Implementation of Priority 1, Priority 2, and Priority 3 Recovery Tasks for Giant Garter Snake (*Thamnophis gigas*) – continuing Surveys in Merced County, California, with an Expansion to Northern Fresno County

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Abstract

For the second consecutive year, we investigated the potential presence of giant garter snakes north and east of the San Joaquin River and the current status of declining historical populations south and east of the San Joaquin River in the Grassland Ecological Area in Merced County, California. We also sampled historical populations at Mendota Wildlife Area in Fresno County, California. Trapping began on May 1, 2007 and continued through September 8, 2007. Sixty four traplines were established with 48,762 trap days accrued, constituting an increase of 10,762 trap days over 2006 due largely to the expansion to Mendota Wildlife Area; one hundred fourteen total traplines were established over the two years. Ten giant garter snakes were captured in all during the two-year study; four giant garter snakes were captured during 2007, two of which were first marked during 2006. Of the four giant garter snakes captured in 2007, one was captured twice, constituting a decrease from 32 capture events in 2006 to 5 capture events in 2007 despite the increase in trapping effort. In 2007, all giant garter snakes were encountered along the Los Banos Creek corridor between the San Joaquin River and the City of Los Banos. As during 2006, no giant garter snakes were encountered north of the San Joaquin River. Likewise, no giant garter snakes were encountered at Mendota Wildlife Area or elsewhere in Fresno County where they were last observed in 2001. Tissue samples collected as a result of these surveys were contributed to a parallel genetic study conducted by Dr. Tag Engstrom, CSU Chico.

All giant garter snakes observed during this study were sexually mature adults, indicating a skewed size distribution typical of declining or senescing populations. Giant garter snakes were not encountered at the majority of historical localities surveyed despite the presence of linear aquatic habitat, suggesting that other variables may contribute to the species' regional decline. Analyses of region-wide habitat associations suggest that, in addition to channelized features such as ditches, drains, and canals, shallow summer wetlands are probably critical components influencing giant garter snake distribution and persistence.

Standardized surveys should continue to further assess regional distribution and to collect the long-term mark-recapture data required to analyze population demographics, including such factors as survivorship, age structure, and fecundity that may indicate reasons for decline or the affected life history variables. Additional studies should target the interactions between water quality, water management, and pathology to assess the reasons for the precipitous decline of giant garter snakes in the San Joaquin Valley. Foremost, recovery efforts should prioritize ensuring stable sources of spring and summer water emphasizing shallow-water wetland habitats where giant garter snakes persist.

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INTRODUCTION

Background

This document summarizes the results of the project entitled **Implementation of Priority 1, Priority 2, and Priority 3 Recovery Tasks for Giant Garter Snake (*Thamnophis gigas*) – continuing Surveys in Merced County, California, with an Expansion to Northern Fresno County**. Funded by the Central Valley Project Improvement Act Habitat Restoration Program (HRP) during Fiscal Year 2007, the project was completed in accordance with the terms and conditions of Fish and Wildlife Service (FWS) Agreement No. 802707G112.

Project Goals and Objectives

The project goals and objectives are:

- To investigate the presence of giant garter snakes north and east of the San Joaquin River in Merced County, including, but not limited to the East Side Canal and Drainage Management Area within the Stevinson Management District and Merquin County Water District (SMWD), and the Merced National Wildlife Refuge Complex;
- To assess the current status of giant garter snake populations within the Grasslands Ecological Area, including, but not limited to Federal- and State-managed refuges and wildlife areas and private lands along the Santa Fe Grade corridor south and west of the San Joaquin River in Merced County;
- To assess the current status of giant garter snakes in the vicinity of Mendota Pool in Fresno County
- To contribute tissue samples for the parallel genetic study proposed by Dr. Tag Engstrom, CSU Chico;
- To provide a methodological foundation for future monitoring.

Species Description

The giant garter snake (GGS) is an aquatic snake endemic to the Great Central Valley of California. Described as among California's most aquatic garter snakes (Fitch 1940), GGS are historically associated with low-gradient streams and valley floor wetlands and marshes and, more recently, with areas supporting rice agriculture (G. Hansen and J. Brode 1993; G. Hansen 1998; USFWS 1999; Wylie *et al*. 1997). GGS once ranged throughout the wetlands of California's Central Valley from Buena Vista Lake near Bakersfield, Kern County, north toward the vicinity of Chico in Glenn and Colusa Counties (Hansen and Brode 1980). Due mainly to loss or degradation of aquatic habitat resulting from agricultural and urban development, GGS has been either extirpated or else suffered serious declines throughout much of its former range. The current known distribution of GGS is patchy, and extends from near Chico in Butte County, south to Mendota Wildlife Area in Fresno County. GGS was listed by DFG as rare on June 27, 1971 and was designated as threatened following the passage of the California Endangered Species Act in 1984 (California Fish and Game Code §2050-2116). The U.S Fish and Wildlife Service listed GGS as threatened under the Federal Endangered Species Act on October 20, 1993 (58 FR 54053). GGS is considered vulnerable by the World Conservation Union (IUCN) (Baillie 1996).

GGS emerge in March and are generally active (foraging and breeding) from April through September, seeking winter refuge during the onset of cooling temperatures in the fall (Brode 1988; E. Hansen 2005; G. Hansen and J. Brode 1993; USFWS 1999; Wylie *et al*. 1997). Particularly in the Sacramento Valley, rice fields have become important habitat for giant garter snakes. Irrigation water typically enters the rice lands during April along canals and ditches. GGS use these canals and their banks as permanent habitat for both spring and summer active behavior and overwintering. Where these canals are not regularly maintained, a lush aquatic, emergent and streamside vegetation develops prior to the spring emergence of giant garter snakes. This vegetation, in combination with cracks and holes in the soil, provides much needed sheltering cover during spring emergence and throughout the remainder of the summer active period. Emergent rice provides dense, shallow-water habitat during and after GGS parturition (birth), typically occurring from mid-July into August.

GGS feed on small fishes, tadpoles, and small frogs (Fitch 1941, Hansen 1980, USFWS 1999), specializing in ambushing prey underwater (Brode 1988). Historically, giant garter snakes probably preyed on native species such as the thick-tailed chub (*Gila crassicauda*), the California red-legged frog (*Rana aurora draytonii*), which have been extirpated from the giant garter snake's current range, as well as the pacific treefrog (*Pseudacris regilla*) and Sacramento blackfish (*Orthodox microlepidus*), (Cunningham

1959; Rossman *et al.* 1996; USFWS 1999). GGS now utilize introduced species, such as small bullfrogs (*Rana catesbeiana*) and their larvae, carp (*Cyprinus carpio*), and mosquitofish (*Gambusia affinis*). While juveniles probably consume insects and other small invertebrates, GGS are not known to consume prey such as small mammals or birds.

Large vertebrates, including raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), red foxes (*Vulpes vulpes*), gray foxes (*Urocyon cinereoargentius*), river otters (*Lutra canadensis*), opossums (*Didelphis virginiana*), Harriers (*Circus cyaneus*), Hawks (*Buteo* spp.), Herons (*Ardea herodius*, *Nycticorax nyctycorax*), Egrets (*Ardea alba*, *Egretta thula*), and American Bitterns (*Botaurus lentiginosus*) prey on GGS (USFWS 1999). In areas near urban development, GGS may also fall prey to domestic or feral house cats (G. Hansen pers. comm.). In permanent waterways, introduced predatory game fishes, such as bass (*Micropterus* spp.), sunfish (*Lepomis* spp.), and channel catfish (*Ictalurus* spp.), likely prey on GGS and compete with them for smaller prey (Hansen 1998, USFWS 1993).

GGS coexist with the valley garter snake (*Thamnophis sirtalis fitchi*) and, in limited instances, both may be found together with the mountain garter snake (*Thamnophis elegans elegans*), a subspecies of the western terrestrial garter snake, where the range of *T. e. elegans* extends to the Central Valley floor. The extent of competition among these species is unknown, but it is likely that differences in habitat use and foraging behavior allow their coexistence (Brode 1988, USFWS 1999).

Continued loss of wetland or other suitable habitat resulting from agricultural and urban development constitutes the greatest threat to this species' survival. The conversion of Central Valley wetlands for agriculture and urban uses has resulted in the loss of as much as 95% of historical habitat for the GGS (Wylie *et al.* 1997). In areas where GGS has adapted to agriculture, maintenance activities such as vegetation and rodent control, bankside grading or dredging, and discharge of contaminants may also threaten their survival (Hansen and Brode 1980, Brode and Hansen 1982, Hansen and Brode 1993, USFWS 1999, Wylie *et al.* 2004). In developed areas, threats of vehicular mortality are also increased.

Project Area Description and History

Overview

Access for this study included Mendota Wildlife Area (MWA), the San Luis National Wildlife Refuge complex (SNLNWR), the consortium of privately owned properties situated within Grasslands RCD, the Merced National Wildlife Refuge complex (MNWR), the privately owned Modesto Properties situated west of MNWR's Snobird Unit south of Highway 140, and the core of Stevinson Water District along with its associated rights-of-way along the East Side Canal corridor (Figures 1 and 2).

SNLNWR lies south of the San Joaquin River, encompassing wetlands east and west of Highway 165 south to the City of Los Banos. Grasslands RCD lies to the west of SNLNWR, extending from Highway 140 south to the Merced/Fresno County line (Figure 3). Encompassing privately managed lands adjacent to SNLNWR through the Los Banos Creek and Santa Fe Grade corridor, North Grassland Water District (GWD) extends to Highway 152 in the City of Los Banos. South GWD continues through the Santa Fe Grade corridor south of Highway 152.

The Stevinson and Merquin Water Districts are located on the Stevinson and Gustine U.S. Geological Survey 7.5-Minute topographic quadrangles, east of the confluence of the Merced and San Joaquin Rivers in Merced County, California (Figures 1-4). The East Side Canal bisects these quadrangles passing from east to west through the Districts. The Big Bottom Lake region lies upon the southern portion of the Gustine Quadrangle at the northern edge of the San Joaquin River (Figures 1-3). The East Side Canal corridor extends southeast from SMWD through the Arena Plains and Snobird Units of the Merced National Wildlife Refuge Complex (MNWR) to the Mariposa Bypass, East Side Bypass, and Merced Unit of the MNWR (Figure 4). Intersecting the East Side Canal in this reach are Bear Creek and Atwater Drain.

Prior to the outset of the study in 2006, efforts were made to establish access to the expansive lands managed by California Department of Fish and Game (DFG) in the Los Banos area. Access to DFG lands within Merced County (e.g., Volta Wildlife Area, Los Banos Wildlife Area) was not granted. Access to MWA in Fresno County was eventually obtained during the fourth week of July, well after the spring peak in giant garter snake activity. MWA is depicted entirely within the Tranquility Quadrangle, approximately 3 miles south of the town of Mendota near White's Bridge, immediately south of Alkali Sink Ecological Reserve approximately ten miles west of the town of Kerman. Encompassing lands both east and west of Fresno Slough, part of the area's western boundary falls along Santa Fe Grade Road. The area includes all or part of Sections 9, 10, 11, 13, 14, 15, 16, 20, 21, 22, 23, 24, 25, 26, 27, 28, 33, 34, 35, and 36, in Township 14 South, Range 15 East; and all or part of Sections 18, 19 and 30, in Township 14 South, Range 16 East, Mount Diablo baseline and meridian.

Stevinson and Merquin Water Districts

The Stevinson Water District provides water to 7,560 acres of irrigated land within its service area and 1,340 acres of neighboring land. Stevinson Water District also delivers surface water to the Merquin County Water District, pursuant to contractual obligations, to serve 6,000 acres of agricultural land. In the combined districts, water is distributed through approximately 66,900 feet of open ditch laterals.

At the southern edge of the Stevinson and Merquin water Districts (SMWD), Big Bottom Lake was created in the 1960s to contain agricultural drain water and now provides shallow open water habitat for waterfowl and other aquatic species. Turner Slough, which contained flowing water during 2006 and reportedly flows year round (R. Kelley, *pers. comm.*), supports dense patches of cattail (*Typha* sp.) and bulrush (*Scirpus* sp.) and scattered willows and cottonwoods overhanging its banks. The lower Borges area, adjacent to Big Bottom Lake, is choked with cattail and contains only isolated patches of standing water. Water is pumped into the lower Borges area from Big Bottom Lake for storm water storage; it also serves as a groundwater percolation basin.

Habitat within the Drainage Management Area resembles that of a perennial marsh, meeting all criteria associated with the biological needs of GGS. The wetlands are characterized by sinuous open-water channels and pools interspersed with dense patches of emergent vegetation dominated by cattail and bulrush. Established populations of aquatic prey species, including bullfrogs, sunfish, and mosquitofish are present in densities comparable to those observed throughout the range of GGS. Upland habitat is characterized by a mixture of grassland and ruderal vegetation accompanied by stands of cottonwood and willow that are also scattered throughout the wetlands. Topography is variable, providing ample high ground for overwintering GGS.

