridors between reserves.

5.2 Methods

5.2.1 Surveys on Reserves

Surveys for Other Covered Species comprise surveys for covered avian species, western pond turtle, and other rarely occurring species.

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. All the reserves are surveyed on 3 consecutive days when possible to minimize bias associated with changes in weather and the movement of birds between tracts, reserves, and off-reserve locations. 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 western pond turtles are conducted during surveys for giant gartersnakes 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*). The locations of all observations of Other Covered Species are recorded using hand-held GPS units.

5.2.2 Basin-Wide 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 was established in each region. Each road transect covers 48–51 kilometers (30–32 miles) and is surveyed in approximately 1.5 hours. Survey times were assigned to road segments in each transect to minimize variation in effort. A single observer drives slowly (when possible) and scans the area for Other Covered Species, occasionally stopping at pullouts or backtracking where appropriate. Stops occur frequently to scan large fields for Other Covered Species, but the duration and number of stops are constrained by the time allotted for each segment and transect. Each survey route is depicted in Figure 5-1.

5.3 Results

In addition to those species documented in surveys, other wildlife species have been observed during monitoring efforts on the reserves. A complete list of common and scientific names of all species observed on reserves from 2004 through 2012 is presented in Appendix C-1.

5.3.1 Generalized Avian Surveys

In total, 126 avian species were detected on reserves in 2013, up from 122 in 2012. The number of species observed each year has ranged from a low of 116 in 2010 to a high of 139 in 2009, with an average of 125 avian species detected each year. A complete list of the number of individuals of each avian species detected on reserves in 2013 is provided in Appendix C-2.

Table 5-1 summarizes the number of individuals and number of species recorded from 2011 through 2013 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 is generally uncommon and serves as a good indicator 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.

The annual average number of raptors detected per survey on reserve lands from 2005 through 2013 has fluctuated, reaching a high of 0.172 in 2009 and a low of 0.08 in 2012 (Figure 5-2). Red-tailed hawk is by far the most abundant raptor on reserve lands, followed by northern harrier and American kestrel. Numbers of most species increased in 2013, following a 3- to 4-year decline. The largest numbers of raptors are found on the BKS and Atkinson tracts, followed by Elsie and Tufts, which host resident burrowing owls in most years. Raptors are most abundant on reserves from July through December, when fledglings, migrants, and wintering birds begin to appear.

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 only 1% of the wetlands that historically covered the Central Valley still exist today, this group is of high management concern in the region.

The average number of waterfowl detected per survey on reserve lands from 2005 through 2013 has also exhibited substantial annual variation, ranging from a low of 1.2 in 2006 to a high of 9.3 in 2008 (Figure 5-3). Greater white-fronted goose is the most abundant species of waterfowl on reserve lands, followed by the American coot, snow goose, mallard, and northern shoveler. Although the highest average number of waterfowl as a group peaked in 2008, the numbers of greater white-fronted goose peaked in 2007, while numbers of snow geese peaked in 2009. Large changes in the number of individuals within and between years are a common pattern for waterfowl migrating through and wintering in the Central Valley. Annual variation in waterfowl numbers on reserve lands appears to have leveled off since 2010. Although they were not systematically counted or recorded, large numbers of waterfowl, especially geese, were also observed on non-reserve lands in 2013.

The largest number of waterfowl by far are found on the Lucich North tract, followed by BKS, Natomas Farms, and Lucich South, although considerable variation is present between years. Waterfowl numbers are highest in January and February when large numbers of geese 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 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.

There is considerable annual variation in the average number of neotropical migrants detected per survey on reserve lands from 2005 through 2013, ranging from a low of 0.342 in 2006 to a high of 0.923 in 2008 (Figure 5-4). Cliff swallow has been the most abundant neotropical migrant on reserve lands in most years, followed by barn swallow. Both these species consume prodigious numbers of insects each year. Cliff swallow numbers have increased dramatically over the last 3 years, primarily due to nesting activity on the BKS reserve. The largest numbers of neotropical migrants are found on the BKS and Atkinson tracts, followed by Natomas Farms, Huffman West, and Lucich North. Neotropical migrants begin arriving on reserve lands in March, reach peak numbers in May and June, and are gone by September.

Shorebirds

Shorebirds are a diverse group that includes sandpipers, plovers, stilts, avocets, snipes, and phalaropes. They are closely associated with wetland areas; the majority of species migrates 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). Like waterfowl, shorebirds are a group of high management concern in the region.

There is considerable annual variation in the average number of shorebirds detected per survey on reserve lands from 2005 through 2013, ranging from a high of 1.72 in 2009 to a low of 0.41 in 2013 (Figure 5-5). Long-billed dowitcher has been the most abundant shorebird on reserve lands in most years, followed by killdeer. There was a simultaneous decline in 2013 in the numbers of all shorebirds regularly observed on reserve lands. The largest numbers of shorebirds by far are found on the BKS tract, followed by Lucich South, Lucich North, and Sills. Some species of shorebird are resident and can be observed on reserve lands at any time of year. However, shorebirds reach their peak numbers in December and January of each year.

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). Numbers detected on reserves have undergone a relatively steady and significant decline over the period 2005–2013 (R^2=0.724, p=0.002; 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 away from nesting habitats 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 2013.

There has been a significant increase over the period 2005–2013 in the numbers of Canada geese detected on reserves (R^2=0.579, p=0.014; Figure 5-6). Although California is outside the original breeding range of this species, numerous resident populations of Canada geese 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 fifth 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.

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 western pond turtle. Although suitable foraging habitat for Aleutian cackling goose (formerly Aleutian Canada goose) is present, this species has not been detected in the Basin since comprehensive monitoring began in 2004. Suitable nesting habitat for bank swallow is not present in the Basin. Suitable habitat for the vernal pool species—vernal pool fairy shrimp, mid-valley fairy shrimp, vernal pool tadpole shrimp, California tiger salamander, and western spadefoot—has not been reported in the Basin except for the 11 vernal pools (1 acre) created on the BKS tract and a few potentially suitable wetlands on private property along the extreme eastern edge of the Basin. To date, no evidence of occupancy of the 11 pools at BKS by any covered species has been observed. Several blue elderberry shrubs, the host plant for valley elderberry longhorn beetle, have been documented in the Basin, but the beetle itself has not been documented to occur 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. With the exception of western pond turtle, these species have also been documented breeding on reserves at some point since comprehensive monitoring began. These breeding records are summarized in Table 5-2. Although western pond turtle has not been documented breeding on reserves, small juvenile pond turtles have been observed on reserve lands, indicating that breeding likely has occurred there.

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 Basin-wide surveys are summarized in Table 5-4.

Loggerhead Shrike

The average number of loggerhead shrike detections per survey on reserves has cycled over the course of the monitoring period, peaking in 2009 and again in 2012 (Table 5-3, Figure 5-7). Although there was a slight decrease in 2013, the average number of detections in 2013 was the fourth highest over the 9 years of monitoring. The decrease was due primarily to a sharp decline in the number of shrikes detected in November 2013 (Figure 5-7). Overall, there has been a upward trend in shrike detections on reserves. Pairs of shrikes were observed on the Lucich North, Rosa, and Souza tracts, and evidence of breeding was documented on the Nestor and Atkinson tracts. Based on the pattern of detections, there are at least two pairs along the northern edge of the Basin that regularly use the Lucich North and Frazer tracts, at least one pair regularly using the Nestor/Bennett North/Bolen West tracts, one pair using the Atkinson tract, and at least two pairs regularly using the tracts of the Fisherman's Lake Reserve. Shrikes are most frequently detected in August and December (Figure 5-7).

While the average number of shrike detections per survey on reserves has increased over the monitoring period, the average number of shrike detections per survey during Basin-wide surveys has decreased moderately (R^2=0.352, p=0.094) during the same period (Table 5-4, Figure 5-7). The two pairs that were regularly detected along Pacific Avenue through 2012, and the pair occupying the area just southwest of the intersection of Highway 99 and Elkhorn Boulevard, although detected early in the year, disappeared during 2013. Construction and vegetation removal along Pacific Avenue and tree and shrub removal within the Elkhorn Boulevard territory likely contributed to this decline.

White-Faced Ibis

When surveys first began, white-faced ibis were regularly detected in small numbers on reserves from June through September. However, in 2007, and continuing through 2010, white-faced ibis began nesting in large numbers on the BKS tract in the Central Basin Reserve (Table 5-2). In 2011 the ibis abandoned the BKS nesting colony and did not nest in the Basin. However, 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 Reserve nesting colony was active again in 2013. Ibis from this colony foraged extensively in the rice fields of the adjacent Lucich South and Bennett South tracts.

The proportion of surveys on reserves in which ibis were detected has generally increased since monitoring began (Table 5-3, Figure 5-8), while the proportion of Basin-wide surveys in which ibis have been detected has remained stable or decreased slightly (Table 5-4, Figure 5-8). While ibis are regularly detected throughout most of the year, numbers increase dramatically during the summer and fall (Figure 5-8).

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.

The proportion of surveys on reserves in which tricolored blackbirds were detected has remained generally stable or decreased slightly since monitoring began (Table 5-3, Figure 5-9), while the proportion of Basin-wide surveys in which tricolored blackbirds have been detected has generally decreased (Table 5-4, Figure 5-9). While tricolored blackbirds have been detected on reserves during every month of the year, they typically are absent from the Basin from November through March (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 was observed to be paired on one survey, although no evidence of nesting was ever 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 reserve tracts.

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 Power Balance Pavilion and 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 observed.

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, there were three pairs 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 and fledged a total of at least two 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.

A new 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 did not return to the site in 2013.

The mean number of owls detected per survey on reserves in which burrowing owls were detected has declined since reaching a peak in 2009 as the nesting colony on the Elsie and Tufts tracts has declined in total numbers (Table 5-3, Figure 5-10). Conversely, the mean number of owls detected per survey on Basin-wide surveys has been increasing, at least partly due to new colonies being discovered (Table 5-4, Figure 5-10). However, the increase has continued beyond the year of initial detection, indicating a general increase in numbers. While burrowing owls are regularly detected during all months of the year, their numbers and detectability increase during the period June through September as young begin to fledge (Figure 5-10).

Western Pond Turtle

Western pond turtles are known to occur in several areas of the Basin, including Fisherman's Lake and near the Prichard Lake and Elkhorn pumping stations. Red-eared sliders (*Trachemys scripta elegans*), a naturalized but nonnative species that superficially resembles western pond turtle, can be difficult to distinguish from western pond turtles before they slip into the water and disappear. In 2013, adult western pond turtles were observed regularly in Fisherman's Lake adjacent to the Rosa and Natomas Farms tracts during the summer months. Juvenile western pond turtles were also documented at the BKS tract, in the canal adjacent to the Lucich North tract, and at Natomas Farms, indicating that reproduction is probably occurring on these tracts. A large adult was also observed in October on the Frazer tract.

5.4 Discussion

TNBC reserves provide important habitats for wildlife in the Central Valley. In total, 126 species of birds were recorded on reserves in 2013—the vast majority 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. Monitoring results to date clearly indicate that TNBC reserves meet the objective outlined in the NBHCP to provide open space to benefit wildlife species.

In 2013, the number of loggerhead shrikes detected deceased slightly from 2012, but the overall trend on reserves is increasing. Conversely, shrike detections on non-reserve lands are decreasing. Overall, shrike detections appear to be increasingly clustered around reserve properties and the increasing frequency with which shrikes are observed in created marsh habitats indicates that reserve lands make up a substantial portion of the home range of shrike pairs and provide important resources for this population.

The white-faced ibis population has been increasing steadily in the Basin over the last decade. This species is known to nest in only a few scattered locations in the Central Valley (Ryder and Manry 1994). The breeding colony at the BKS tract was the first record of breeding ibis in the Basin. Ibis have continued to nest in the Basin (with the exception of 2011) since then, making extensive use of reserves throughout the year.