Merced National Wildlife Refuge Complex

Merced NWR totals 10,228 acres, including the 2,464-acre Arena Plains Unit and 1,904-acre Snobird Unit. Programs regulating activities such as grazing, burning, and farming are in place for managing avian species as well as the native grasslands and associated wildflower fields. Water piped belowground from the Merced Irrigation District provides 15,000 acre feet of water to refuge wetlands annually.

Acquired in June of 1992, the Arena Plains Unit of the Merced NWR consists of 2,464 acres south of Highway 140 and contains the San Joaquin Valley's largest block of undisturbed sand dunes, perched wetlands, and vernal pool habitat. Backing up to the East Side Canal at its southern end, Arena Plains supports a mosaic of seasonal, perennial, and permanent wetlands and is bisected in part by Atwater Drain. Light grazing is applied by special permit to manage vegetation.

Southwest and contiguous with Arena Plains, the Snobird Unit of the Merced consists of 1,904 acres acquired in February of 2004. Extending south from the edge of the East Side Canal, Snobird includes the terminus of Atwater Drain and is bisected by Bear Creek and Deep Slough. Federal managers are awaiting a final assessment of the property's infrastructure and surface water is not currently applied (R. Albers, *pers. comm.*).

San Luis National Wildlife Refuge Complex

This 26,609-acre refuge is a mixture of managed seasonal and permanent wetlands, riparian habitat associated with 3 major watercourses, and native grasslands/alkali sinks/vernal pools. The refuge is primarily managed to provide habitats for migratory and wintering birds.

The Refuge is a remnant of San Joaquin bottomland/floodplain habitat. Marsh basins and riparian channels are natural in topography, but must be artificially flooded by distributing 30,000 acre-feet of CVPIA water supplies.

The Kesterson Unit of San Luis NWR consists of 10,621 acres and is located 4 miles east of Gustine and approximately 18 miles north of Los Banos in Merced County, California. It is a mixture of seasonal and permanent wetlands, riparian habitat associated with 3 watercourses, native grasslands, and vernal pools. Originally established in July 1970 as Kesterson NWR, the unit now consists of the original Kesterson Unit, the newly acquired adjacent Freitas Ranch, and the Blue Goose property.

The original 5,700-acre unit was originally developed by U.S. Bureau of Reclamation (USBR) as a series of holding ponds (approximately 1,283 acres) known as Kesterson Reservoir for agricultural drain water which had been transported via the San Luis Drain. The delivery of the selenium-laden drain water from San Luis Drain officially ceased on June 9, 1986. Portions of the ponds were filled with 18" of clean, off-site dirt in 1988 to reduce wildlife exposure to selenium contamination.

The Kesterson Unit of San Luis NWR is within the historic floodplain of the San Joaquin River. The lands consist of native grasslands, wetlands, riparian habitat, and vernal pool and floodplain habitat. The Kesterson Unit is bisected by Mud Slough.

Grassland Water District and Grasslands RCD

Formed under Section 34000 of the State Water Code, the Grassland Water District (GWD) comprises approximately 51,537 acres of primarily wetland habitat. The District maintains approximately 110 miles of canals in order to execute its primary function of delivering water to the landowners within its boundaries.

The approximately 75,000-acre Grasslands RCD comprises private hunting clubs and other privately owned wetland areas, as well as all or portions of several state and federal refuges (such as Kesterson NWR, Volta WA, Los Banos WA, Freitas Unit, Salt Slough Unit, Blue Goose Unit, Gadwall Unit). To achieve a goal of sustaining waterfowl habitat, the management objectives of the Grassland RCD include encouraging natural food plant production (such as swamp timothy, smartweed, and wildlife millet) and habitat protection. Land uses include seasonally flooded wetlands, moist soil impoundments, permanent wetland, irrigated pasture, and croplands.

The Grassland RCD contains most of the 51,530-acre GWD, which is a legal entity established to receive and distribute CVP water. GWD delivers CVP water to the wetland areas within its boundaries. GWD contains approximately 165 separate ownerships, most of which are hunting or duck clubs. Perpetual easements have been purchased by the Service to help preserve wetland-dependant migratory bird habitat on approximately 31,000 acres serviced by the GWD.

Mendota Wildlife Area

Acquired by the Wildlife Conservation Board from 1954 to 1991, the approximately 11,802-acre MWA comprises intensively-managed, semi-permanent wetlands and associated uplands surrounding a 600-acre segment of the Fresno Slough, a natural drainage providing both a source of water and a riparian corridor. MWA is managed primarily as seasonally flooded wetland to provide the habitat needs of migratory waterfowl and associated species, with approximately 9,800 acres of the area managed as seasonally flooded wetlands. In addition to riparian corridor and wetland acreage, several hundred acres of upland and alkali sink habitat are maintained for upland species as well as threatened or endangered species*.* Primary plant communities and habitat types are seasonally flooded freshwater emergent wetland, valley foothill riparian and, to a lesser extent, alkali sink scrub. The geologic history of the area is that of a typical floodplain, characterized by fine textured clays. Water table levels are generally high, drainage is poor, and soil salinity is sufficiently high to restrict vegetation types. Precipitation averaging less than six inches per annum comes from winter rains.

A water conveyance infrastructure services the numerous ponds or wetlands. Surrounding lands are managed primarily for agricultural purposes; crops, such as tomatoes, cotton, alfalfa and sugar beets, are cultivated. Horses and sheep are pastured on some adjacent or nearby fields. Little surrounding land remains in a natural condition, with the notable exception of the 932-acre Alkali Sink Ecological Reserve, which is also managed by DFG.

Historical and Recent Species Occurrence within the Project Area

Extant GGS populations within the San Joaquin Valley are represented by three unique management areas; North and South Grasslands (Grasslands Ecological Area), Mendota Area, and the Lanare/Burrel Area (Tulare Lake Basin and Kern-Wasco Area populations are presumed extirpated, and observations of deteriorating habitat at Burrell-Lanare in 1992 led to the conclusion in the final listing that this population, if it was not already extirpated, was severely and imminently threatened [USFWS 1993].). With one exception (CNDDB # 144), all reported occurrences of GGS in the San Joaquin Valley originate south and west of the San Joaquin River where large wetland complexes remain (Figure 1). None are known from SMWD. The closest known occurrence of GGS (CNNDB #27) to the SMWD is in Kesterson National Wildlife Refuge (in Los Banos Creek approximately 0.5 mile north of Highway 140, 3 miles northeast of Gustine). This occurrence is approximately 3.8 miles southwest of the Big Bottom Lake and lower Borges area (collectively known by the SMWD as the Drainage Management Area). Other occurrences (#184 - south of Carnation Road, 1.5 miles east of Gustine, west of the sewage treatment facility; #135 - east of Gustine in vicinity of Los Banos Creek and Santa Fe Grade; and #26 – vicinity of Los Banos Creek and Gun Club Road) are within 5 miles of the southern boundary of SMWD.

Most of these locality records were established by George Hansen during a range-wide status and distribution survey conducted for DFG during 1976 and 1977. This study determined that GGS were potentially extirpated from wetland regions of Buena Vista and Tulare Lake basins near Bakersfield in Kern County that had been drained for agriculture. However, populations near Mendota and Los Banos were described as widespread, occurring in densities comparable to those found in the rice growing regions of the Sacramento Valley (G. Hansen and J. Brode 1980).

During a second status and distribution survey conducted from 1986-1987, George Hansen did not find GGS in areas where he had detected them ten years prior (G. Hansen 1988). Hansen found that although much of the available habitat had deteriorated significantly since the 1970's, suitable habitat remained throughout the region. Hansen speculated that GGS present along the railroad bed at the northern boundary of MWA in the 1970's may have suffered declines due to flooding which overtopped this winter refugium in 1985 (G. Hansen 1988). This did not account for declines observed throughout the Los Banos area.

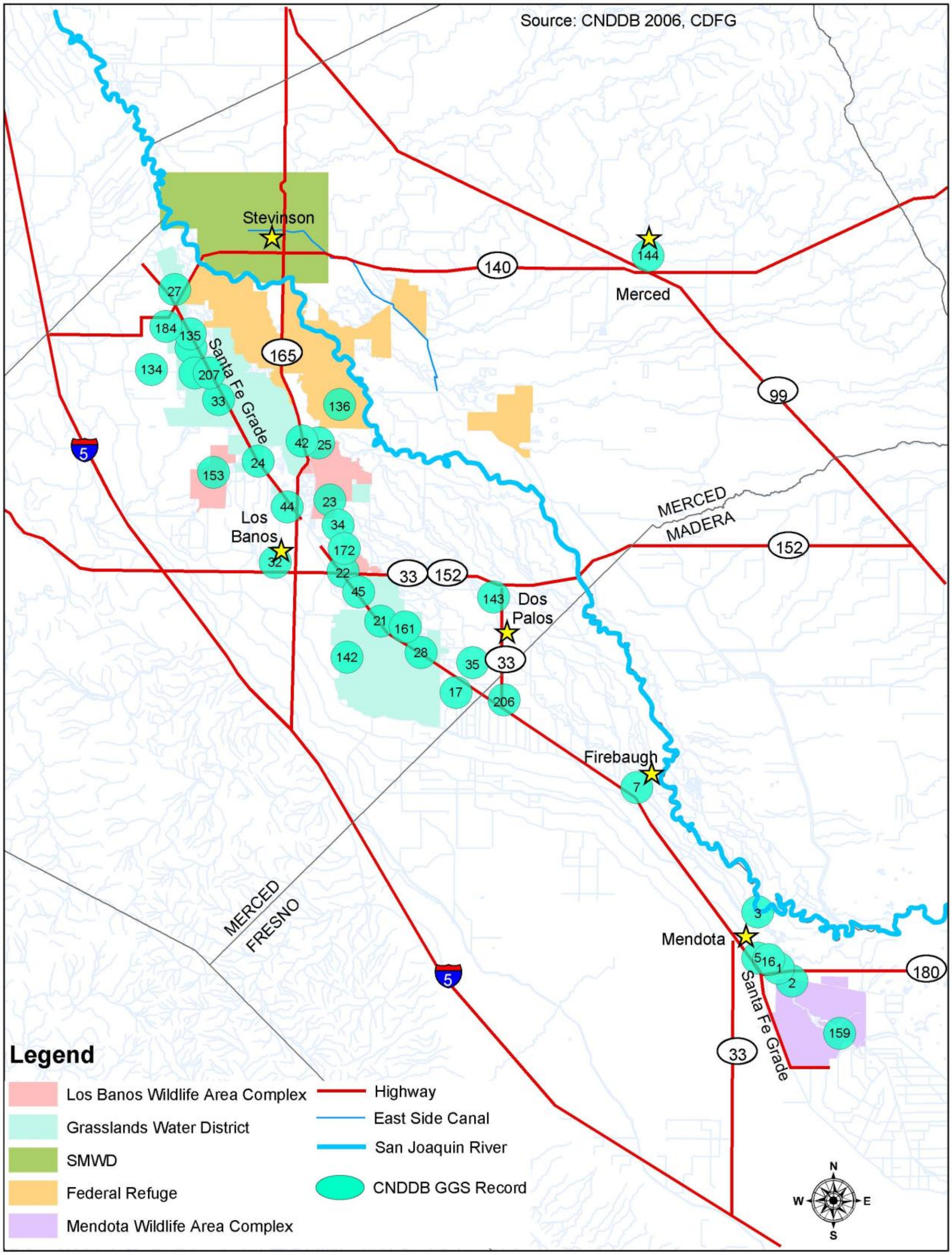
Due to the poor results of the 1986-1987 surveys, a study was engaged in 1995 to revisit all the locations shown to support the species during 1976-1977. With the exception of one road-killed individual at MWA and two potential GGS in South GWD that eluded capture, Hansen observed no GGS south of San Joaquin County (G. Hansen 1996). Hansen found that many or most of the sites established in the 1970's had deteriorated in quality and that many features were either maintained without water or without ample vegetative cover during the spring and summer GGS active season (G. Hansen 1996). Hansen noted that although many sites had deteriorated, suitable aquatic habitat was still present region-wide, leading him to observe that GGS appeared to have declined more rapidly and to a greater extent than had suitable habitat. This discordance suggests that factors other than habitat loss may contribute to the decline of GGS in SJV.

Extensive trapping was conducted by the U.S. Geological Survey and California Department of Fish and Game in the Grasslands Wetlands and Mendota Wildlife Areas of the San Joaquin Valley from 1999 through 2004. These surveys resulted in the capture and identification of 88 GGS over the five-year period (J. Sloan, pers. comm.). Thirty-one snakes were captured in 2003, with a reduction to13 snakes in 2004 (Dickert 2003, Sloan 2004). A parallel trapping effort conducted throughout the San Luis NWR complex during 2004 did not detect GGS (Williams *et al.* 2004). Trapping was conducted again by DFG in 2006 at Mud Slough and Volta, resulting in 7 GGS captured within the Volta Wasteway; none were captured at Mud Slough (DFG 2007).

Trapping efforts in Mendota were last engaged in 2001 (Dickert 2005). Of the five sites sampled, one produced 18 GGS captures (NDDB # 159) (Figure 1, Figure 2). No population estimates are available for this region and no tissue samples are available for genetic analyses.