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). In 2012, no tricolored blackbirds were documented nesting in the Basin for the first time since 2006, and in 2013, an initial nesting attempt was made on the Willey Wetlands Preserve, but this attempt was abandoned quickly. It should be noted that prior to the establishment of the TNBC reserve system, nesting habitat was extremely limited in the Basin.

The proportion of surveys on reserve lands in which tricolored blackbirds are detected appears to exhibit a slight decreasing trend, while the proportion of Basin-side surveys in which tricolored blackbirds are detected shows a more steeply decreasing trend. The results indicate that tricolored blackbird populations in the Basin may be in trouble and continue to be monitored closely.

In 2013, the general decline in the average number of burrowing owls detected per survey continued the decrease that began in 2010. The decrease was due primarily to a reduction in the number and reproductive performance of the breeding pairs 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 for a time—would be necessary after so many years of use.

The three breeding burrowing owl colonies in the Basin on non-reserve lands continued to exhibit stable numbers, and the overall average number of detections per survey remained high, although it did decrease slightly in 2013, probably due to the lack of reproduction at the Sleep Train Arena colony.

The burrowing owls that have consistently occupied the Elsie and Tufts tracts in the Central Basin Reserve occur along both sides of the Highline Canal where the levee is both higher and wider than others in the Basin. Other observations of burrowing owls in rice-growing areas occur in similar conditions, suggesting that raising and widening berms along the larger drainage canals may provide additional burrowing owl habitat.

Western pond turtles continue to be detected in low numbers in the Basin. The number of reserves on which western pond turtles have been documented increased when a large adult was spotted on the Frazer tract in 2013.

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, California tiger salamander) are generally lacking in the Basin. None of these species have been detected, and little habitat capable of supporting them has been reported since implementation of the NBHCP.

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, western 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 were documented using reserve lands extensively, and hatchling western pond turtles were documented adjacent to Lucich North, BKS, and Natomas Farms, while adults have been observed on the Rosa and Frazer tracts.

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.
- Continue to look for opportunities to raise and enlarge rice checks and roads bordering agricultural fields to provide nesting habitats for burrowing.
- Consider maintaining an unplowed/unfarmed (but mowed or grazed as necessary) strip of land on upland agricultural fields, 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. TNBC should consider the following actions to provide additional security 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.

5.7 References

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Table 5-1. Summary of Results of Monthly Avian Surveys by Tract,[a] 2011–2013

Reserve	Waterfowl			Raptors			Neotropical Migrants			Shorebirds			All Bird Species		
	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
North Basin Reserve															
Atkinson	29 (2)	15 (2)	28 (3)	46 (6)	48 (8)	39 (7)	90 (8)	87 (10)	84 (9)	10 (1)	47 (1)	17 (1)	3,645 (64)	2,617 (65)	2,086 (66)
Bennett North	1,399 (13)	1,667 (13)	2,444 (12)	14 (3)	10 (4)	15 (3)	26 (3)	28 (4)	101 (3)	335 (5)	421 (6)	125 (3)	3,706 (49)	3,874 (50)	4,860 (46)
Bennett South	341 (7)	160 (5)	177 (5)	25 (6)	17 (7)	23 (6)	12 (1)	3 (1)	21 (4)	44 (2)	49 (3)	5 (1)	2,217 (45)	3,741 (41)	1,544 (39)
Bolen North	—	3 (1)	76 (2)	3 (2)	1 (1)	3 (3)	2 (1)	3 (2)	—	15 (1)	55 (3)	24 (1)	508 (28)	512 (20)	548 (20)
Bolen South	29 (2)	—	—	19 (6)	16 (5)	15 (6)	23 (4)	26 (3)	45 (2)	46 (3)	136 (2)	62 (2)	787 (36)	851 (27)	536 (31)
Bolen West	469 (4)	1,364 (7)	430 (2)	5 (2)	5 (4)	23 (5)	2 (1)	—	—	56 (4)	10 (3)	19 (2)	1,479 (29)	1,908 (26)	722 (23)
Frazer	834 (11)	14,08 (11)	737 (10)	834 (11)	16 (6)	19 (6)	125 (4)	90 (4)	66 (3)	28 (2)	112 (4)	130 (3)	1,890 (43)	3,047 (47)	1,889 (42)
Huffman East	37 (4)	162 (2)	109 (4)	15 (4)	12 (4)	16 (4)	50 (2)	3 (2)	16 (3)	19 (1)	3 (1)	25 (3)	1,618 (29)	3,709 (24)	948 (29)
Huffman West	—	2 (1)	6 (1)	13 (6)	32 (5)	26 (3)	37 (4)	10 (2)	25 (4)	19 (2)	27 (2)	29 (2)	952 (32)	795 (30)	994 (28)
Lucich North	3,345 (15)	3,571 (16)	4,286 (17)	27 (4)	29 (5)	29 (4)	81 (3)	122 (5)	152 (4)	237 (5)	112 (3)	268 (4)	6,473 (63)	6,495 (52)	8,485 (58)
Lucich South	1,386 (11)	5,826 (15)	3,296 (10)	28 (3)	25 (5)	34 (4)	18 (3)	5 (2)	1 (1)	257 (8)	838 (8)	79 (5)	7,046 (51)	9,988 (52)	5,779 (46)
Nestor	13 (2)	526 (5)	1,048 (6)	22 (4)	10 (3)	22 (3)	2 (2)	2 (1)	90 (2)	59 (3)	84 (5)	82 (3)	604 (29)	1,523 (38)	2,547 (36)
Ruby Ranch	21 (2)	702 (2)	53 (2)	7 (2)	8 (4)	11 (3)	3 (1)	12 (1)	9 (1)	90 (4)	290 (5)	10 (1)	1,169 (31)	2,380 (29)	878 (25)
Vestal	13 (3)	3 (2)	3 (2)	12 (3)	11 (5)	16 (3)	7 (4)	7 (3)	4 (2)	15 (3)	14 (2)	6 (1)	1,149 (41)	1,330 (34)	746 (37)
Central Basin Reserve															
BKS	5,855 (17)	7,176 (18)	5,241 (22)	77 (7)	80 (8)	102 (9)	413 (7)	852 (5)	591 (7)	1,758 (8)	1,820 (8)	731 (7)	15,444 (81)	19,506 (81)	14,919 (81)
Bianchi West	80 (3)	275 (2)	165 (4)	6 (2)	7 (2)	8 (4)	—	—	72 (2)	53 (3)	23 (3)	126 (5)	508 (31)	1,736 (19)	841 (28)
Elsie	86 (4)	510 (5)	168 (3)	18 (4)	23 (3)	10 (5)	13 (1)	5 (1)	—	36 (4)	191 (4)	138 (5)	765 (22)	1,271 (25)	638 (25)
Frazer South	124 (6)	604 (5)	32 (3)	12 (3)	12 (3)	25 (5)	34 (1)	3 (1)	10 (1)	30 (4)	50 (4)	30 (1)	1,414 (28)	2,887 (33)	1,484 (31)
Sills	541 (5)	1,841 (6)	4,312 (8)	18 (2)	14 (4)	18 (5)	8 (1)	2 (1)	60 (1)	165 (5)	141 (6)	79 (6)	3,738 (30)	3,782 (37)	6,261 (39)
Tufts	594 (4)	1,873 (5)	7 (2)	29 (4)	7 (4)	9 (3)	2 (1)	2 (1)	—	36 (3)	516 (3)	56 (3)	1,352 (23)	3,108 (27)	400 (20)
Fisherman's Lake Reserve															
Allegheny	—	2 (1)	—	6 (2)	7 (3)	6 (2)	14 (4)	15 (3)	12 (4)	4 (1)	10 (1)	3 (1)	746 (43)	1,016 (36)	496 (34)
Cummings	166 (8)	118 (9)	78 (7)	17 (7)	13 (4)	20 (4)	41 (5)	74 (7)	60 (10)	10 (2)	6 (2)	10 (1)	1,066 (56)	1,035 (60)	1,560 (62)
Natomas Farms	168 (7)	146 (7)	126 (8)	12 (4)	4 (3)	13 (5)	40 (6)	89 (7)	72 (5)	13 (2)	10 (1)	8 (2)	1,236 (61)	1,260 (47)	869 (48)
Rosas	6 (1)	8 (1)	21 (3)	11 (6)	18 (6)	21 (6)	76 (6)	199 (6)	80 (8)	19 (2)	7 (1)	15 (1)	1,073 (52)	939 (48)	824 (53)
Souza	2 (1)	—	—	5 (3)	5 (5)	20 (4)	15 (2)	17 (4)	12 (3)	1 (1)	6 (1)	2 (1)	720 (29)	647 (30)	369 (27)

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

Table 5-2. Number of Pairs of Other Covered Species on TNBC Mitigation Lands, 2004–2013

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
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)
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 (1 Lucich North, 1 Rosa, 1 Souza)
Tricolored blackbird	0	~900 (BKS)	0	~1,200 (BKS)	~4,900 (~900 BKS, ~4,000 Frazer)	~1,500 (BKS)	~700 (BKS)	0	0	0
White-faced ibis	0	0	0	~750 (BKS)	~1,500 (BKS)	~2,500 (BKS)	~2,500 (BKS)	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, 2005–2013

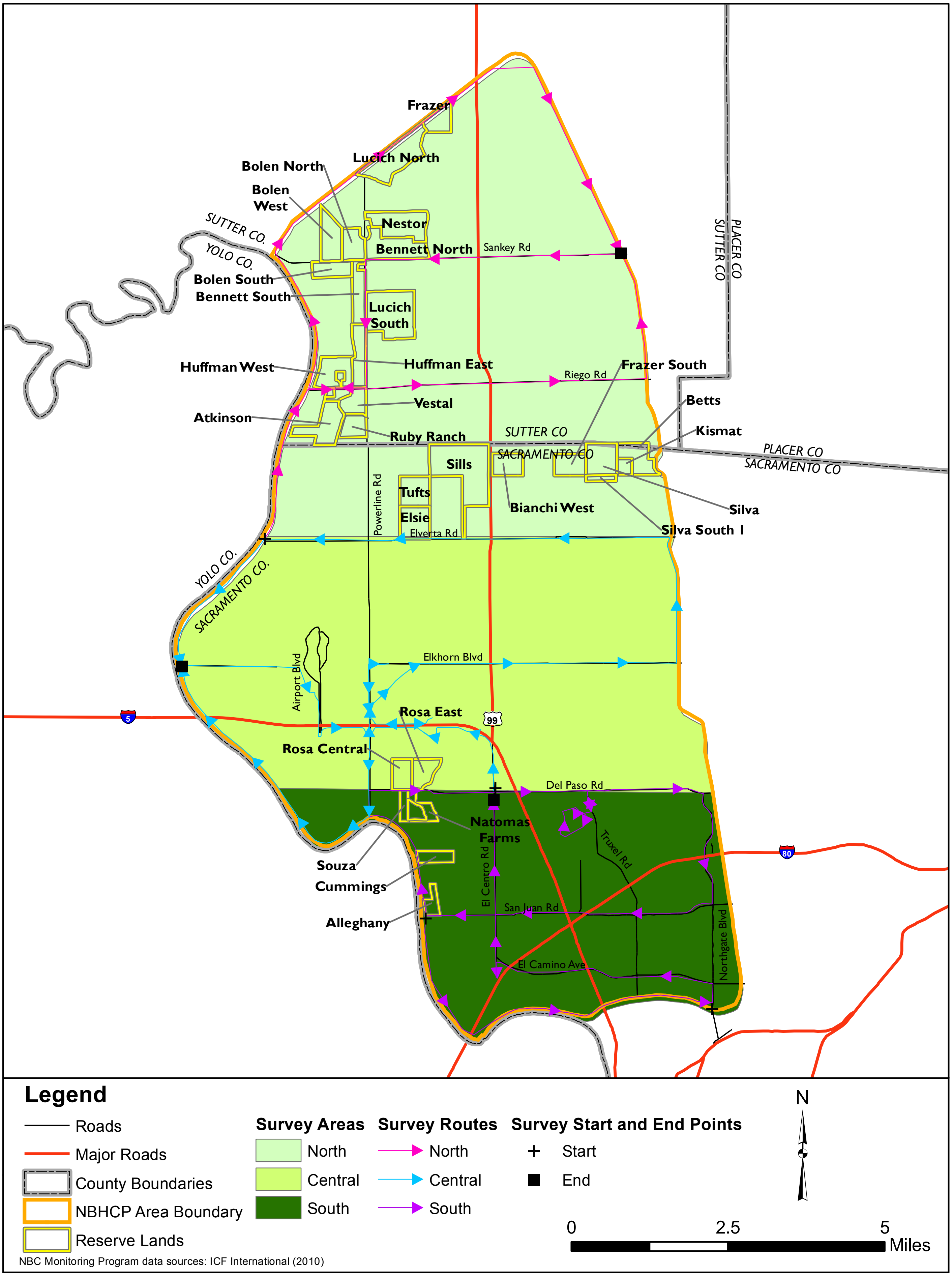
Species	2005	2006	2007	2008	2009	2010	2011	2012	2013
White-faced ibis[a]	0.06	0.04	0.06	0.08	0.22	0.15	0.11	0.11	0.16
Burrowing owl	0.02	0.03	0.00	0.12	0.20	0.17	0.13	0.06	0.04
Loggerhead shrike	0.07	0.04	0.10	0.21	0.24	0.06	0.13	0.18	0.16
Tricolored blackbird[a]	0.13	0.05	0.04	0.07	0.09	0.04	0.06	0.03	0.05

[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, 2005–2013

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013
White-faced ibis[a]	0.25	0.09	0.26	0.23	0.23	0.14	0.06	0.16	0.16
Burrowing owl	0.31	0.59	0.03	1.60	3.29	3.81	4.65	6.72	5.03
Loggerhead shrike	3.00	2.53	2.24	1.80	3.31	2.00	2.06	2.13	1.44
Tricolored blackbird[a]	0.31	0.15	0.24	0.07	0.11	0.00	0.03	0.06	0.09

[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.



Q: \ PROJECTS \ NBC \ 04002_04 \ ARCMAP \ REPORT_2009 \ CHAPTER5_SPECIES \ FIGURE5_1_SURVEY_ROUTES.MXD (04-12-10)

Figure 5-1
Monthly Basin-Wide Survey Routes

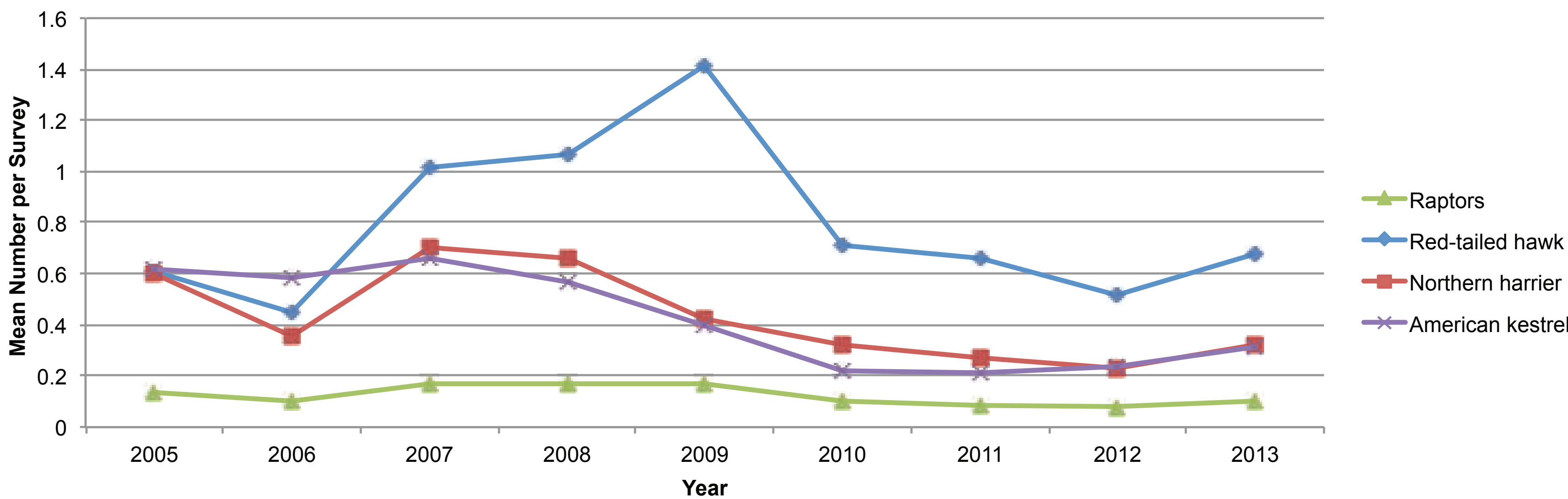


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Figure 5-2
Mean Number of Raptors Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2013

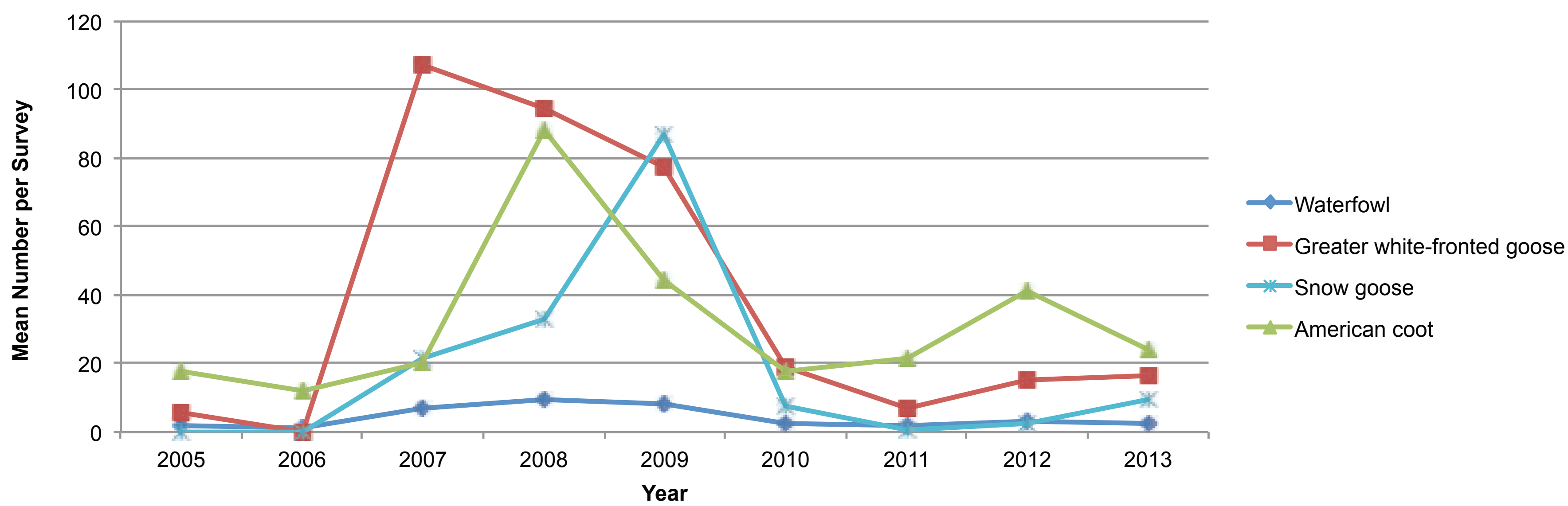

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Figure 5-3
Mean Number of Waterfowl Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2013

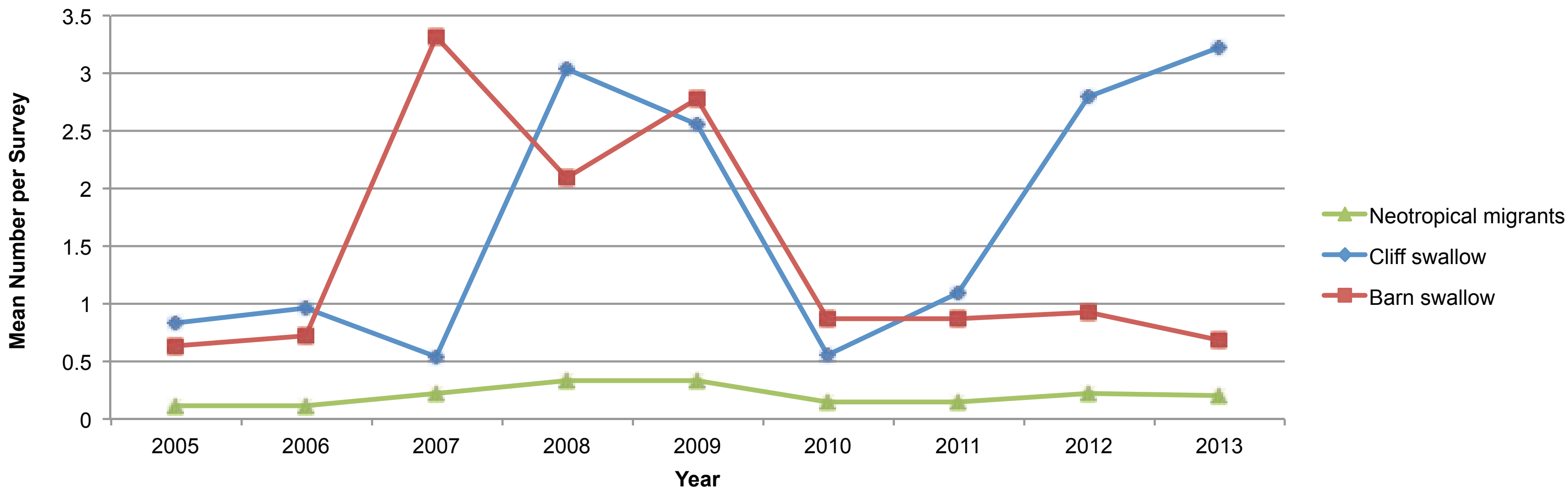

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Figure 5-4
Mean Number of Neotropical Migrants Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2013