The U.S. Geological Survey, in a cooperative study with the U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program, sampled for GGS within the species' historical range at Buena Vista, Fresno Slough, Kern Refuge, Kings River, and North Kings River during 2006. Though suitable habitats were found, GGS were not detected, thus supporting the previous supposition that GGS are likely extirpated south of Fresno.

Figure 1. Historical Distribution of Giant Garter Snakes in the Central San Joaquin Valley



METHODS and MATERIALS

Sampling

Sampling entailed a combination of visual encounter surveys and trapping methods to assess giant garter snake presence.

Visual encounter surveys were initiated following the snakes' emergence from winter refuge and continued throughout the spring portion of the active season. Beginning in May, we conducted visual encounter surveys by walking or kayaking along channels, wetlands, and nearby upland areas to search for basking and mating snakes. Primary searching areas included the vegetated banks of channels and drainages, marshland edges, and potential upland basking and refuge sites. We also checked beneath surface cover and debris, such as boards or trash, found near aquatic habitat. Extensive searches were also made for snakes while driving along the numerous paved and gravel roadways occurring throughout the aquatic habitat present within the study area. Visual encounter surveys were conducted incidental to all trap checking activities.

Floating modified minnow traps were placed along the edges of channels, streams, and associated marshland. Traps were not purposely baited, but captured numerous frogs, tadpoles, and fish that undoubtedly served as attractants to GGS. As many as 600 traps were deployed as 50-trap transects for minimum 14-day intervals between May 1 and September 8, when giant garter snakes are typically most active (G. Hansen and J. Brode 1993, E. Hansen 2004). GPS units were used to record the UTM coordinates of each unique trap location, and environmental characteristics, such as vegetation and substrate types, were noted for each point. Traplines were arranged with traps set at 10-meter (32.8-foot) intervals, resulting in traplines approximately 500 meters (1640 feet) long. Trap design and placement were modeled after methods refined by USGS (Casazza et al. 2000). All traps were checked daily.

Vertebrates within each trap, e.g., aquatic prey species, were tallied within all traps at 14-day intervals and, as with GGS, the totals were converted to an index of relative abundance based on the proportion of individuals captured per unit effort, i.e., individuals per trap day(s) (Table 7). Although totals may be impacted by intraguild predation occurring during the sampling period, impacts are expected to have been similar among sites. Because sampling at all sites entailed identical methods, preliminary comparisons of prey composition among sites and between regions (i.e., Sacramento Valley) are standardized, and are therefore expected to provide a reasonably accurate description of potential differences.

Concordant with efforts in 2006, a reference trapline was re-established where GGS were detected at the northern terminus of Mosquito Ditch (Figure 5). Reference traplines are by definition left in place throughout the snakes' active season, and are useful for several reasons. Permanent reference sites increase the probability of recapturing individuals through time, resulting in better estimates of survival and recruitment. Reference sites can also provide better information regarding species response to changing habitat conditions over time than do non-reference traplines, thereby developing information to inform the adaptive management process. Finally, reference sites provide information on seasonal variation in giant garter snake activity that short-term traplines cannot.

A second set of 25 traps was deployed in conjunction with permeable silt fencing placed in managed marsh habitats. Trapping in shallow wetlands can be ineffective without a well-defined interface between terrestrial or vegetative and open water habitats. The purpose of these traplines was to test the hypothesis that drift fences would improve capture success by providing a foraging boundary similar to the boundary present in linear water conveyance features. These traplines were set in areas of open or densely vegetated shallow (≤ 1.5 meters [4.9 feet]) water without a naturally occurring foraging boundary that would direct snakes toward the traps. The resulting *drift fence* traplines were arranged with traps set on alternating sides of the fencing material at 5-meter (16.5-foot) intervals.

Traps used for drift fence traplines were constructed of eight-mesh hardware cloth (64 squares per square inch) rather than the standard four-mesh hardware cloth (16 squares per square inch) typically used. Little is known of newborn or juvenile GGS due to their low visual detectability, their ability to pass through coarser four-mesh traps, and the inability to PIT tag those that are captured. Newborn GGS may also die after becoming ensnared in the larger mesh (Wylie *et al.* 2004). Because newborn giant garter snakes cannot pass through the smaller eight-mesh cloth, this material was selected in an effort to sample for this smaller size class and to reduce the risks of mortality associated with four-mesh traps. Traps used for rotating and reference traplines were made of standard four-mesh hardware cloth for the durability needed to withstand extended periods in water, frequent transport, and resetting.

Terrestrial trapping was considered in order to increase the likelihood of capture success in areas demonstrated to support GGS during 2006. Although preliminary monitoring of maximum and minimum temperatures indicated that terrestrial traps could be maintained within a tolerable range of temperatures, intensive bankside maintenance prevented their successful deployment.

Weight, total length, snout to vent length, sex, diagnostic scale measurements, and other physical features such as scars and tumors were noted for all snakes captured. Captured snakes were implanted with passive integrated transponder (PIT) tags for permanent identification. Tissue and/or blood was collected and archived for genetic analyses. All snakes were released at their point of capture after recording data.

Tissue was collected by clipping 1-2 scales from the terminal end of the tail using either surgical scissors or a scalpel. The tail was then sealed using surgical glue. Instruments were sterilized with hydrogen peroxide (H_2O_2) and isopropyl alcohol ($CH_3CHOHCH_3$) at the time of each use to prevent cross contamination. Tissue was stored in 70% ethanol (ETOH).

Specific conductivity (EC), pH, and water temperature were measured during the same time periods using a portable YSI 556 Multi-Probe unit.

Spatial Analysis

All spatial-data analysis, including the estimation of parcel area, trap line distance, and the preparation of all figures was accomplished using the Environmental Systems Research Institute, Inc. (ESRI) Geographic Information Systems program ArcMap Version 9.2.

Population Evaluation

The software program CAPTURE (White et al. 1978; White et al. 1982) was used to estimate population size in discrete habitat segments on the basis of capture histories of marked individuals. The statistical models used to estimate population size from mark/recapture data assume the population being sampled is a *closed* population; that is, that neither immigration nor emigration occurs during the sampling period. Clearly, water conveyance features are highly interconnected, not only to one another but also to the lands they serve. Giant garter snakes are highly mobile, and vary significantly in their activity over time and between years. Accordingly, the closed population assumption is violated, biasing population estimates to an unknown degree. In response, sampling has been organized in 2-week periods to to reduce the bias associated with violation of the closed population assumption by limiting the time available for immigration or emigration to occur.

RESULTS

Overview

Trapping began on May 1, 2007 and continued through September 8, 2007. Sixty four traplines were established with 48,762 trap days accrued, constituting an increase of 10,762 trap days over 2006 due largely to the expansion to Mendota Wildlife Area. All trapping occurred within Merced and Fresno counties; Madera County was not sampled. Four giant GGS were captured in all. Of these four GGS, one was captured twice, constituting a decrease from 33 capture events in 2006 to 5 capture events in 2007 despite the increase in trapping effort. Two of the four GGS captured in 2007 were marked previously in 2006. All GGS were encountered along the Los Banos Creek corridor between the San Joaquin River and the City of Los Banos. As during 2006, no GGS were encountered north of the San Joaquin River. Likewise, no GGS were encountered at Mendota Wildlife Area or elsewhere in Fresno County.

Regions North and East of the San Joaquin River

Twenty traplines were established north of the San Joaquin River where water quality is reportedly superior to that occurring within the Grasslands Ecological Area to the south (R. Kelley, pers. comm.) and where GGS surveys are not known to have occurred prior to 2006 (R. Kelley, pers. comm.; M. Owens, pers. comm.). Traplines were established within Stevinson Water District within the East Side Canal from Stevinson Ranch Golf Course/Lake Honda southeast to the Mariposa Bypass near Merced National Wildlife Refuge (MNWR). At MNWR's main unit, traplines were established encompassing drainages and wetlands both north and south of Sandy Mush Road. At MNWR's Arena Plains and Snobird units, traplines were established within Bear Creek, Atwater Drain, and within and along the East Side Canal. Two traplines were established in Drake Ditch, connecting the East Side Canal and Bear Creek at the privately owned Modesto Properties situated west of MNWR's Snobird Unit south of Highway 140. Although forty-seven valley garter snake (*Thamnophis sirtalis fitchi*) observations were recorded within regions north of the San Joaquin River (12 of 20 sites), GGS were not encountered. Because valley garter snakes were not marked to detect recaptures, the number of individuals is unknown. The majority of areas trapped appeared suitable for GGS, and all possessed water throughout the summer active season.

Figure 2. Overview of SJV Trapping Effort by USGS, USFWS and DFG from 1999 to 2004

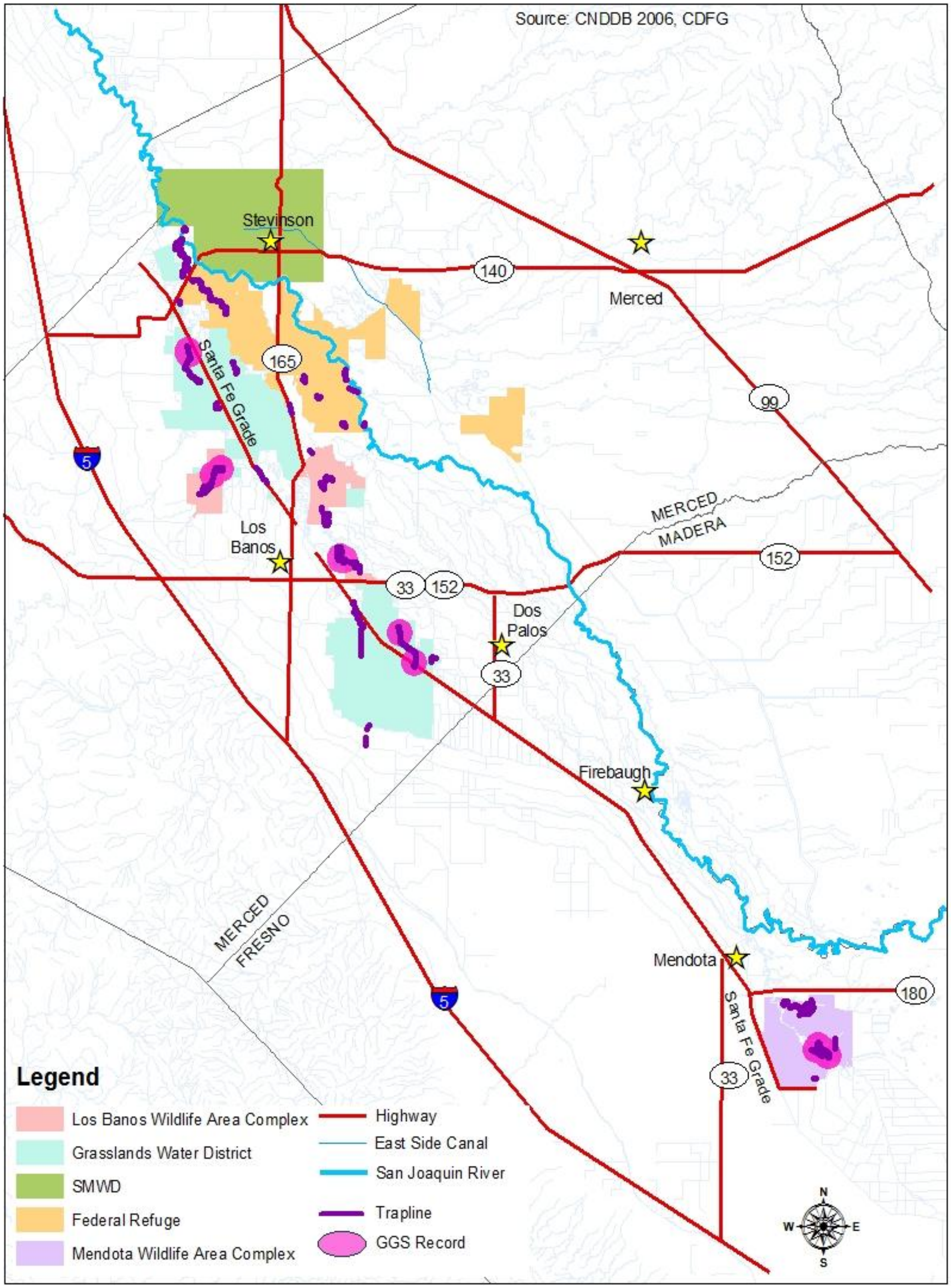


Figure 3. Overview of SJV Trapping Effort and Capture Results during 2006 and 2007

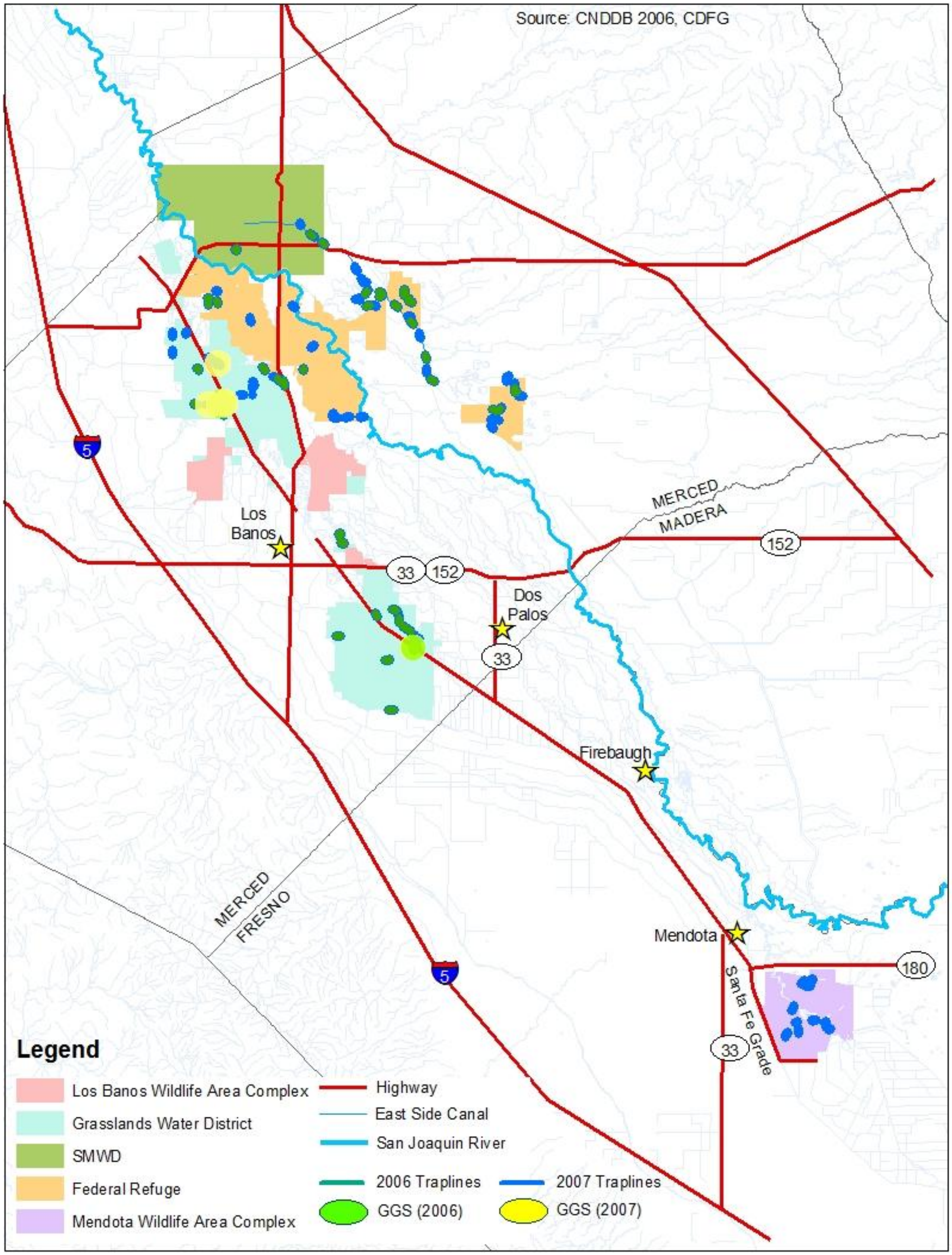
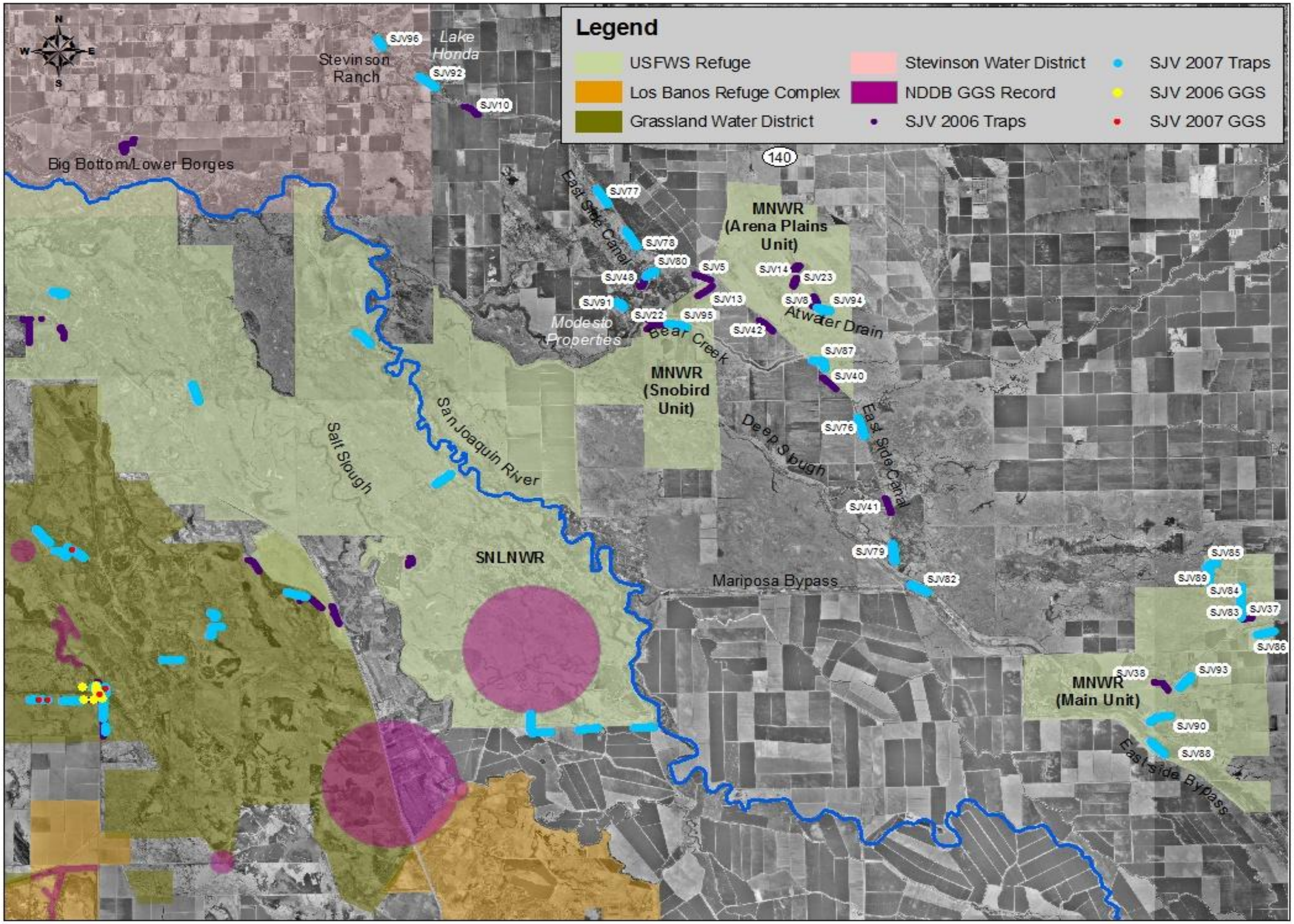


Figure 4. Trapping Effort and Capture Results North and East of the SJV River During 2006 and 2007



Regions South and West of the San Joaquin River

Thirty-one traplines were established south of the San Joaquin River at areas of historical giant garter snake occurrence along the Los Banos Creek and Santa Fe Grade corridors. Sampling was restricted to the San Luis National Wildlife Refuge complex (SNLNWR) and the consortium of privately owned properties situated within Grassland Water District (GWD). In South GWD (south of Highway 152), traplines were established in Poso Canal, Agatha Canal, and Bennett Drain. Within North GWD (north of Highway 152), traplines were established within West Side Ditch, Los Banos Creek, Mosquito Ditch (northern end of the Volta Waste Way), Salinas Service Ditch, Ingomar Drain, Hollister Drain, Eagle Ditch, and San Luis Spillway Ditch. The four giant garter snakes documented during 2007 were captured within the Salinas Service Ditch, Mosquito Ditch, Hollister Drain, and Eagle Ditch. Although one GGS was captured in south GWD a historically occupied locality at the junction of Agatha Canal and Poso Drain during 2006, none were captured in 2007. Traplines established within the San Luis, Blue Goose, Freitas, Kesterson, and West Bear Creek units of SNLNWR did not result in GGS encounters despite their proximity to historical occurrences.

Control sites were established during both years to assess GGS activity patterns over time. In 2006, a control site was established at the northern terminus of Mosquito Ditch, resulting in 30 captures among 7 individual snakes. Capture frequency was fairly regular throughout 2006 (Figure 3) and recaptures were sufficient to estimate the local population at 7 ± 0.4932 (95% C.I. not estimable). Re-established in 2007 and remaining in place from May 12th to August 10th, this same trapline produced only one recapture of a female GGS first marked the previous year. Visual encounter surveys were unproductive in both years, and, in a marked change from 2006, traps at this location remained practically devoid of prey species during the first several weeks of trapping in 2007.

Aquatic drift fences were also used during both years in an effort to improve capture success. At Mud Slough and at the junction of Los Banos Creek and Mosquito Ditch, aquatic drift fences were established in backwaters and areas of dense vegetation where standard trapping was impractical. Despite abundant vegetative cover and aquatic prey, and in the case of Mosquito Ditch, the immediate presence of GGS there and within adjacent features during 2006, none were captured in drift fence traplines. In comparison, drift fence transects deployed in the Sacramento Valley in 2006 resulted in as many as 15 captures of GGS per transect with an associated capture per unit effort ratio of 0.0052; conversely, drift fence transects deployed in the Sacramento Valley in 2007 resulted in 1 capture with an associated capture per unit effort ratio of 0.0007. Although no GGS were captured within the SJV drift fence array, adult and neonate valley garter snakes were. Thirty one valley garter snake captures were recorded within this region in all.

Regions South and West of the San Joaquin River

Thirteen traplines were established in Fresno County south of Highway 180 at Mendota Wildlife Area at areas of historical and recent giant garter snake occurrence at Hamburger Slough, the Tule Island segment of Fresno Slough, and within the series of the ditches and drains serving the area's seasonal wetlands. Because access to Mendota Wildlife Area was not granted until late in the sampling season, only 13 of the original 20 projected traplines were established. However, to increase the probability of capture success, four transects at Tule Island where DFG observed giant garter snakes in 2001 were left in place for two rotations (28+ days), accruing 12,376 trap days in all. Although seven captures of valley garter snakes were recorded, results for GGS remained negative.

Habitat Variables

Though consistent at most sites, prey densities decreased significantly within traps at the northern terminus of Mosquito Ditch, the control site where overall GGS captures decreased from 30 in 2006 to 1 in 2007. Though reasons for the decrease are not clear, unlike the abundant prey observed throughout the 2006 season, during 2007 traps remained almost entirely devoid of prey species (e.g., larval bullfrogs, small carp, mosquitofish) at the same location until late June, after which they rebounded significantly (associated water metrics are not available for comparison during this period). Compared by an index of catch per unit effort, pooled prey densities at this site during the second half of May, decreased from 0.05467 to 0.006825 from 2006 to 2007. Throughout the region south and west of the San Joaquin River, relative abundance decreased significantly from 2006 to 2007 ($p = 0.000965679$; $df = 60$) (Table 1). Relative abundance of prey did not change significantly in the region north of the San Joaquin River from 2006 to 2007 (Table 1) or differ significantly between regions within the same year (Table 2). Whether the apparent decrease in prey abundance in the region south of the San Joaquin River relates to the corresponding decrease in GGS observations is unknown, although preliminary analyses indicate no statistical correlation between prey abundance and GGS capture success (Table 3 and Table 4). For prey densities at the northern terminus of Mosquito Ditch, see SJV Transects 6, 17, and 60 in Table 7.

Water metrics were measured at locations throughout regions north of the SJ River (Stevinson-Merquin Water District), south of the SJ River, (Grassland Water District) and south at Mendota Wildlife Area, resulting in 72 sampling events from 2006 to 2007. The mean ($\bar{x}$) and range (R) for pH in each of these regions was $\bar{x}$=8.13, R=7.50 to 9.41; $\bar{x}$=8.09, R=7.63 to 9.07; and $\bar{x}$=8.28, R=8.03 to 8.63, respectively. The mean and range for specific conductivity (EC) (mS/cm at 25°C) in each region was $\bar{x}$=0.252, R=0.119 to 2.166; $\bar{x}$=0.878, R=0.333 to 2.253; and $\bar{x}$=0.925, R=0.847 to 0.984, respectively (Table 8). In comparison, the California Regional Water Quality Control Board's stated water quality objectives for the SJ River from Friant Dam to Mendota Pool list pH values between 6.5 and 8.5 and EC≤150 microhmos/cm at 25°C (0.150 mS/cm at 25°C) (1998). While information is generally lacking on suitable pH and salinity ranges for GGS prey species, a cursory review of the literature indicates a pH below 5 as either harmful or lethal to a number of amphibian species (Al-Aqtum 1999; Dale *et al*. 1985; Glos *et al*. 2003). Likewise, salinity levels above 4.5‰ (7.03 mS/cm EC at 25°C) are considered unsuitable for the California red-legged frog (Jennings and Hayes 1994); though poorly documented, ranges for other Ranid frogs (e.g., *Rana catesbeiana*) are probably similar. Tolerance ranges to salinity and pH for GGS are unknown.