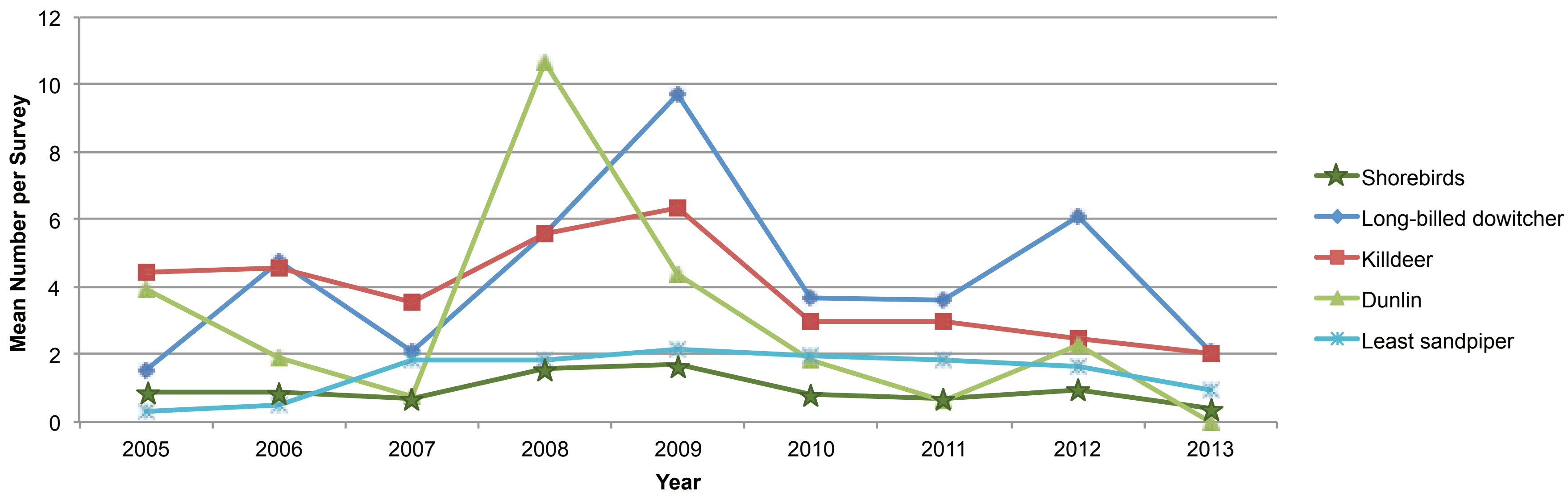

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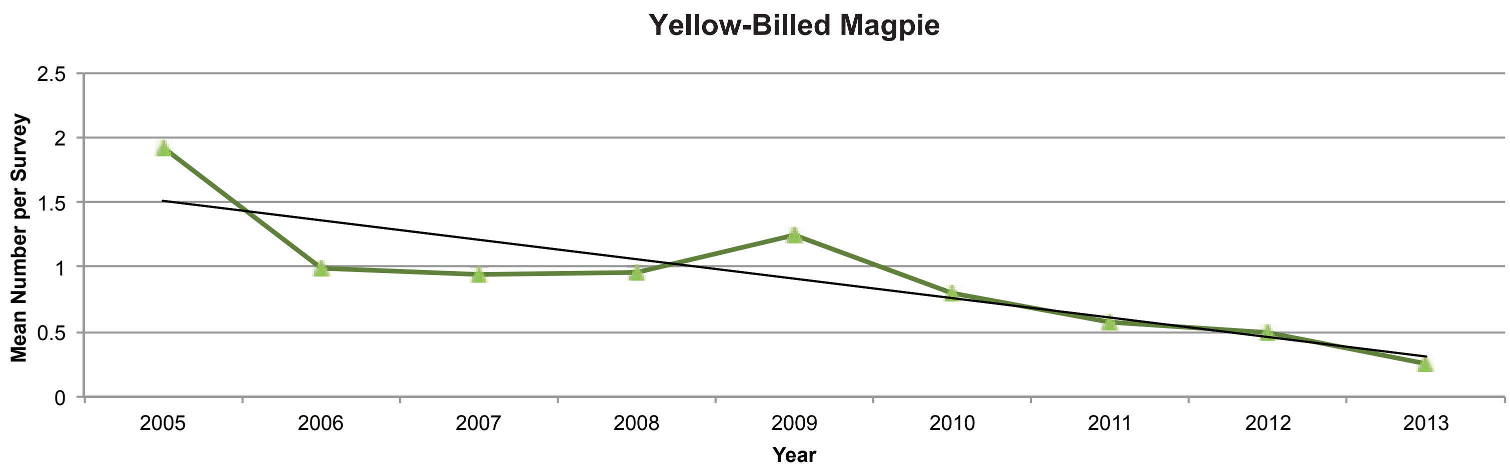
Figure 5-5
Mean Number of Shorebirds Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2013



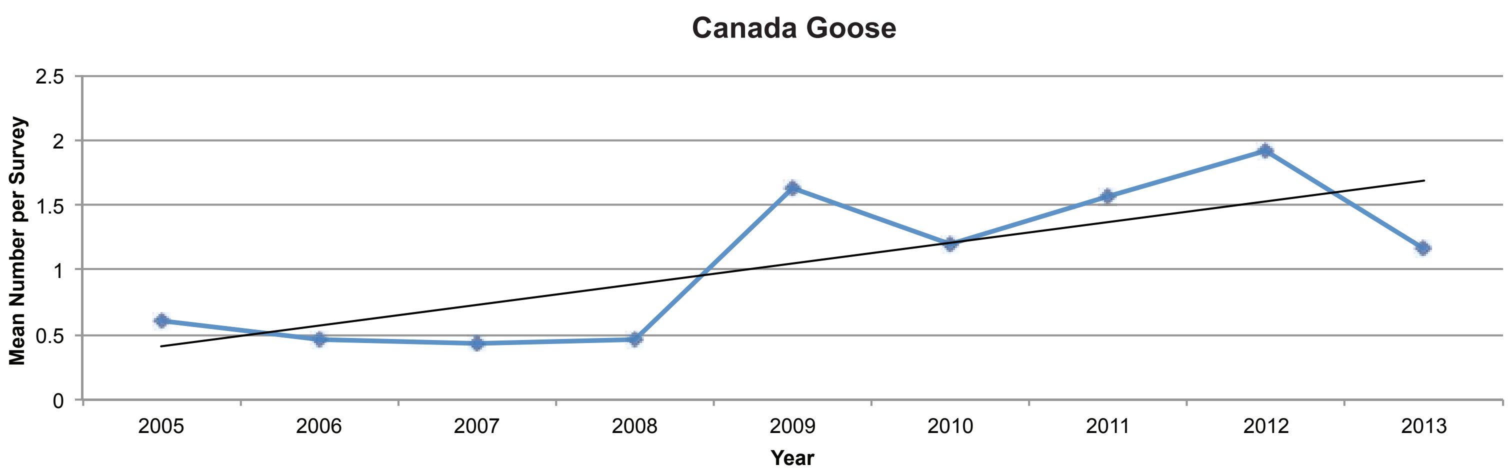
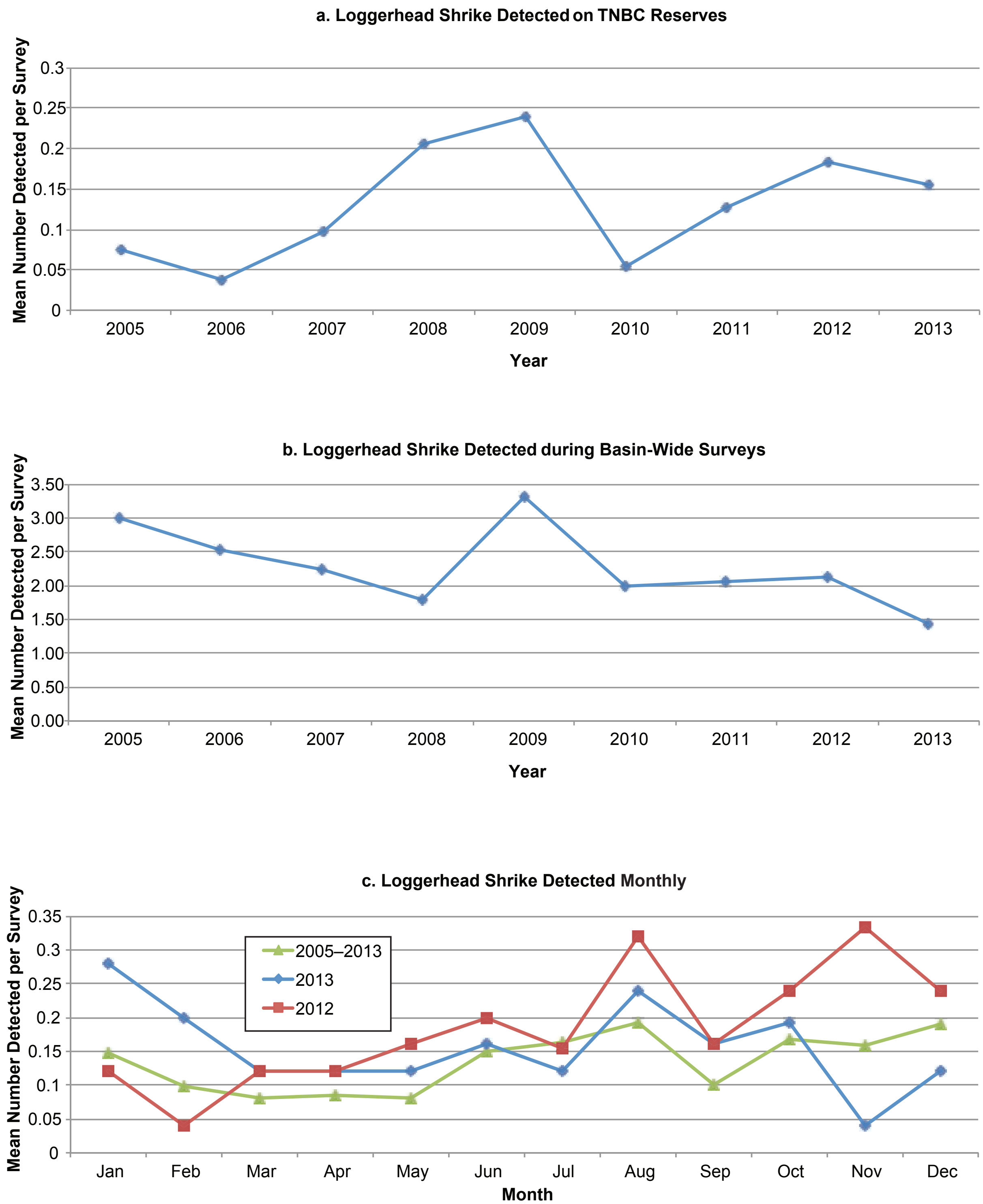


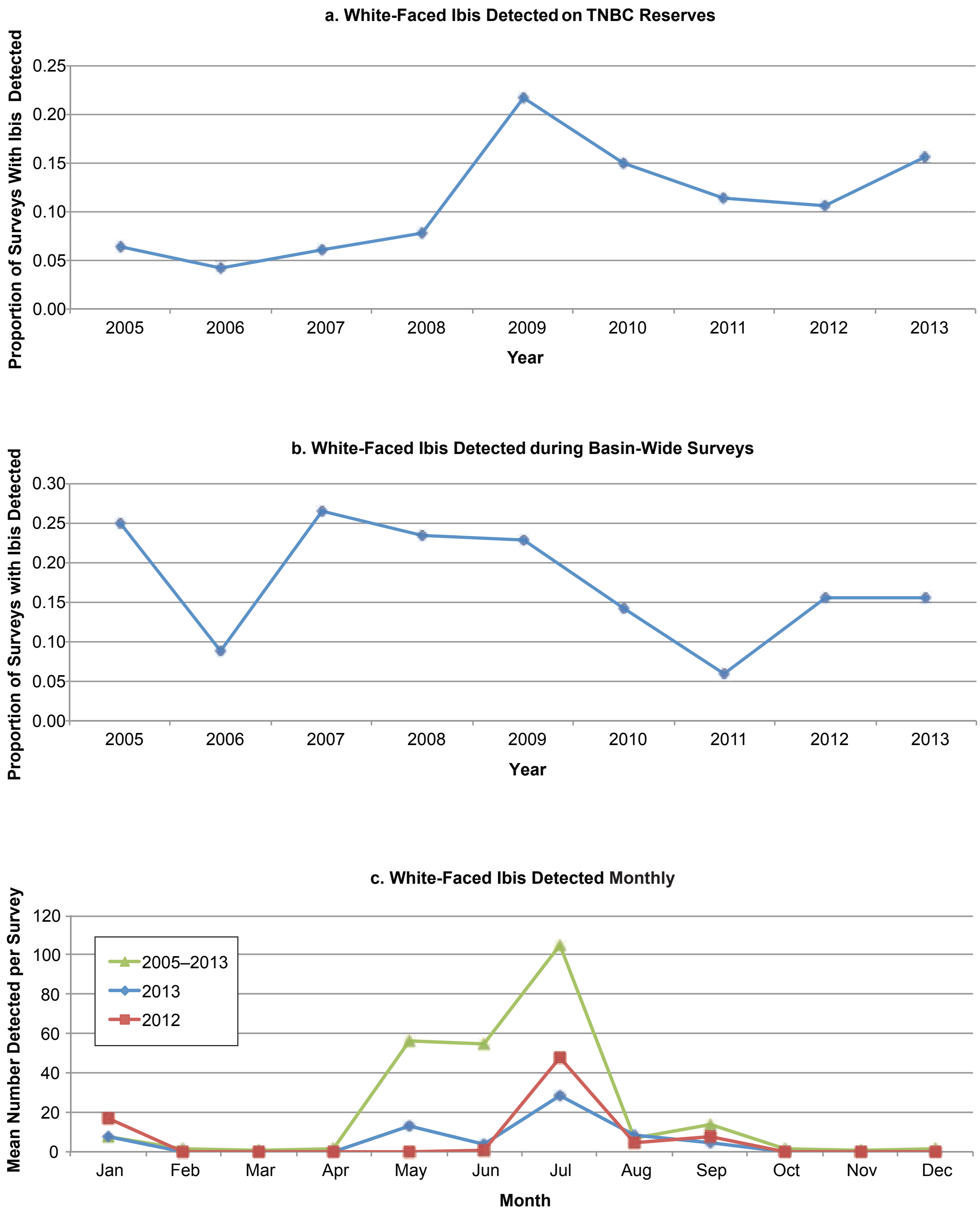
Figure 5-6
Mean Number of Yellow-Billed Magpies and Canada Geese Detected per Survey on TNBC Reserves in the Natomas Basin, 2005–2013