Pair-wise analyses (2-sample t-test) of EC and pH were conducted to assess potential differences between years and between regions (see Tables 9 through 13). The only significant change in pH occurred within North GWD between 2006 and 2007 (p = 0.014545129; df= 36), where mean pH decreased (Table 10). The only significant difference in EC (and, by inference, salinity) occurred between sites north of the SJ River and sites to the south, which is concordant with the established assertion that water north of the SJ River possesses fewer salts (Table 12 and Table 13). Temporal trends in intra-season water metrics were not analyzed. The impacts of pH and EC on GGS distribution and abundance remain unclear.

Table 1: Statistical analysis of SJV prey density within regions in 2006 and 2007 (**H_o:** mean value of prey density in 2006 equals the mean value of prey density in 2007)

SJV prey density south of SJ River 2006-2007
t-Test: Two-Sample Assuming Equal Variances

	2006	*2007*
Mean	0.236767113	0.076478344
Variance	0.066016188	0.01291916
Observations	29	33
Pooled Variance	0.037697773	
Hypothesized Mean Difference	0	
df	60	
t Stat	3.243436281	
P(T<=t) one-tail	0.000965679	
t Critical one-tail	1.670648865	
P(T<=t) two-tail	0.001931358	
t Critical two-tail	2.000297804	

SJV prey density north of SJ River 2006-2007
t-Test: Two-Sample Assuming Equal Variances

	2006	*2007*
Mean	0.096352941	0.110793467
Variance	0.03815394	0.0259743
Observations	17	20
Pooled Variance	0.031542136	
Hypothesized Mean Difference	0	
df	35	
t Stat	-0.246476805	
P(T<=t) one-tail	0.403376527	
t Critical one-tail	1.68957244	
P(T<=t) two-tail	0.806753055	
t Critical two-tail	2.030107915	

Table 2: Statistical analysis of respective SJV prey density by region (**H_0:** mean value of prey density in one region equals the mean value of prey density in another region)

SJV respective prey density 2006
t-Test: Two-Sample Assuming Equal Variances

	North	*South*
Mean	0.096352941	0.236767113
Variance	0.03815394	0.066016188
Observations	17	29
Pooled Variance	0.055884461	
Hypothesized Mean Difference	0	
df	44	
t Stat	-1.944508983	
P(T<=t) one-tail	0.029121953	
t Critical one-tail	1.680229977	
P(T<=t) two-tail	0.058243906	
t Critical two-tail	2.015367547	

SJV respective prey density 2007
t-Test: Two-Sample Assuming Equal Variances

	North	*South*
Mean	0.110793467	0.076478344
Variance	0.0259743	0.01291916
Observations	20	33
Pooled Variance	0.01778284	
Hypothesized Mean Difference	0	
df	51	
t Stat	0.90806938	
P(T<=t) one-tail	0.184056329	
t Critical one-tail	1.675284951	
P(T<=t) two-tail	0.368112658	
t Critical two-tail	2.007583728	

Table 2 (cont.): Statistical analysis of respective SJV prey density by region (**H_o:** mean value of prey density in one region equals the mean value of prey density in another region)

SJV respective prey density 2007
t-Test: Two-Sample Assuming Equal Variances

	MWA	*North*
Mean	0.043276619	0.110793467
Variance	0.001284635	0.0259743
Observations	13	20
Pooled Variance	0.016417011	
Hypothesized Mean Difference	0	
df	31	
t Stat	-1.479090742	
P(T<=t) one-tail	0.074603406	
t Critical one-tail	1.695518742	
P(T<=t) two-tail	0.149206811	
t Critical two-tail	2.039513438	

SJV respective prey density 2007
t-Test: Two-Sample Assuming Equal Variances

	MWA	*South*
Mean	0.043276619	0.076478344
Variance	0.001284635	0.01291916
Observations	13	33
Pooled Variance	0.009746108	
Hypothesized Mean Difference	0	
df	44	
t Stat	-1.027057507	
P(T<=t) one-tail	0.155003346	
t Critical one-tail	1.680229977	
P(T<=t) two-tail	0.310006692	
t Critical two-tail	2.015367547	

Table 3: Statistical analysis of respective prey density in successful traplines and unsuccessful traplines south of the San Joaquin River (**H_0:** mean value of prey density in successful traplines equals the mean value of prey density in unsuccessful traplines)

South of SJ River respective prey density 2006
t-Test: Two-Sample Assuming Equal Variances

	Successful Traplines	*Unsuccessful Traplines*
Mean	0.054537815	0.265923801
Variance	0.001970275	0.070352481
Observations	4	25
Pooled Variance	0.062754458	
Hypothesized Mean Difference	0	
df	27	
t Stat	-1.566949139	
P(T<=t) one-tail	0.064386568	
t Critical one-tail	1.703288423	
P(T<=t) two-tail	0.128773137	
t Critical two-tail	2.051830493	

South of SJ River respective prey density 2007
t-Test: Two-Sample Assuming Equal Variances

	Successful Traplines	*Unsuccessful Traplines*
Mean	0.024920635	0.081634115
Variance	0.000105291	0.013945879
Observations	3	30
Pooled Variance	0.013052938	
Hypothesized Mean Difference	0	
df	31	
t Stat	-0.819778347	
P(T<=t) one-tail	0.209300551	
t Critical one-tail	1.695518742	
P(T<=t) two-tail	0.418601103	
t Critical two-tail	2.039513438	

Table 4: Statistical analysis of prey density in the Natomas Basin (Sacramento County) and the San Joaquin Valley (pooled amongst regions) (**H_0:** mean value of prey density in the Natomas Basin equals the mean value of prey density in the San Joaquin Valley)

Pooled prey density 2006
t-Test: Two-Sample Assuming Equal Variances

	Natomas Basin	*SJV*
Mean	0.042786389	0.184874919
Variance	0.005912211	0.059338264
Observations	69	46
Pooled Variance	0.027188073	
Hypothesized Mean Difference	0	
df	113	
t Stat	-4.527144453	
P(T<=t) one-tail	7.44161E-06	
t Critical one-tail	1.658450217	
P(T<=t) two-tail	1.48832E-05	
t Critical two-tail	1.981180296	

Pooled prey density 2007
t-Test: Two-Sample Assuming Equal Variances

	Natomas Basin	*SJV*
Mean	0.057573633	0.080337132
Variance	0.008715774	0.014757521
Observations	74	66
Pooled Variance	0.011561525	
Hypothesized Mean Difference	0	
df	138	
t Stat	-1.250418161	
P(T<=t) one-tail	0.106631462	
t Critical one-tail	1.655970383	
P(T<=t) two-tail	0.213262923	
t Critical two-tail	1.977303512	

Figure 5. Trapping Effort and Capture Results in North GWD) 2006-2007

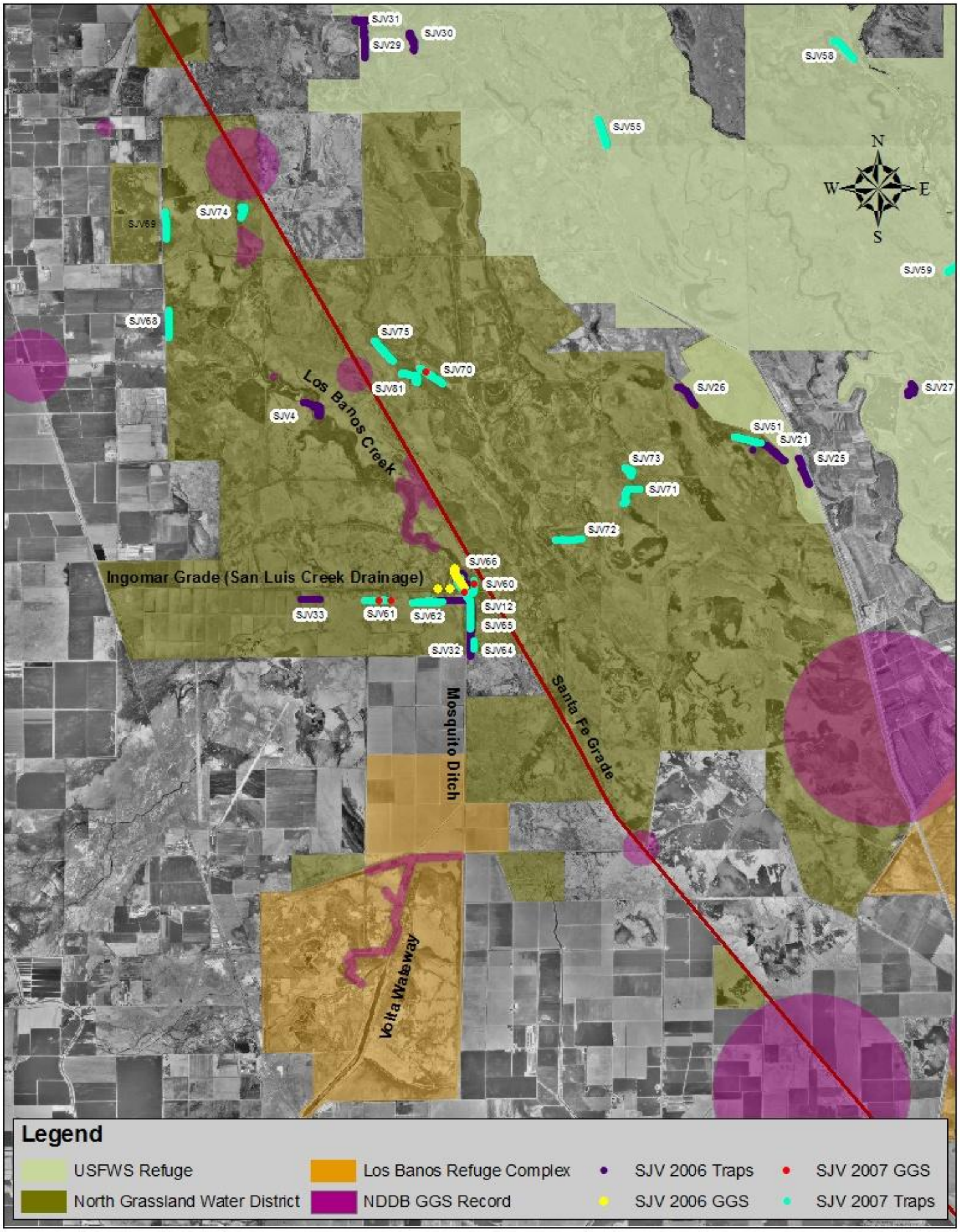


Figure 6. Trapping Effort and Capture Results in Mendota Wildlife Area in 2007

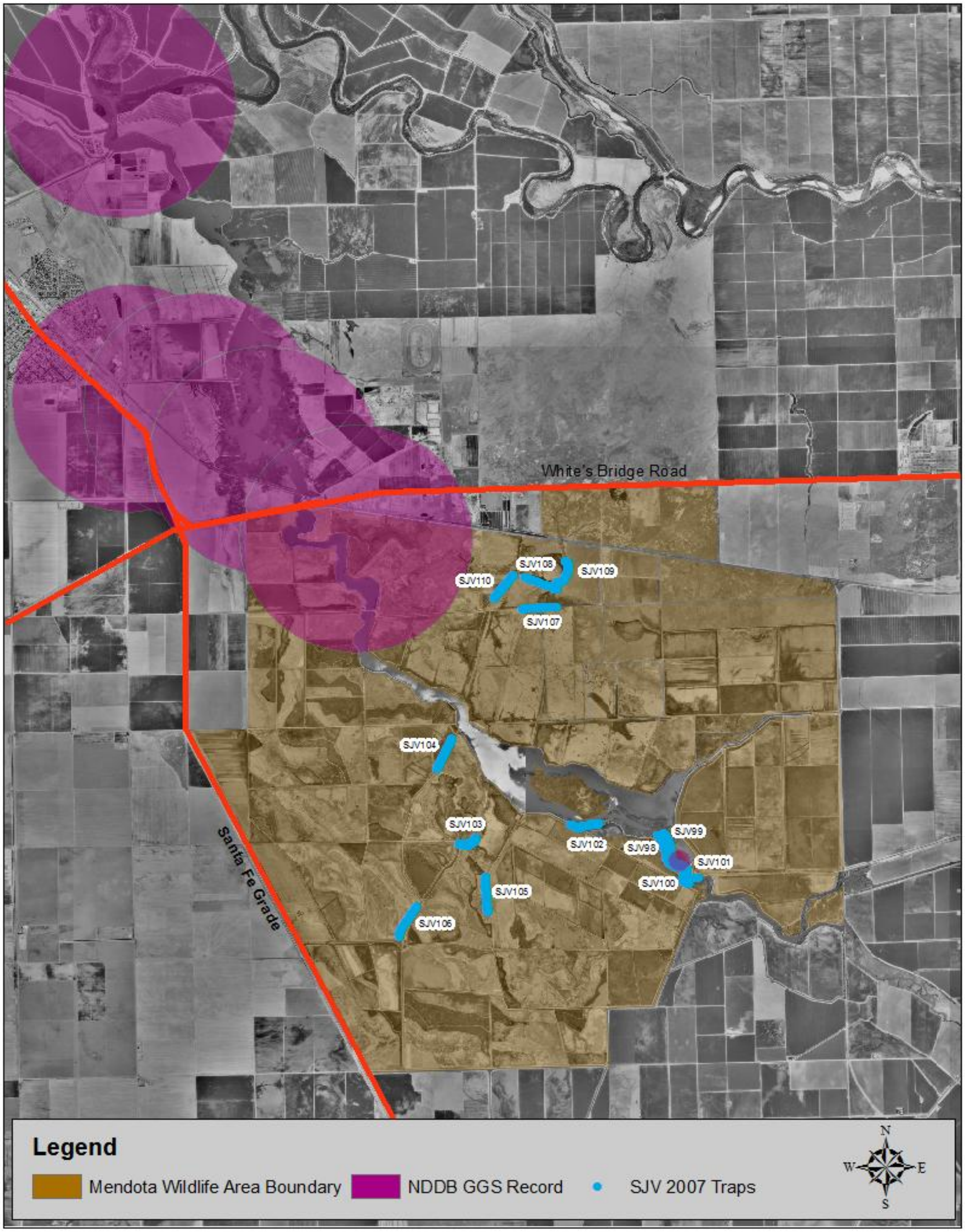


Figure 7. **Pooled Length Frequency Distribution of SJV Giant Garter Snake Capture Events during 2006 and 2007**

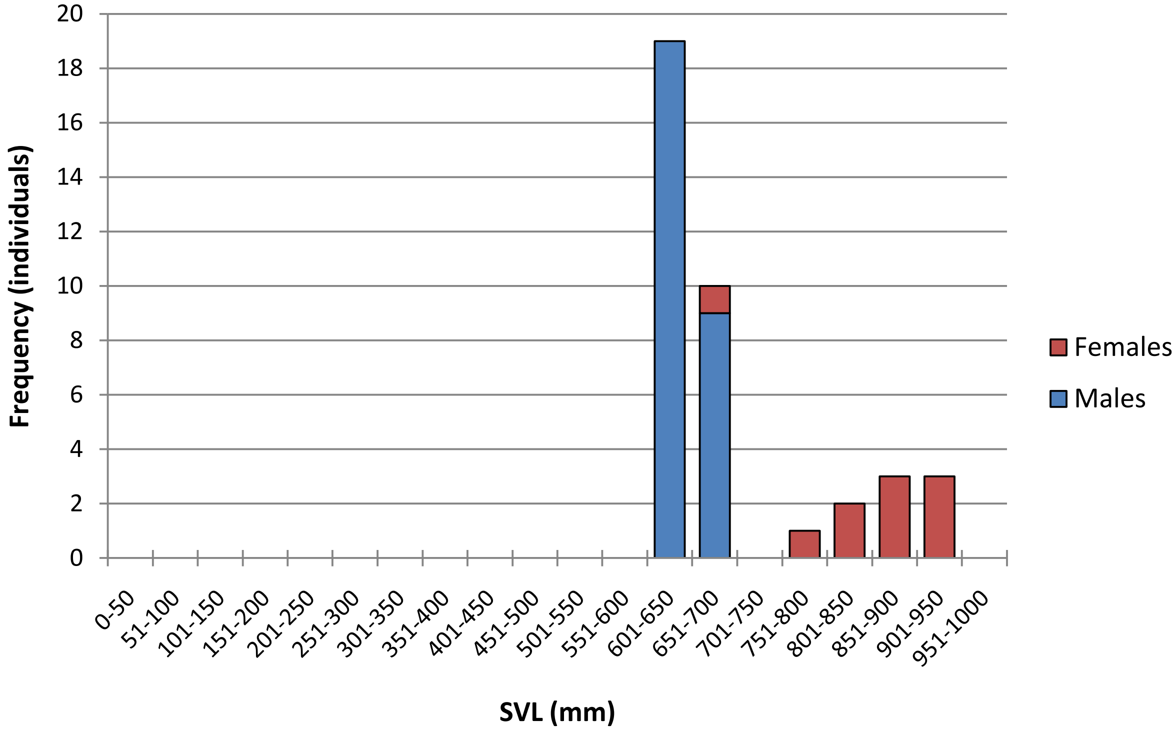
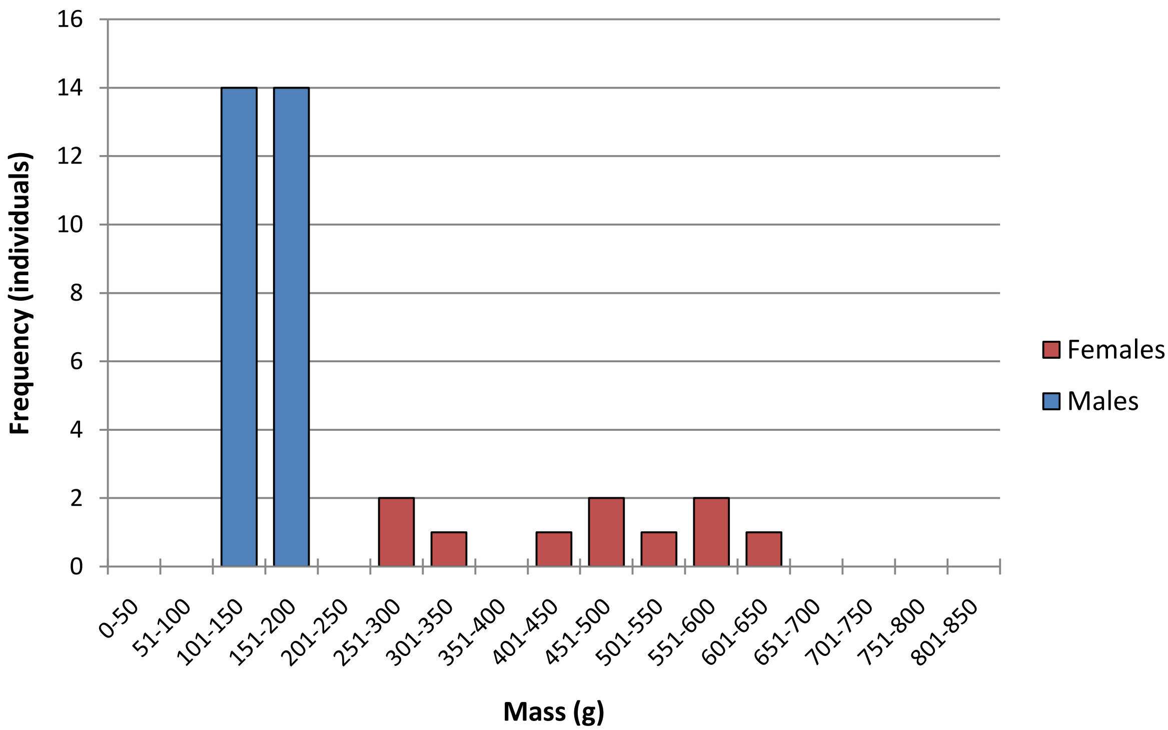


Figure 8. **Pooled Mass Frequency Distribution of SJV Giant Garter Snake Capture Events during 2006 and 2007**



Of the eight GGS captured in 2006, five were male and three were female (M:F gender ratio of 2.5:1 in North GWD, 1.67:1 overall). All were large, sexually mature adults, with females averaging 365.7 grams and 790 millimeters snout-to-vent length (SVL) and males averaging 133 grams and 647.4 SVL. In a pattern typical of declining or senescing populations, no young were observed, and, unlike snakes observed in the Sacramento Valley during the same time, females were not perceptibly gravid (E. Hansen, unpublished data). Though all snakes displayed the lumps caused by the parasitic nematode infection now associated with this species throughout its range, each appeared otherwise healthy and robust.

Of the four giant garter snakes captured in 2007, two were male and two were female (M:F gender ratio of 1:1). Consistent with those observed in 2006, all were large, sexually mature adults, with females averaging 540.7 grams and 941.7 millimeters snout-to-vent length (SVL) and males averaging 130.5 grams and 647.4 SVL. Two of these individuals – one male and one female – were originally captured and PIT tagged in 2006. Though not verified by sonogram or radiograph, at least one female captured during 2007 appeared gravid.

Table 5: Statistical attributes of San Joaquin Valley giant garter snake size parameters in 2006 and 2007

2006-7 SJV Male GGS SVL	
Mean	649.5357143
Standard Error	2.907062256
Median	645
Standard Deviation	15.38272755
Sample Variance	236.6283069
Skewness	0.913444816
Range	57
Minimum	628
Maximum	685
Sum	18187
Count	28
Confidence Level (95.0%)	5.964798982

2006-7 SJV Female GGS SVL	
Mean	857.1
Standard Error	26.27565413
Median	892.5
Standard Deviation	83.09091406
Sample Variance	6904.1
Skewness	-0.977054242
Range	260
Minimum	685
Maximum	945
Sum	8571
Count	10
Confidence Level (95.0%)	59.43965908

2006-7 SJV Male GGS Mass	
Mean	147.9285714
Standard Error	3.335685111
Median	150
Standard Deviation	17.65078651
Sample Variance	311.5502646
Skewness	-0.71083711
Range	64
Minimum	107
Maximum	171
Sum	4142
Count	28
Confidence Level (95.0%)	6.844260427

2006-7 SJV Female GGS Mass	
Mean	454.4
Standard Error	36.99675661
Median	465.5
Standard Deviation	116.9940169
Sample Variance	13687.6
Skewness	-0.144146151
Range	312
Minimum	297
Maximum	609
Sum	4544
Count	10
Confidence Level (95.0%)	83.6924778

Table 6: Sampling effort and capture results

North of SJ River								
	Transect	**Traps**	**Days**	**Trap Days**	**Total Captures**	**Captures/ Trap Day**	**Total Individuals***	**Individuals/ Trap Day**
2006	SJV2	50	14	700	0	0	0	0
	SJV5	50	15	750	0	0	0	0
	SJV7	50	15	750	0	0	0	0
	SJV8	50	2	100	0	0	0	0
	SJV10	50	15	750	0	0	0	0
	SJV13	50	14	700	0	0	0	0
	SJV14	50	15	750	0	0	0	0
	SJV19	50	14	700	0	0	0	0
	SJV22	50	15	750	0	0	0	0
	SJV23	50	15	750	0	0	0	0
	SJV24	50	8	400	0	0	0	0
	SJV37	50	15	750	0	0	0	0
	SJV38	50	8	160	0	0	0	0
	SJV39	50	15	750	0	0	0	0
	SJV40	50	15	750	0	0	0	0
	SJV41	50	15	750	0	0	0	0
	SJV42	50	15	750	0	0	0	0
	SJV45	50	14	700	0	0	0	0
	SJV46	50	15	750	0	0	0	0
	SJV48	50	14	700	0	0	0	0

Table 6: Sampling effort and capture results (continued)

North of SJ River (continued)								
	Transect	**Traps**	**Days**	**Trap Days**	**Total Captures**	**Captures/ Trap Day**	**Total Individuals***	**Individuals/ Trap Day**
2007	SJV76	50	14	700	0	0	0	0
	SJV77	50	14	700	0	0	0	0
	SJV78	50	14	700	0	0	0	0
	SJV79	50	14	700	0	0	0	0
	SJV80	50	15	750	0	0	0	0
	SJV82	50	14	666	0	0	0	0
	SJV83	50	14	699	0	0	0	0
	SJV84	50	1	50	0	0	0	0
	SJV85	50	13	650	0	0	0	0
	SJV86	50	14	697	0	0	0	0
	SJV87	50	14	700	0	0	0	0
	SJV88	50	14	700	0	0	0	0
	SJV89	50	14	700	0	0	0	0
	SJV90	50	14	697	0	0	0	0
	SJV91	50	14	700	0	0	0	0
	SJV92	50	14	700	0	0	0	0
	SJV93	50	14	700	0	0	0	0
	SJV94	50	14	700	0	0	0	0
	SJV95	50	14	625	0	0	0	0
	SJV96	25	10	245	0	0	0	0

Table 6: Sampling effort and capture results (continued)

South of SJ River

	Transect	Traps	Days	Trap Days	Total Captures	Captures/ Trap Day	Total Individuals*	Individuals/ Trap Day
2006	SJV1	50	15	750	0	0	0	0
	SJV3	50	15	750	1	0.0013	1	0.0013
	SJV4	50	15	750	0	0	0	0
	SJV6	50	15	750	7	0.0093	3	0.0040
	SJV9	50	15	750	0	0	0	0
	SJV11	49	15	735	0	0	0	0
	SJV12	50	14	700	2	0.0029	2*	0.0029
	SJV15	50	5	250	0	0	0	0
	SJV16	50	15	750	0	0	0	0
	SJV17	50	68	3400	23	0.0068	7	0.0021
	SJV18	50	29	1450	0	0	0	0
	SJV20	50	7	350	0	0	0	0
	SJV21	50	15	750	0	0	0	0
	SJV25	50	2	100	0	0	0	0
	SJV26	50	15	750	0	0	0	0
	SJV27	50	14	700	0	0	0	0
	SJV28	50	14	700	0	0	0	0
	SJV29	50	14	700	0	0	0	0
	SJV30	50	14	700	0	0	0	0
	SJV31	50	15	750	0	0	0	0
	SJV32	50	15	750	0	0	0	0
	SJV33	50	15	750	0	0	0	0
	SJV34	50	14	700	0	0	0	0