00890.10 (04-02-14) SS

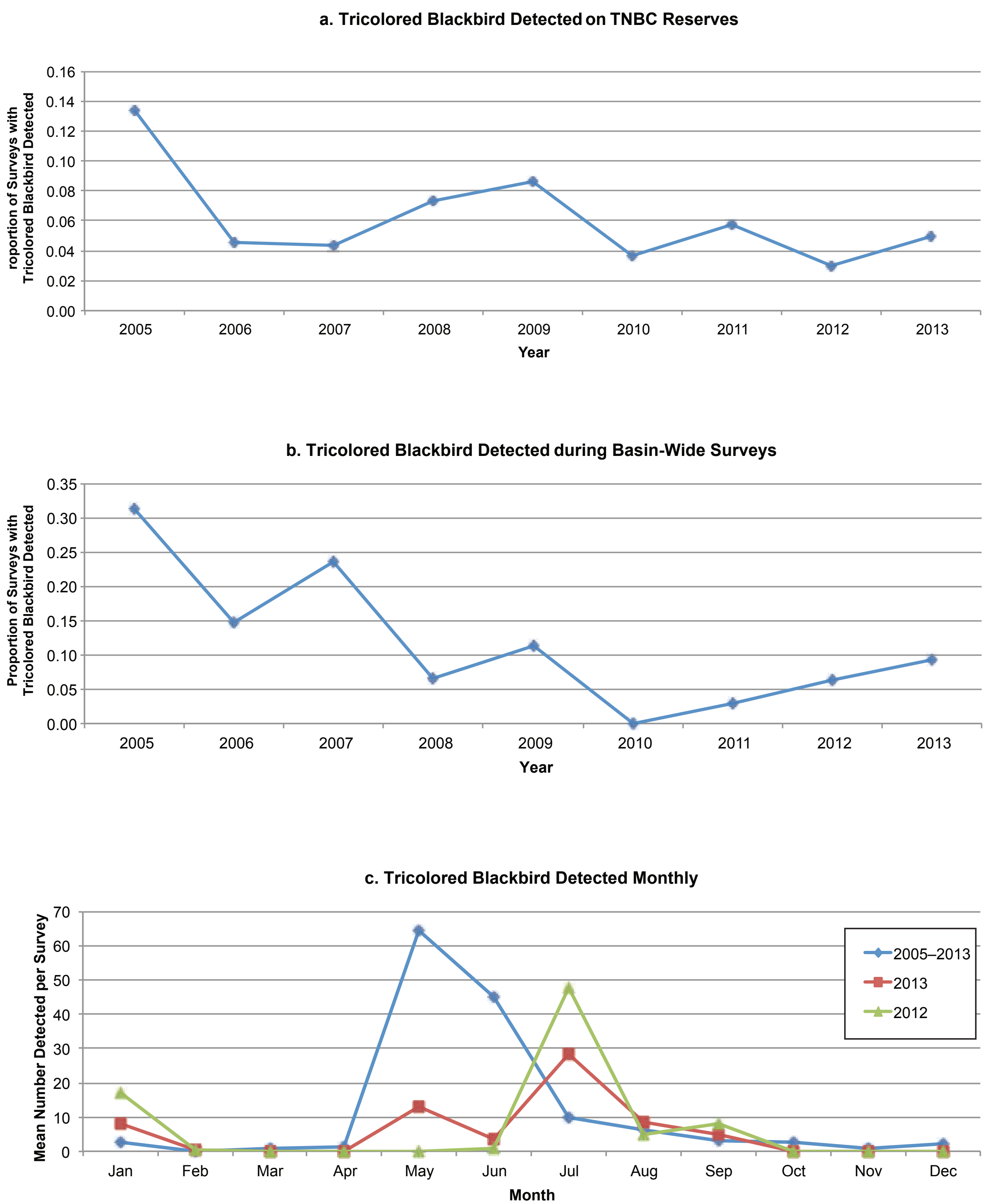
ICF INTERNATIONAL

Figure 5-7
Mean Number of Loggerhead Shrikes Detected on TNBC Reserves (a), during Basin-Wide Surveys (b), and Monthly (c) in the Natomas Basin, 2005–2013



00890.10 (04-02-14) SS

Figure 5-8
Proportion of Surveys with Ibis Detected on TNBC Reserves (a), during Basin-Wide Surveys (b), and the Mean Number of Ibis Detected per Month (c) in the Natomas Basin, 2005–2013



00890.10 (04-02-14) SS

Figure 5-9
Proportion of Surveys With Tricolored Blackbird Detected on TNBC Reserves (a), during Basin-Wide Surveys (b), and the Mean Number of Tricolored Blackbirds Detected per Month (c) in the Natomas Basin, 2005–2013

00890.10 (04-02-14) SS

Figure 5-10
Mean Number of Burrowing Owls Detected on TNBC Reserves (a), during Basin-Wide Surveys (b), and Monthly (c) in the Natomas Basin, 2005–2013

Appendix A
NBHCP Reserve Land Cover Data

Reserve and Land Cover Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
North Basin Reserve										
Atkinson[a]										
Fallow (including fallow rice)	21.0	108.0	70.2	44.3	–	122.7	161.2	161.2	108.7	64.4
Fresh emergent marsh	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Grass hay	–	–	–	21.3	–	–	–	–	–	–
Grassland (created)	–	–	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8
Milo	21.3	–	–	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
Other row crops	–	9.8	52.5	–	–	–	–	–	–	–
Rice	145.6	48.9	44.4	52.5	145.7	44.3	–	–	52.5	96.9
Riparian scrub	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
Ruderal	3.6	3.6	3.6	0.7	0.7	0.7	–	–	–	–
Seasonal wetland	0.1	0.1	0.1	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
Wheat	–	21.3	–	–	21.3	–	–	–	–	–
Bennett North										
Fallow	–	–	67.0	147.8	10.8	10.8	–	–	–	–
Fresh emergent marsh (created)	7.0	7.0	7.0	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	2.7	2.6	2.6
Rice	213.8	213.8	146.9	–	137.0	137.0	147.8	147.8	147.8	147.8
Riparian scrub	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ruderal	3.2	3.2	3.2	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
Fresh emergent marsh (created)	19.10	19.10	19.10	19.10	19.10	19.10	19.1	19.1	19.1	19.1
Irrigated grassland	–	–	–	–	–	4.4	5.3	–	–	–
Grassland (created)	109.9	22.7	28.1	28.7	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
Rice	–	–	81.8	82.0	86.4	82.0	59.7	59.5	86.4	73.2
Riparian scrub	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	0.8	–	–	–	–	–	–	–
Bolen North										
Fallow (to allow field leveling)	112.5	–	–	–	–	–	–	112.5	–	–
Rice	–	112.5	112.5	112.5	112.5	112.5	112.5	–	112.5	112.5
Bolen South										
Alfalfa	–	–	–	43.9	43.9	43.9	43.9	43.9	43.9	43.9
Fallow	–	101.7	–	–	–	–	–	57.8	–	–
Grass hay	–	–	–	–	–	–	–	–	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
Wheat	–	–	101.7	57.8	57.8	57.8	57.8	–	–	–

[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).

Appendix A-1. Continued

Reserve and Land Cover Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Bolen West										
Fallow (including fallow rice)	–	–	–	155.1	–	–	–	–	155.1	–
Rice	–	–	–	–	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
Grassland (created)	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	10.6	7.9
Open water	–	–	–	–	–	–	–	–	–	2.7
Huffman East										
Alfalfa	–	–	–	–	–	–	–	15.6	–	–
Fallow	–	15.6	–	–	–	–	–	–	–	15.6
Grass hay	–	–	–	15.6	15.6	–	–	–	15.6	–
Rice	134.4	118.8	118.8	118.8	118.8	118.8	118.8	118.8	118.8	18.8
Wheat	–	–	15.6	–	–	15.6	15.6	–	–	–
Huffman West[c]										
Alfalfa	67.9	67.9	67.9	67.9	67.9	122.6	44.5	99.5	99.5	99.5
Grass hay								58.4	58.4	58.4
Milo	58.4	–	–	–	–	–	–	–	–	–
Other row and grain crops	–	–	–	58.4	58.4	–	–	–	–	–
Tomatoes	54.7	–	–	54.7	54.7	–	–	–	–	–
Wheat	–	113.1	113.1	–	–	58.4	113.3	–	–	–
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
Disturbed/bare	–	–	–	–	–	–	–	–	27.4	11.1
Grassland (created)	–	–	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Nonnative annual grassland	23.9	23.9	24.0	27.5	27.5	27.5	27.5	27.5	0.1	0.1
Ruderal	15.8	15.8	15.0	15.0	15.0	15.0	15.0	15.0	14.9	14.9
Seasonal wetland	3.5	3.5	3.5	–	–	–	–	–	–	–
Open water	–	–	–	–	–	–	–	–	–	16.3
Lucich South										
Rice	328.1	328.1	328.1	328.1	328.1	328.1	328.1	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
Ruderal	3.1	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
Ruby Ranch										
Developed—high density	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

[b] Open water was mapped in 2013 due to the enlargement of an existing linear water conveyance feature.
[c] Acreage of reserve decreased in 2010 due to 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	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Fallow	–	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
Ruderal	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Vestal										
Rice	–	–	93.8	93.8	93.8	93.8	93.8	93.8	93.9	93.9
Valley oak woodland	–	–	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
Fresh emergent marsh (created)	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3	140.3
Irrigated grassland	95.5	0.0	95.5	–	–	–	–	–	–	–
Nonnative annual grassland	92.7	188.2	92.7	188.2	188.2	188.2	188.2	188.2	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
Riparian scrub	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
Seasonal wetland	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
Elsie										
Fallow	–	–	–	158.0	–	–	158.0	158.0	–	–
Rice	–	–	–	–	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
Sills										
Fallow	–	11.9	294.5	–	–	–	–	25.6	25.6	25.6
Grass hay	142.1	–	–	–	–	–	–	–	–	–
Other row and grain crops	–	–	–	12.3	280.8	–	–	–	–	–
Rice	432.0	420.2	137.6	436.4	167.9	448.7	448.7	410.6	410.6	423.1
Sunflower	–	–	–	–	–	–	–	12.6	12.6	–
Silva South 1										
Nonnative annual grassland										0.2
Rice	–	–	–	–	–	–	–	–	–	28.8
Tufts										
Fallow	–	–	–	–	–	146.7	–	–	–	–
Rice	–	147.7	147.7	147.7	147.7	1.0	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
Other row and grain crops	–	–	–	–	–	–	–	26.8	6.0	26.8