Table 6: Sampling effort and capture results (continued)

South of SJ River (continued)

Year	Transect	Traps	Days	Trap Days	Total Captures	Captures/ Trap Day	Total Individuals*	Individuals/ Trap Day
2006 (continued)	SJV35	50	14	700	0	0	0	0
	SJV36	50	15	750	0	0	0	0
	SJV43	50	15	750	0	0	0	0
	SJV44	50	15	750	0	0	0	0
	SJV47	25	28	700	0	0	0	0
	SJV49	25	13	325	0	0	0	0
	SJV50	50	2	100	0	0	0	0
2007	SJV51	50	14	700	0	0	0	0
	SJV52	50	14	700	0	0	0	0
	SJV53	50	19	950	0	0	0	0
	SJV54	50	14	700	0	0	0	0
	SJV55	50	14	700	0	0	0	0
	SJV56	50	9	450	0	0	0	0
	SJV57	50	14	700	0	0	0	0
	SJV58	50	14	700	0	0	0	0
	SJV59	50	14	700	0	0	0	0
	SJV60	50	92	3720	1	0.0003	1	0.0003
	SJV61	50	15	750	2	0.0027	2	0.0027
	SJV62	50	15	750	0	0	0	0
	SJV63	25	35	818	0	0	0	0
	SJV64	50	14	700	1	0.0014	1	0.0014
	SJV65	50	14	700	0	0	0	0
	SJV66	50	14	700	0	0	0	0
	SJV67	50	14	700	0	0	0	0

Table 6: Sampling effort and capture results (continued)

South of SJ River (continued)								
	Transect	Traps	Days	Trap Days	Total Captures	Captures/ Trap Day	Total Individuals*	Individuals/ Trap Day
2007 (continued)	SJV68	50	6	300	0	0	0	0
	SJV69	50	14	700	0	0	0	0
	SJV70	50	14	700	1	0.0014	1	0.0014
	SJV71	50	14	700	0	0	0	0
	SJV72	50	14	700	0	0	0	0
	SJV73	50	14	700	0	0	0	0
	SJV74	50	14	620	0	0	0	0
	SJV75	50	14	700	0	0	0	0
	SJV81	50	13	640	0	0	0	0
	SJV97	50	14	628	0	0	0	0
	SJV111	50	7	349	0	0	0	0
	SJV112	50	7	332	0	0	0	0
	SJV113	50	14	700	0	0	0	0
	SJV114	50	14	700	0	0	0	0

Table 6: Sampling effort and capture results (continued)

Mendota Wildlife Area								
	Transect	**Traps**	**Days**	**Trap Days**	**Total Captures**	**Captures/ Trap Day**	**Total Individuals***	**Individuals/ Trap Day**
2007	SJV98	50	28	1400	0	0	0	0
	SJV99	50	32	1600	0	0	0	0
	SJV100	50	34	1700	0	0	0	0
	SJV101	50	32	1600	0	0	0	0
	SJV102	50	14	700	0	0	0	0
	SJV103	50	14	700	0	0	0	0
	SJV104	50	13	645	0	0	0	0
	SJV105	50	14	693	0	0	0	0
	SJV106	50	11	543	0	0	0	0
	SJV107	50	14	696	0	0	0	0
	SJV108	50	14	700	0	0	0	0
	SJV109	50	14	700	0	0	0	0
	SJV110	50	14	699	0	0	0	0

***In several instances, individuals captured at one transect were subsequently recaptured at another transect (i.e. each of the individuals captured at SJV6 and SJV12 were subsequently recaptured at SJV17). The sum of individuals captured at each transect is therefore greater than the actual number of individuals captured in the study area during a particular year.**

Table 7: Prey Densities

North of SJ River 2006

Transect ID	General Location	Trap Days	Ranid Larva	Density	Ranid Adult	Density	Centrar-chids	Density	Carp	Density	Mosquito-fish	Density	Catfish	Density
SJV2	ATWATER DRAIN AT ARENA PLAINS	700	31	0.044286	5	0.007143	11	0.015714	3	0.004286	23	0.03285	227	0.32428
SJV5	EAST SIDE CANAL AT SNOBIRD	750	0	0	2	0.002667	0	0	47	0.062667	4	0.00533	54	0.072
SJV7	TURNER SLOUGH	750	0	0	3	0.004	5	0.006667	2	0.002667	0	0	100	0.13333
SJV10	EAST SIDE CANAL AT HWY 140	750	22	0.029333	1	0.001333	13	0.017333	1	0.001333	8	0.01066	31	0.04133
SJV13	ATWATER DRAIN AT SNOBIRD	700	2	0.002857	8	0.011429	5	0.007143	3	0.004286	1	0.00142	149	0.21285
SJV14	ARENA PLAINS WETLAND 2	750	0	0	2	0.002667	12	0.016	0	0	21	0.028	229	0.30533
SJV19	EAST SIDE CANAL AT STEVINSON RANCH	700	550	0.785714	9	0.012857	15	0.021429	4	0.005714	0	0	115	0.16428
SJV22	BEAR CREEK AT SNOBIRD	750	46	0.061333	46	0.061333	0	0	22	0.029333	0	0	110	0.14666
SJV23	ARENA PLAINS WETLAND 3	750	0	0	3	0.004	7	0.009333	2	0.002667	1	0.00133 3	566	0.75466 7
SJV37	MERCED NWR 1 MARSH	750	21	0.028	13	0.017333	0	0	0	0	17	0.02266	558	0.744
SJV39	MERCED NWR 2 DITCH	750	0	0	1	0.001333	1	0.001333	0	0	3	0.004	183	0.244
SJV40	EAST SIDE CANAL 4	750	0	0	0	0	2	0.002667	1	0.001333	0	0	151	0.20133
SJV41	EAST SIDE CANAL 5	750	3	0.004	9	0.012	8	0.010667	4	0.005333	0	0	92	0.12266 7
SJV42	EAST SIDE CANAL 6	750	0	0	4	0.005333	7	0.009333	4	0.005333	0	0	270	0.36
SJV45	EAST SIDE CANAL 7	700	1	0.001429	19	0.027143	2	0.002857	9	0.012857	0	0	102	0.14571
SJV46	MERCED NWR 4 DEAD MAN CREEK E	750	3	0.004	0	0	2	0.002667	0	0	0	0	11	0.01466
SJV48	MODESTO PROPERTIES DRAKE DITCH	750	64	0.085333	9	0.012	1	0.001333	0	0	0	0	17	0.02266

Table 7: Prey Densities (continued)

North of SJ River 2007

Transect ID	General Location	Trap Days	Ranid Larva	Density	Ranid Adult	Density	Centrar-chids	Density	Carp	Density	Mosquito -fish	Density	Catfish	Density
SJV76	EAST SIDE CANAL 1	700	0	0	0	0	0	0	10	0.014285	4	0.00571	0	0
SJV77	EAST SIDE CANAL 2 @ MODESTO PROPERTIES	700	30	0.042857	0	0	0	0	1	0.001428	5	0.00714	0	0
SJV78	EAST SIDE CANAL 3 @ MODESTO PROPERTES EAST	700	1	0.001428	0	0	2	0.002857	1	0.001428	3	0.00428	0	0
SJV79	EAST SIDE CANAL 4	700	0	0	8	0.011428	1	0.001428	3	0.004285	0	0	2	0.00285
SJV80	CRANE DITCH @ MODESTO PROPERTIES	750	42	0.056	5	0.006666	3	0.004	10	0.013333	3	0.004	0	0
SJV82	EAST SIDE CANAL 5 @ MARIPOSA BYPASS	666	19	0.028528	1	0.001501	18	0.027027	20	0.030030	10	0.01501	0	0
SJV83	MERCED NWR NORTH - DITCH 1	699	3	0.004291	14	0.020028	25	0.035765	0	0	6	0.00858	0	0
SJV84	MERCED NWR NORTH - DITCH 2	50	0	0	1	0.02	4	0.08	1	0.02	0	0	0	0
SJV85	MERCED NWR NORTH - DUCK SLOUGH	650	418	0.643076	0	0	0	0	3	0.004615	1	0.00153	0	0
SJV86	MERCED NWR NORTH - DEADMAN CREEK	697	4	0.005738	1	0.001434	0	0	0	0	10	0.01434	2	0.00286
SJV87	ARENA PLAINS - BEAR CREEK	700	2	0.002857	0	0	0	0	0	0	1	0.00142	5	0.00714
SJV88	MERCED NWR SOUTH - EAST SIDE BYPASS	700	2	0.002857	7	0.01	14	0.02	0	0	1	0.00142	2	0.00285
SJV89	MERCED NWR NORTH - NW LAKE	700	0	0	1	0.001428	8	0.011428	6	0.008571	3	0.00428	3	0.00428
SJV90	MERCED NWR SOUTH - WEST DITCH	697	39	0.055954	5	0.007173	0	0	0	0	1	0.00143	0	0

Table 7: Prey Densities (continued)

North of SJ River 2007 (cont.)

Transect ID	General Location	Trap Days	Ranid Larva	Density	Ranid Adult	Density	Centrar-chids	Density	Carp	Density	Mosquito -fish	Density	Catfish	Density
SJV91	WALLY'S FORD @ MODESTO PROPERTIES	700	3	0.004285	13	0.018571	24	0.034285	0	0	0	0	3	0.00428
SJV92	EAST SIDE CANAL 6 @ STEVINSON RANCH	700	61	0.087142	4	0.005714	22	0.031428	2	0.002857	0	0	0	0
SJV93	MERCED NWR SOUTH - DEADMAN CREEK	700	18	0.025714	1	0.001428	1	0.001428	0	0	0	0	0	0
SJV94	ARENA PLAINS - ATWATER DRAIN	700	30	0.042857	7	0.01	47	0.067142	0	0	21	0.03	9	0.01285
SJV95	BEAR CREEK @ SNO-BIRD	625	285	0.456	0	0	4	0.0064	3	0.0048	0	0	0	0
SJV96	EAST SIDE CANAL 7 @ STEVINSON RANCH NORTH	245	6	0.024489	0	0	7	0.028571	1	0.004081	0	0	0	0

Table 7: Prey Densities (continued)

Transect ID	General Location	Trap Days	Ranid Larva	Density	Ranid Adult	Density	Centrar-chids	Density	Carp	Density	Mosquito -fish	Density	Catfish	Density
South of SJ River 2006														
SJV1	BIG WATER DRAIN AT SANTA FE ROAD	750	3	0.004	0	0	0	0	10	0.013333	14	0.01866	62	0.08266
SJV3	AGATHA/POSO	750	1	0.001333	3	0.004	10	0.013333	6	0.008	10	0.01333	131	0.174667
SJV4	LOS BANOS CREEK N	750	0	0	2	0.002667	0	0	0	0	134	0.17866	785	1.04666
SJV6	LOS BANOS CREEK SW	750	0	0	1	0.001333	8	0.010667	27	0.036	5	0.00666	77	0.10266
SJV9	MUD SLOUGH AT KLAMATH CLUB	750	1	0.001333	1	0.001333	13	0.017333	1	0.001333	6	0.008	59	0.07866
SJV11	AGATHA CANAL AT CLLCC	735	0	0	0	0	0	0	68	0.092517	10	0.01360	157	0.21360
SJV12	SAN LUIS CREEK EAST	700	54	0.077143	1	0.001429	1	0.001429	12	0.017143	8	0.01142	32	0.04571
SJV15	LOS BANOS CREEK SE	250	0	0	0	0	8	0.032	6	0.024	28	0.112	359	1.436
SJV16	MUD SLOUGH AT KLAMATH CLUB 2	750	1	0.001333	7	0.009333	56	0.074667	5	0.006667	12	0.016	53	0.07066
SJV17	LOS BANOS CREEK 2	3400	4	0.001176	6	0.001765	8	0.002353	0	0	0	0	123	0.03617
SJV18*	DRIFT FENCE AT MUD SLOUGH/KLAMATH	1450	1	0.00069	3	0.002069	24	0.016552	2	0.001379	141	0.09724	8	0.00551
SJV21	BLUE GOOSE INTERIOR 1	750	1	0.001333	1	0.001333	7	0.009333	3	0.004	16	0.02133	52	0.06933
SJV25	BLUE GOOSE AT HWY 165	100	1	0.01	12	0.12	15	0.15	0	0	5	0.05	0	0
SJV26	BLUE GOOSE INTERIOR 2	750	3	0.004	12	0.016	18	0.024	1	0.001333	1	0.00133	56	0.07466
SJV27	SAN LUIS NWR DEAD MAN’S SLOUGH	700	500	0.714286	8	0.011429	25	0.035714	20	0.028571	3	0.00428	700	1
SJV28	MOSQUITO DITCH NE	700	69	0.098571	1	0.001429	8	0.011429	88	0.125714	4	0.00571	66	0.09428

Table 7: Prey Densities (continued)