Reserve and Land Cover Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ruderal	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
Valley oak woodland	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Wheat	46.4	–	–	18.9	–	–	–	–	–	–
Cummings										
Fallow	59.6	17.7	–	–	–	–	–	–	–	–
Fresh emergent marsh (created)	–	37.1	37.1	37.1	37.1	37.1	37.1	37.1	37.2	37.2
Grassland (created)	3.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Nonnative annual grassland	2.0	4.8	4.8	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
Valley oak woodland	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
Grass hay	–	–	–	44.1	44.1	44.1	44.1	–	–	–
Grassland (created)	9.2	9.2	10.8	10.8	10.8	10.8	10.8	10.1	11.6	11.6
Nonnative annual grassland	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	5.4	5.4
Ruderal	3.1	3.1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Valley oak woodland	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Wheat	44.1	44.1	44.1	–	–	–	–	–	–	–
Rosa Central										
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
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
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
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	–	–	–	–	–	–
Non-riparian woodland	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	–	–	–

[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	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ruderal	0.1	0.1	0. 1	0.1	0.1	0.1	–	–	–	–
Safflower	–	–	–	–	–	–	–	–	11.0	–
Sunflower	–	–	–	–	–	–	–	11.0	–	–
Wheat	39.5	28.7	–	–	–	–	–	–	–	–
Grass hay	–	–	–	–	–	–	–	–	–	39.7

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Figure A-1
North Basin Reserve—Frazer and Lucich North Tracts, 2013

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Figure A-2
North Basin Reserve—Nestor, Bennett North, Bennett South, and Lucich South Tracts, 2013

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Figure A-3
North Basin Reserve—
Bolen West, Bolen North, and Bolen South Tracts, 2013

Figure A-4
North Basin Reserve—Huffman West and Huffman East Tracts, 2013

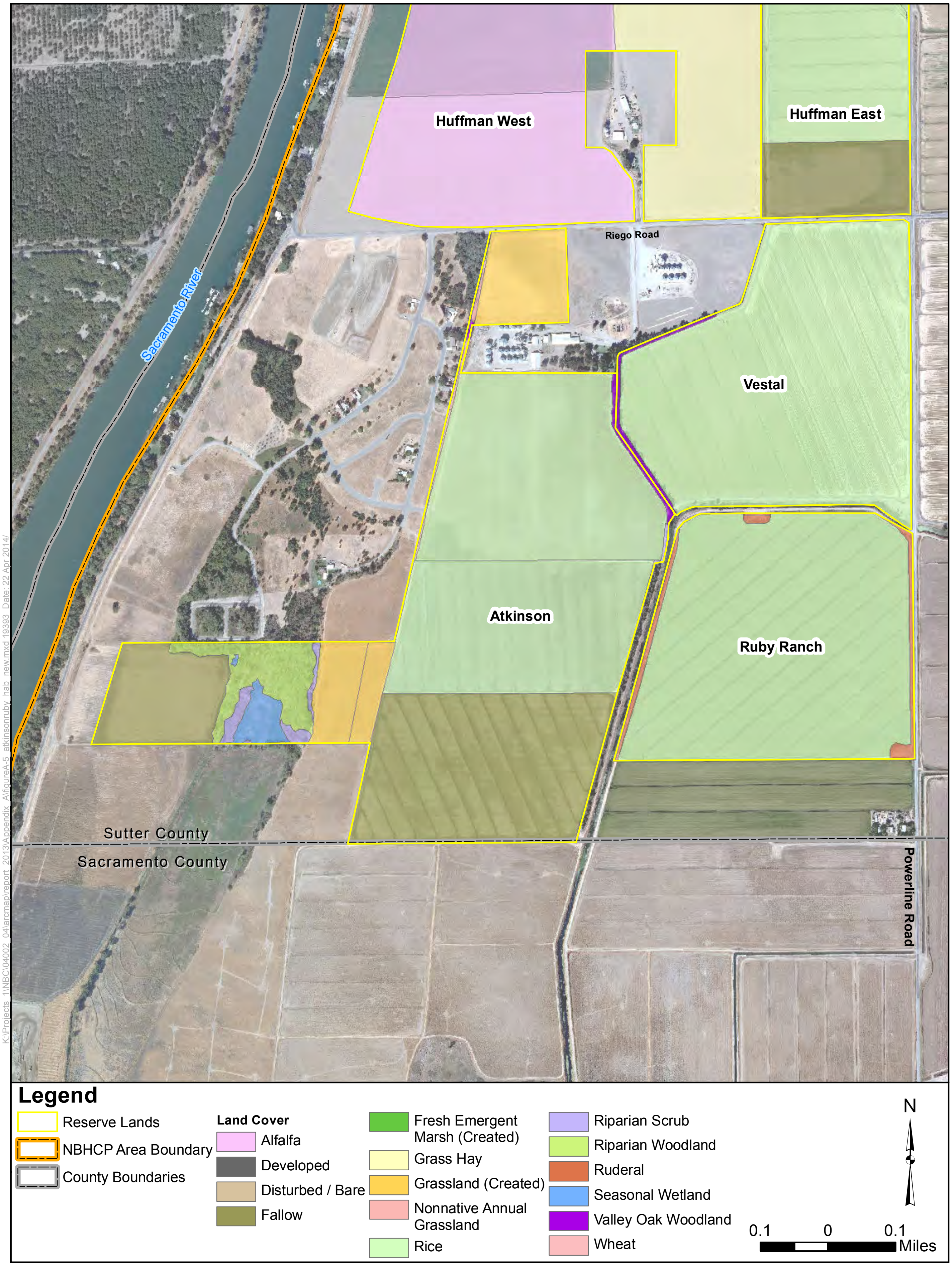

Figure A-5
North Basin Reserve—Atkinson, Vestal, and Ruby Ranch Tracts, 2013

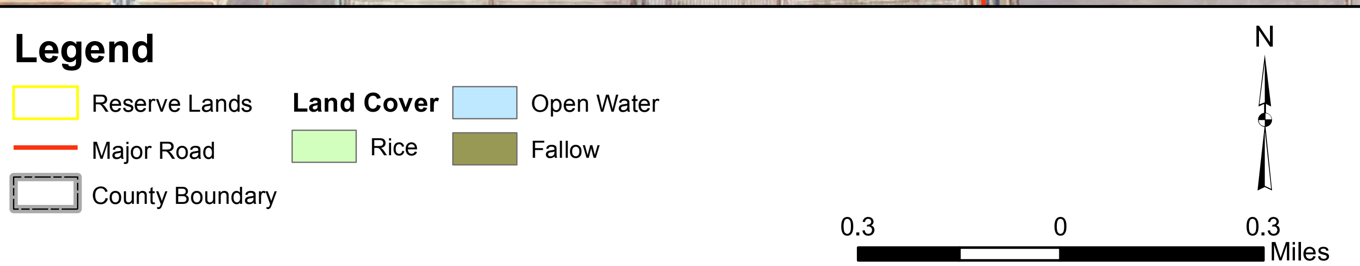

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Figure A-6
Central Basin Reserve—Elsie, Sills, Bianchi West, and Tufts Tracts, 2013

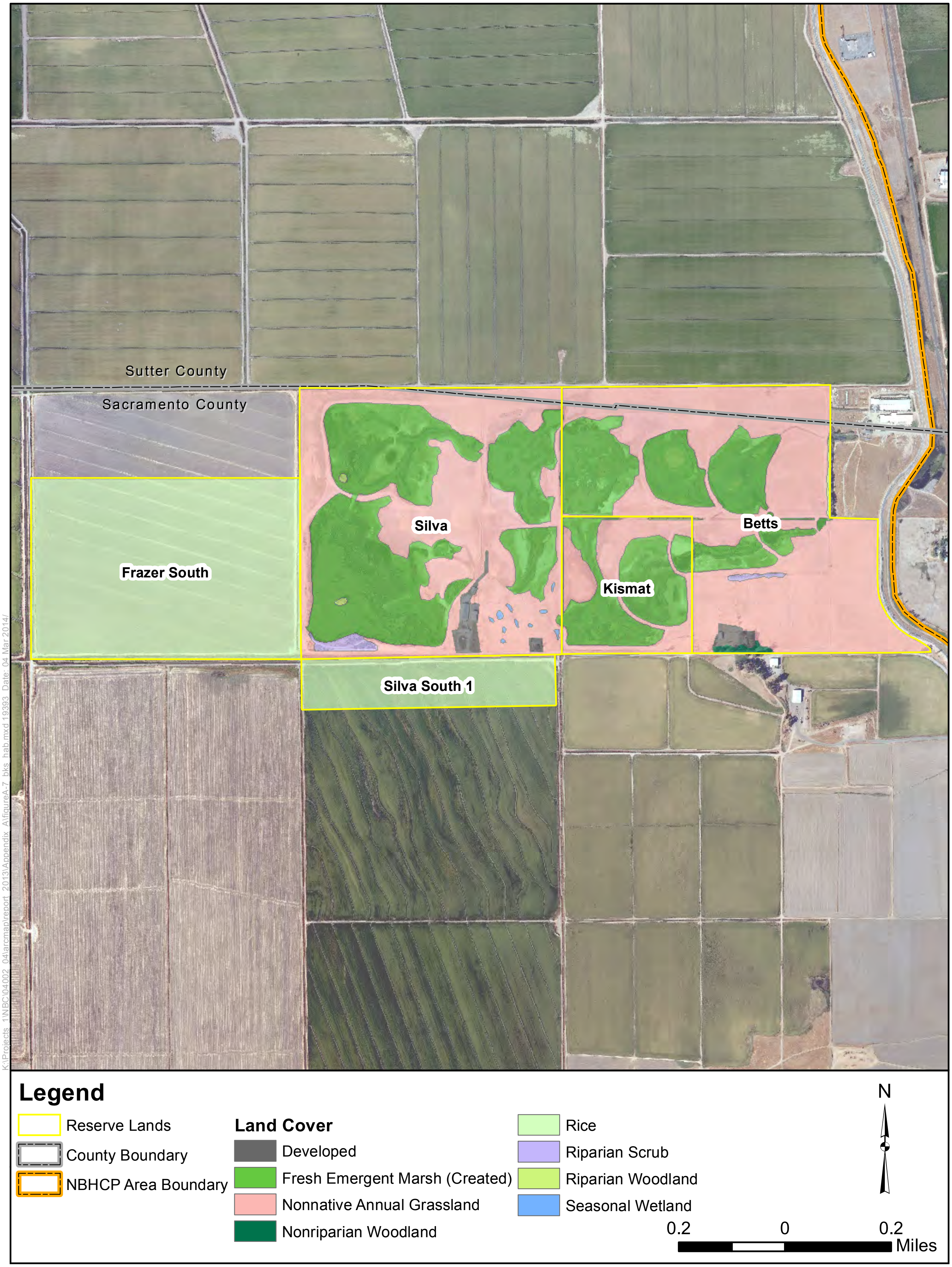

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Figure A-7
Central Basin Reserve—Frazer South, Betts, Kismat, Silva, and Silva South1 Tracts, 2013

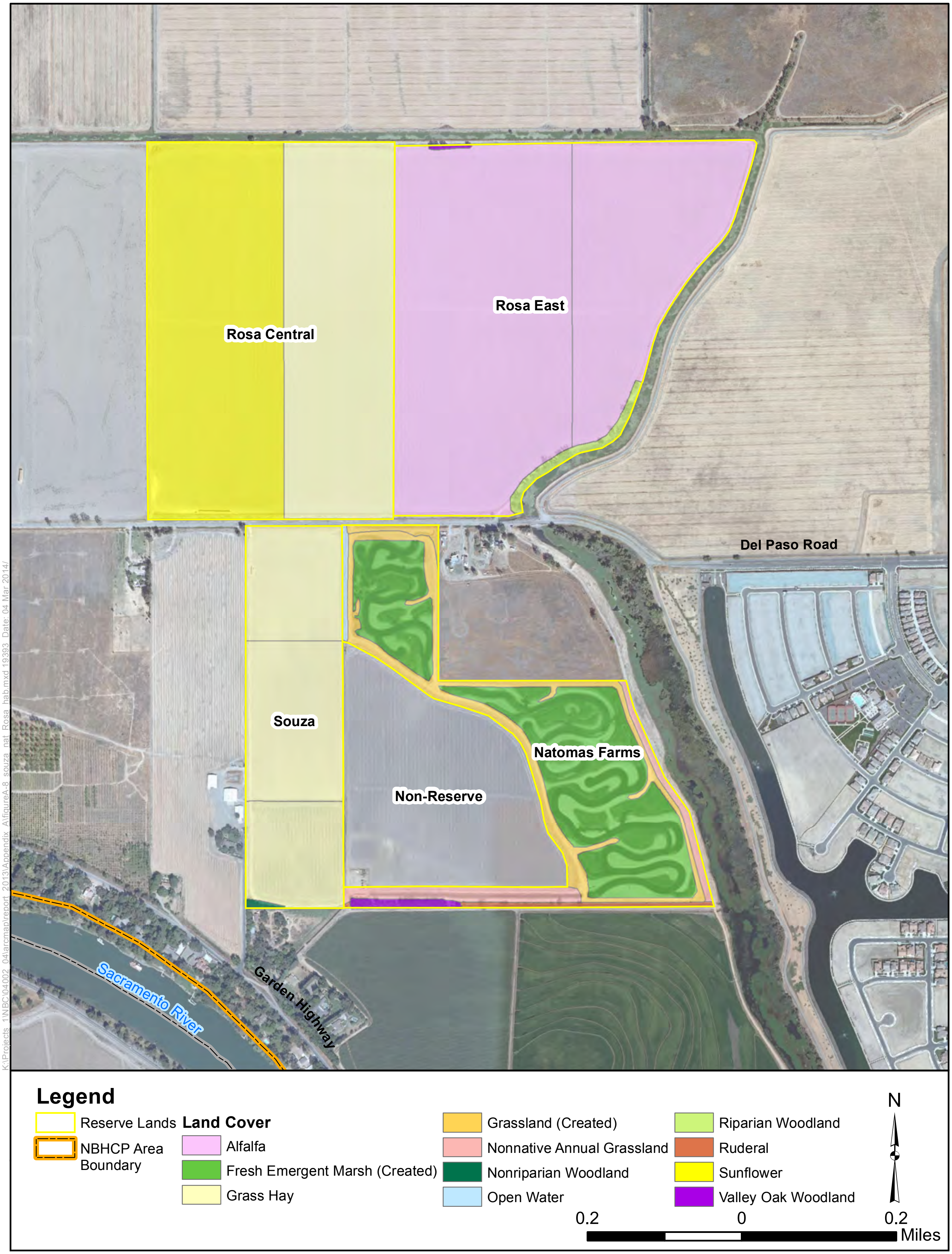

Figure A-8
Fisherman's Lake Reserve—Rosa Central, Rosa East, Souza, and Natomas Farms Tracts, 2013

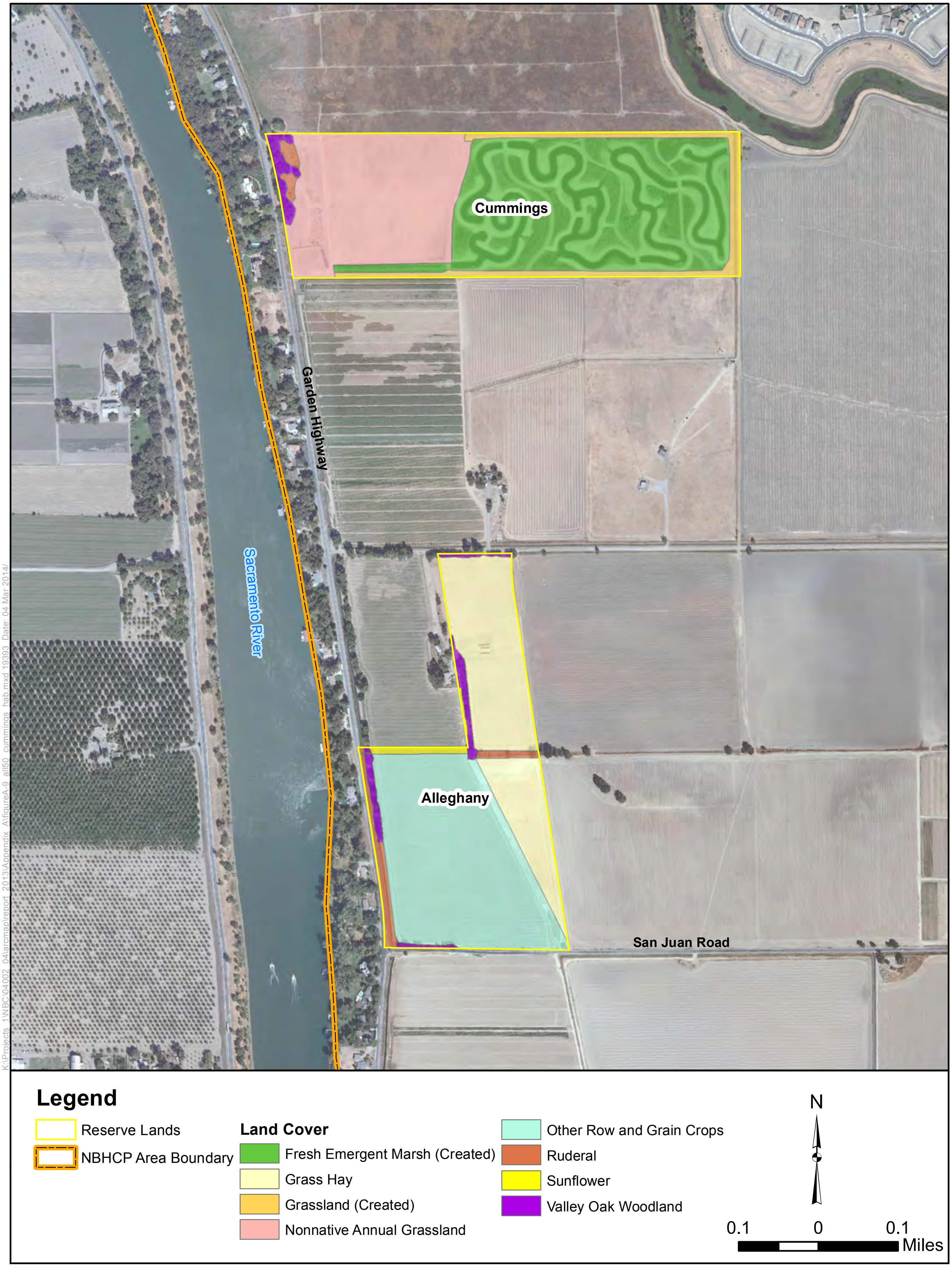

Figure A-9
Fisherman's Lake Reserve—Cummings and Alleghany Tracts, 2013

Appendix B
Floristic Survey Results

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
Ferns and Fern Allies																										
Azollaceae	**Mosquito Fern Family**																									
Azolla filiculoides	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.

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
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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*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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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			

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*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	

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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**																									

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Crassula aquatica/solieri	Water pygmy-weed										X	X														
*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		

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*Trifolium fragiferum**	Strawberry clover															X										
*Trifolium glomeratum**	Clustered clover															X										
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																	

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Juglandaceae	**Walnut family**																									
Juglans hindsii (Juglans californica var. *hindsii)*	California black walnut															X						X	X	X		X
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										

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
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			

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
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																		

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
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 discolor**	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			

		North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve				
Scientific Name (previous scientific name)[a]	Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	Lucich North	Lucich South	Nestor	Ruby Ranch	Vestal	BKS	Bianchi West	Elsie	Frazer South	Sills	Tufts	Alleghany	Cummings	Natomas Farms	Rosa East & Central	Souza
*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

Common Name	Scientific Name
Mammals	
Coyote	*Canis latrans*
Raccoon	*Procyon lotor*
River otter	*Lontra canadensis*
Striped skunk	*Mephitis mephitis*
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*
Audubon's cottontail	*Silvilagus audubonii*
Bat	*Myotis* sp.
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*
Ruddy duck	*Oxyura jamaicensis*
Ring-necked pheasant	*Phasianus colchicus*

Common Name	Scientific Name
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 moorhen	*Gallinula chloropus*
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*
Long-billed curlew	*Numenius americanus*
Western sandpiper	*Calidris mauri*

Common Name	Scientific Name
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*
Western scrub-jay	*Aphelocoma californica*
Yellow-billed magpie	*Pica nuttalli*

Common Name	Scientific Name
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*
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*
Song sparrow	*Melospiza melodia*
Lincoln’s sparrow	*Melospiza lincolnii*
White-crowned sparrow	*Zonotrichia leucophrys*

Common Name	Scientific Name
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	
Western pond turtle	*Clemmys 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*

	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve					
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Greater white-fronted goose	0	1,240	0	6	0	30	20	7	0	1,280	1,210	0	0	0	604	50	0	0	600	0	0	0	0	0	0	**5,047**
Snow goose	0	16	0	0	0	400	0	0	0	0	281	0	0	0	0	0	0	0	2,200	0	0	0	0	0	0	**2,897**
Canada goose	0	2	0	0	0	0	10	0	0	44	1	0	0	0	279	0	0	2	0	0	0	0	2	10	0	**350**
Wood duck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	**2**
American wigeon	0	30	2	0	0	0	12	0	0	28	0	50	0	0	2	0	0	0	0	0	0	0	0	0	0	**124**
Mallard	17	220	47	0	0	0	367	90	6	1,083	252	32	13	3	438	85	0	22	136	3	0	32	6	8	0	**2,860**
Blue-winged teal	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	**14**
Cinnamon teal	1	1	0	0	0	0	19	4	0	44	0	12	0	0	40	0	0	8	2	0	0	2	0	0	0	**133**
Northern shoveler	0	0	0	0	0	0	0	0	0	78	580	430	0	0	42	24	80	0	700	0	0	0	0	0	0	**1,934**
Northern pintail	0	0	0	0	0	0	0	0	0	2	100	74	0	0	12	6	8	0	200	0	0	0	0	0	0	**402**
American green-winged teal	10	0	0	0	0	0	30	0	0	162	60	0	0	0	2	0	0	0	0	0	0	0	0	0	0	**264**
Canvasback	0	0	0	0	0	0	0	0	0	6	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**7**
Redhead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	**2**
Greater scaup	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	**9**
Lesser scaup	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	**5**
Bufflehead	0	4	1	0	0	0	0	0	0	0	0	0	0	0	160	0	0	0	0	0	0	0	0	0	0	**165**
Common goldeneye	0	0	0	0	0	0	0	0	0	28	0	0	0	0	8	0	0	0	0	0	0	13	23	0	0	**72**
Common merganser	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	**3**
Ruddy duck	0	63	0	0	0	0	0	0	0	100	0	0	0	0	290	0	0	0	0	0	0	0	0	0	0	**453**
Ring-necked pheasant	5	2	2	0	0	0	0	0	0	1	1	0	0	0	1	0	0	6	0	0	1	3	2	0	0	**24**
Wild turkey	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**60**
California quail	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	**36**
Pied-billed grebe	0	38	15	0	0	0	17	0	0	96	6	0	0	0	181	0	0	0	0	0	0	4	27	0	0	**384**
Eared grebe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**
Western grebe	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
American white pelican	0	0	0	0	0	0	0	0	0	34	0	0	0	0	26	0	0	0	0	0	0	0	25	0	0	**85**
Double-crested cormorant	0	91	0	0	0	0	30	0	0	130	5	0	0	1	120	0	0	0	2	0	0	6	7	0	0	**392**
American bittern	0	0	1	0	0	0	1	4	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	**9**
Great blue heron	1	37	13	2	1	6	32	7	0	54	32	32	15	5	69	11	2	16	31	2	0	7	7	6	0	**388**
Great egret	4	90	36	14	0	6	60	55	12	120	68	68	48	59	123	30	40	41	90	12	0	15	4	15	0	**1,010**
Snowy egret	0	18	2	0	0	0	1	0	0	66	1	0	1	0	135	4	0	8	3	0	0	2	4	5	0	**250**
Green heron	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4	0	1	0	**7**
Black-crowned night-heron	0	0	64	0	0	2	0	8	0	8	3	0	1	1	621	14	0	4	5	1	0	7	0	2	0	**741**
White-faced ibis	123	151	36	83	0	0	4	19	46	57	474	165	80	5	205	9	6	14	144	33	0	0	0	0	0	**1,654**
Turkey vulture	1	4	7	0	1	0	2	0	0	1	5	3	0	0	2	0	0	0	0	0	0	0	0	0	1	**27**

	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve					
Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	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	**Total**
White-tailed kite	7	1	3	0	2	0	2	0	0	0	0	0	0	0	22	0	1	1	2	0	0	3	1	8	1	**54**
Northern harrier	2	5	6	1	4	3	5	4	0	5	13	12	0	0	15	3	3	6	4	0	0	0	1	4	0	**96**
Cooper's hawk	2	0	0	1	0	1	2	0	0	2	1	1	0	0	3	0	0	0	0	0	0	0	0	1	0	**14**
Red-shouldered hawk	6	0	1	0	1	2	1	1	3	0	0	0	0	5	4	2	0	1	1	0	0	1	3	0	0	**32**
Swainson's hawk	1	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	14	**21**
Red-tailed hawk	11	9	9	1	3	13	7	4	7	16	17	9	8	9	39	2	1	13	10	1	2	10	2	1	1	**205**
American kestrel	10	0	1	0	1	1	2	7	16	6	3	0	2	2	10	0	1	4	0	1	4	6	6	6	4	**93**
Peregrine falcon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	**3**
Sora	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**
Common moorhen	0	0	0	0	0	0	1	0	0	7	0	0	0	0	33	0	0	0	0	0	0	2	13	0	0	**56**
American coot	0	738	112	70	0	0	231	8	0	1,154	801	450	40	0	2,984	0	80	0	472	0	0	19	23	0	0	**7,182**
Killdeer	17	89	5	24	27	5	18	7	11	48	7	26	10	6	148	41	11	30	44	2	3	10	7	15	2	**613**
Black-necked stilt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	142	0	0	0	2	0	0	0	0	0	0	**144**
American avocet	0	0	0	0	0	0	0	0	0	0	1	0	0	0	49	0	0	0	0	0	0	0	0	0	0	**50**
Greater yellowlegs	0	15	0	0	0	0	28	0	0	50	19	11	0	0	31	12	6	0	5	14	0	0	0	0	0	**191**
Lesser yellowlegs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	**2**
Long-billed curlew	0	21	0	0	35	14	0	2	18	0	2	45	0	0	0	8	1	0	12	0	0	0	0	0	0	**158**
Least sandpiper	0	0	0	0	0	0	0	16	0	30	50	0	0	0	67	62	40	0	14	0	0	0	0	0	0	**279**
Long-billed dowitcher	0	0	0	0	0	0	84	0	0	140	0	0	0	0	292	0	80	0	0	40	0	0	0	0	0	**636**
Wilson's snipe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**1**
Wilson's phalarope	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0	**5**
Ring-billed gull	0	168	3	0	0	0	0	0	0	0	2	75	4	2	4	2	17	0	85	0	0	0	0	0	0	**362**
California gull	6	2	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	30	0	0	6	0	0	0	**47**
Black tern	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Rock pigeon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	17	**20**
Eurasian collared-dove	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**3**
Mourning dove	69	7	0	12	1	0	0	0	3	2	2	2	10	11	89	1	1	4	0	0	12	41	31	55	51	**404**
Barn owl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**
Great horned owl	0	0	3	0	0	0	0	0	0	0	0	0	0	0	6	1	0	0	0	0	0	0	0	0	0	**10**
Burrowing owl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	8	0	0	0	0	0	**13**
White-throated swift	6	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	**22**
Black-chinned hummingbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**
Anna's hummingbird	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	0	0	**6**
Belted kingfisher	3	0	1	1	0	0	3	0	0	5	1	0	0	0	4	0	0	1	0	0	0	3	5	3	0	**30**
Nuttall's woodpecker	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	1	2	0	**47**
Northern flicker	11	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	1	0	6	0	**21**

	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve					
Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	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	**Total**
Western wood-pewee	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**8**
Black phoebe	21	0	4	0	4	0	11	3	7	25	7	1	5	13	43	0	0	4	1	0	12	35	33	17	8	**254**
Say's phoebe	1	1	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	2	4	1	2	1	**16**
Western kingbird	27	0	1	0	19	1	0	0	14	10	1	0	0	2	21	0	0	0	0	0	0	3	5	8	9	**121**
Loggerhead shrike	5	3	0	0	2	0	2	0	0	9	1	3	0	1	2	0	0	0	0	0	0	3	1	10	5	**47**
Western scrub-jay	80	0	0	0	3	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	14	14	3	2	3	**123**
Yellow-billed magpie	2	0	0	0	1	0	0	0	14	0	0	0	0	2	3	0	0	0	0	0	15	38	0	2	0	**77**
American crow	145	2	0	1	4	0	0	47	13	0	10	2	37	10	7	0	1	0	7	32	12	19	31	0	78	**458**
Horned lark	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	14	18	0	22	6	0	0	0	40	0	**101**
Tree swallow	32	30	7	0	26	0	0	6	2	4	0	30	0	2	24	2	0	0	0	0	0	26	19	18	0	**228**
Northern rough-winged swallow	0	0	12	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**17**
Cliff swallow	0	70	0	0	0	0	30	8	8	120	0	60	0	0	458	70	0	10	60	0	0	11	34	26	2	**967**
Barn swallow	5	0	0	0	0	1	35	2	1	18	0	0	9	0	82	0	0	0	0	0	6	9	13	23	0	**204**
Oak titmouse	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	3	0	0	0	**18**
Bushtit	20	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	42	0	0	0	**90**
Red-breasted nuthatch	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Bewick's wren	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**4**
House wren	18	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	5	8	0	1	0	**36**
Marsh wren	0	66	40	0	0	0	59	1	0	136	35	0	0	1	243	0	0	2	1	0	0	50	47	0	0	**681**
Ruby-crowned kinglet	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	2	0	1	0	**8**
Western bluebird	20	0	0	0	12	0	2	0	21	1	0	0	6	0	0	0	0	0	0	0	6	0	0	0	0	**68**
American robin	31	0	0	0	0	0	0	0	1	0	0	0	0	1	7	0	0	1	0	0	0	3	0	12	8	**64**
Northern mockingbird	24	1	0	1	4	1	0	0	0	3	0	0	0	0	16	0	0	0	0	0	0	4	6	38	6	**104**
European starling	104	0	0	0	27	0	0	0	136	0	0	0	0	30	84	0	0	3	0	0	9	3	0	50	48	**494**
American pipit	24	29	9	23	15	51	26	35	7	38	30	63	13	12	44	6	18	26	156	22	0	4	0	16	2	**669**
Cedar waxwing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	**8**
Orange-crowned warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**1**
Nashville warbler	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**7**
Yellow warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	**2**
Yellow-rumped warbler	18	0	0	0	18	0	0	0	0	2	1	0	0	0	15	0	0	0	0	0	13	29	69	58	5	**228**
Black-throated gray warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**
Common yellowthroat	7	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0	**14**
Wilson's warbler	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
Spotted towhee	15	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	**20**
California towhee	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	7	0	**34**

	North Basin Reserve														Central Basin Reserve						Fisherman's Lake Reserve					
Common Name	Atkinson	Bennett North	Bennett South	Bolen North	Bolen South	Bolen West	Frazer	Huffman East	Huffman West	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	**Total**
Lark sparrow	0	0	0	0	0	0	0	0	0	1	0	0	0	14	0	0	0	0	0	0	1	0	0	0	0	**16**
Savannah sparrow	108	219	194	131	127	98	27	42	85	80	272	216	119	47	106	106	103	239	381	172	6	100	55	116	26	**3,175**
Fox sparrow	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Song sparrow	2	6	26	0	0	0	15	1	0	34	16	0	0	1	30	0	0	1	1	0	1	32	18	1	0	**185**
White-crowned sparrow	148	18	24	0	24	0	0	0	0	144	53	6	12	15	190	0	0	50	0	0	45	73	51	2	0	**855**
Golden-crowned sparrow	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	8	0	**38**
Dark-eyed junco	2	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	51	15	0	0	0	**72**
Black-headed grosbeak	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**2**
Red-winged blackbird	209	894	438	48	22	24	408	232	278	1,642	851	196	94	147	4,990	130	5	621	474	0	91	382	212	50	23	**12,461**
Tricolored blackbird	24	110	0	40	40	0	0	0	0	1,040	90	110	20	28	0	0	0	0	0	1	0	0	0	0	0	**1,503**
Western meadowlark	132	219	217	20	36	42	144	77	22	55	114	89	72	35	274	67	33	116	112	12	10	57	22	111	4	**2,092**
Yellow-headed blackbird	0	0	0	0	0	0	0	0	10	80	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	**95**
Brewer's blackbird	137	106	177	46	32	0	88	249	211	54	381	195	250	174	574	76	78	164	194	5	47	209	3	4	6	**3,460**
Great-tailed grackle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42	0	0	0	0	0	0	0	1	0	0	**43**
Brown-headed cowbird	16	4	3	0	0	1	6	0	31	6	0	10	0	2	87	0	0	28	9	0	0	18	3	1	1	**226**
Bullock's oriole	7	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	1	0	**13**
House finch	179	17	18	23	36	0	45	2	10	81	18	31	0	72	226	0	0	38	46	30	80	103	30	29	42	**1,156**
Lesser goldfinch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	**6**
American goldfinch	0	0	0	0	0	8	0	0	0	0	0	34	8	8	0	0	0	0	0	0	5	22	4	6	0	**95**
House sparrow	7	0	0	0	0	0	0	0	0	0	0	0	0	10	6	0	0	0	0	0	0	0	0	0	0	**23**
Coyote	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	**4**
Western pond turtle	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	**19**
Total	**2,086**	**4,860**	**1,544**	**548**	**536**	**722**	**1,890**	**948**	**994**	**8,485**	**5,880**	**2,547**	**879**	**746**	**14,920**	**841**	**639**	**1,484**	**6,262**	**402**	**496**	**1,560**	**869**	**844**	**369**	**61,351**

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