Transect ID	General Location	Trap Days	Ranid Larva	Density	Ranid Adult	Density	Centrar-chids	Density	Carp	Density	Mosqui to-fish	Density	Transect ID	General Location
South of SJ River 2006 (continued)														
SJV29	SANTA FE CANAL AT KESTERSON	700	479	0.684286	2	0.002857	35	0.05	6	0.008571	12	0.01714	80	0.11428
SJV30	E3P MARSH AT KESTERSON	700	4	0.005714	3	0.004286	25	0.035714	4	0.005714	1	0.00142	148	0.21142
SJV31	BEAVER POND AT KESTERSON	750	244	0.325333	0	0	13	0.017333	0	0	1	0.00133	27	0.036
SJV32	MOSQUITO DITCH SW	750	95	0.126667	14	0.018667	11	0.014667	29	0.038667	1	0.00133	88	0.11733
SJV33	SAN LUIS CREEK W	750	52	0.069333	61	0.081333	2	0.002667	12	0.016	6	0.008	89	0.11866
SJV34	POSO DRAIN AT MALLARD ROAD	700	113	0.161429	8	0.011429	16	0.022857	44	0.062857	0	0	0	0
SJV35	AGATHA CANAL AT CLLCC 2	700	138	0.197143	1	0.001429	8	0.011429	11	0.015714	0	0	4	0.00571
SJV36	AGATHA CANAL AT CLLCC 3	750	92	0.122667	26	0.034667	0	0	9	0.012	0	0	0	0
SJV43	ALMADEN DITCH	750	768	1.024	4	0.005333	14	0.018667	0	0	2	0.00266	47	0.06266
SJV44	HELM CANAL AT FROG POND CLUB	750	19	0.025333	3	0.004	0	0	3	0.004	5	0.00666	3	0.004
SJV47*	LOS BANOS CREEK DRIFT FENCE 1	700	0	0	1	0.001429	0	0	1	0.001429	55	0.07857	29	0.04142
SJV49*	LOS BANOS CREEK DRIFT FENCE 2	325	0	0	1	0.003077	1	0.003077	2	0.006154	83	0.25538	59	0.18153
SJV50	ALMOND DRIVE DITCH	100	17	0.17	0	0	19	0.19	13	0.13	10	0.1	41	0.41

Table 7: Prey Densities (continued)

South of SJ River 2007														
Transect ID	General Location	Trap Days	Ranid Larva	Density	Ranid Adult	Density	Centrar-chids	Density	Carp	Density	Mosquito -fish	Density	Catfish	Density
SJV51	BLUE GOOSE	700	0	0	0	0	9	0.012857	42	0.06	3	0.00428	0	0
SJV52	SNLNWR SOUTH - SOUZA	700	1	0.00142	3	0.004285	2	0.002857	24	0.034285	0	0	32	0.04571
SJV53	SNLNWR - BARRACKS DITCH	950	2	0.002105	7	0.007368	12	0.012631	0	0	1	0.00105	0	0
SJV54	SNLNWR SOUTH - WINTON	700	1	0.001428	3	0.004285	1	0.00142	0	0	2	0.00285	0	0
SJV55	KESTERSON - FREITAS	700	0	0	0	0	3	0.004285	2	0.002857	0	0	0	0
SJV56	SNLNWR SOUTH - SW MARSH 3W	450	1	0.002222	1	0.002222	8	0.017777	0	0	0	0	1	0.00222
SJV57	KESTERSON - MUD SLOUGH	700	1	0.001428	0	0	1	0.001428	2	0.002857	0	0	0	0
SJV58	SNLNWR WEST - BEAR CREEK 1	700	4	0.005714	4	0.005714	0	0	0	0	0	0	0	0
SJV59	SNLNWR WEST - BEAR CREEK 2	700	0	0	2	0.002857	0	0	1	0.001428	0	0	0	0
SJV60	MOSQUITO DITCH @ SALINAS - REFERENCE LINE (5/30/2007)	879	0	0	1	0.001137	1	0.001137	0	0	4	0.00455	0	0
SJV60	MOSQUITO DITCH @ SALINAS - REFERENCE LINE (6/30/2007)	1442	465	0.322468	1	0.000693	40	0.027739	0	0	9	0.00624	22	0.01525
SJV60	MOSQUITO DITCH @ SALINAS - REFERENCE LINE (7/30/2007)	749	323	0.431241	3	0.00400	2	0.002670	0	0	7	0.00934	1	0.00133
SJV61	SALINAS SERVICE DITCH - WEST	750	3	0.004	1	0.001333	4	0.005333	0	0	2	0.00266	0	0
SJV62	SALINAS SERVICE DITCH - EAST	750	0	0	1	0.001333	0	0	0	0	1	0.00133	0	0
SJV63	DRIFT FENCE @ SALINAS / MOSQUITO DITCH	818	0	0	1	0.001222	3	0.003667	0	0	1	0.00122	0	0

Table 7: Prey Densities (continued)

South of SJ River 2007 (continued)														
Transect ID	General Location	Trap Days	Ranid Larva	Density	Ranid Adult	Density	Centrar-chids	Density	Carp	Density	Mosquito -fish	Density	Transect ID	General Location
SJV64	HOLLISTER DRAIN WEST OF SANTA FE GRADE	700	6	0.008571	3	0.004285	2	0.002857	0	0	8	0.01142	1	0.00142
SJV65	MOSQUITO DITCH @ SALINAS - SOUTH	700	0	0	0	0	3	0.004285	0	0	5	0.00714	0	0
SJV66	MOSQUITO PERIPHERAL DRAIN @ SALINAS	700	4	0.005714	1	0.001428	8	0.011428	6	0.008571	5	0.00714	0	0
SJV67	INGOMAR DRAIN @ SALINAS	700	0	0	2	0.002857	5	0.007142	2	0.002857	15	0.02142	0	0
SJV68	WEST SIDE DRAIN @ GUSTINE	300	3	0.01	5	0.016666	8	0.026666	0	0	10	0.03333	0	0
SJV69	WEST SIDE DRAIN @ GUSTINE NORTH	700	1	0.001428	5	0.007140	1	0.00142	0	0	0	0	0	0
SJV70	EAGLE DITCH @ HOLLISTER	700	0	0	1	0.001428	4	0.005714	1	0.001428	16	0.02285	0	0
SJV71	KESTERSON DITCH @ MEADOWLARK / REEVES LAKE	700	0	0	0	0	21	0.03	0	0	6	0.00857	0	0
SJV72	KESTERSON DITCH @ HAY WIRE	700	0	0	1	0.001428	15	0.021428	1	0.001428	4	0.00571	0	0
SJV73	BROOD PONDS @ MEADOWLARK	700	1	0.001428	0	0	143	0.204285	1	0.001428	38	0.05428	0	0
SJV74	LOS BANOS CREEK @ GUSTINE	620	0	0	2	0.003225	1	0.001612	5	0.008064	5	0.00806	0	0
SJV75	EAGLE DITCH @ HOLLISTER NORTHWEST	700	6	0.008571	2	0.002857	27	0.038571	30	0.042857	22	0.03142	0	0
SJV81	HOLLISTER LAKE	640	0	0	0	0	62	0.096875	0	0	28	0.04375	1	0.00156
SJV97	AGATHA EXTENSION @ MALLARD RD.	628	74	0.117834	5	0.007961	1	0.001592	0	0	9	0.01433	3	0.00477
SJV111	AGATHA CANAL @ CWLCC 1	349	0	0	0	0	1	0.00286	4	0.011461	0	0	0	0
SJV112	AGATHA CANAL @ CWLCC 2	332	53	0.159638	1	0.003012	3	0.009036	39	0.117469	4	0.01204	6	0.01807

Table 7: Prey Densities (continued)

South of SJ River 2007 (continued)														
Transect ID	Transect ID	Trans ect ID	Trans ect ID	Transect ID	Trans ect ID	Transect ID	Transect ID	Transect ID	Trans ect ID	Transect ID	Transe ct ID	Transec t ID	Transect ID	Transect ID
SJV113	BENNETT DRAIN @ BRITTO RD.	700	0	0	0	0	31	0.044285	0	0	4	0.00571	0	0
SJV114	POSO DRAIN @ MALLARD RD.	700	1	0.001428	1	0.001428	0	0	0	0	1	0.00142	1	0.00142

Table 7: Prey Densities (continued)

Mendota Wildlife Area 2007														
Transect ID	General Location	Trap Days	Ranid Larva	Density	Ranid Adult	Density	Centrar-chids	Density	Carp	Density	Mosquito -fish	Density	Catfish	Density
SJV98	MENDOTA WA - TULE 1	1400	1	0.000714	0	0	10	0.007142	0	0	0	0	0	0
SJV99	MENDOTA WA - TULE 2	1600	1	0.000625	0	0	10	0.00625	0	0	0	0	0	0
SJV100	MENDOTA WA - TULE 3	1700	1	0.000588	1	0.000588	16	0.009411	0	0	0	0	0	0
SJV101	MENDOTA WA - TULE 4	1600	2	0.00125	3	0.001875	11	0.006875	0	0	1	0.00062	0	0
SJV102	MENDOTA WA - TULE 5	700	17	0.024285	12	0.017142	19	0.027142	1	0.001428	0	0	2	0.00285
SJV103	MENDOTA WA - SLOUGH 6	700	10	0.014285	26	0.037142	15	0.021428	0	0	1	0.00142	0	0
SJV104	MENDOTA WA - DITCH 7 @ LOT 12	645	0	0	1	0.001550	2	0.003100	0	0	0	0	1	0.00155
SJV105	MENDOTA WA - DITCH 8 @ LOT 18	693	24	0.034632	10	0.014430	15	0.021645	0	0	6	0.00865	4	0.00577
SJV106	MENDOTA WA - DITCH 9 @ LOT 15	543	3	0.005524	2	0.003683	4	0.007366	2	0.003683	1	0.00184	4	0.00736
SJV107	MENDOTA WA - EAST DITCH 10	696	23	0.033045	24	0.034482	19	0.027298	0	0	0	0	4	0.00574
SJV108	MENDOTA WA - EAST DITCH 11	700	8	0.011428	4	0.005714	10	0.014285	0	0	1	0.00142	39	0.05571
SJV109	MENDOTA WA - DITCH 12	700	0	0	1	0.001428	14	0.02	0	0	0	0	2	0.00285
SJV110	MENDOTA WA - DITCH 13	699	0	0	1	0.001430	29	0.041487	0	0	0	0	0	0

Density calculated as catch per unit effort (trap day).

* Signifies traps with 16 holes per inch of mesh compared to the standard 4 holes per inch; these traps capture larger number of small prey such as mosquitofish.

Key: Tadpole = *Rana catesbeiana* or *Pseudacris regilla;* Bullfrog = *Rana catesbeiana;* Treefrog = *Pseudacris regilla;* Centrarchid Fish = Sunfish (*Lepomis* spp.) Black basses (*Micropterus* spp.) and Crappie (*Pomoxis* spp.); Carp = *Cyprinus carpio*; Mosquitofish = *Gambusia affinis;* Crayfish = *Procambarus clarkii*

Table 8: Water Metrics

North of SJ River				
Transect ID	GENERAL LOCATION	Date	pH	EC (mS/cm)
SJV2	ATWATER DRAIN AT ARENA PLAINS	8/23/2006	7.93	0.409
SJV5	EAST SIDE CANAL AT SNOWBIRD	8/23/2006	8.21	0.167
SJV7	TURNER SLOUGH	8/24/2006	8.21	0.626
SJV13	ATWATER DRAIN AT SNOWBIRD	8/23/2006	8.44	0.133
SJV14	ARENA PLAINS WETLAND 2	8/23/2006	8.04	0.321
SJV19	EAST SIDE CANAL AT STEVINSON RANCH	8/23/2006	8.01	0.119
SJV22	BEAR CREEK AT SNOWBIRD	8/23/2006	9.41	0.138
SJV24	BIG BOTTOM LAKE	8/24/2006	8.09	0.381
SJV37	MERCED NWR 1	8/23/2006	8.21	0.22
SJV38	MERCED NWR 2 DEAD MAN CREEK WEST	8/23/2006	8.39	0.26
SJV39	MERCED NWR 3	8/23/2006	8.09	0.187
SJV41	EAST SIDE CANAL 5 MARIPOSA	8/23/2006	7.75	0.194
SJV42	EAST SIDE CANAL 6	8/23/2006	8.1	0.164
SJV45	EAST SIDE CANAL 7	8/23/2006	7.97	0.232
SJV46	MERCED NWR 4	8/23/2006	8.1	0.265
SJV48	MODESTO PROPERTIES DRAKE DITCH	8/23/2006	8.26	0.129
SJV83	MNWR NORTH - SERVICE DITCH	9/12/2020	8.17	0.299
SJV86	MERCED NWR DEADMAN CREEK EAST	9/12/2007	8.82	0.223
SJV87	ARENA PLAINS - BEAR CREEK	9/12/2007	7.94	0.215
SJV88	MNWR SOUTH - BEAR CREEK	9/12/2007	8.31	0.269
SJV89	MNWR NORTH - POND	9/12/2007	8.02	0.339
SJV90	MNWR SOUTH - SERVICE DITCH	9/12/2007	8.12	0.25
SJV92	ESC AT STEVINSON RANCH	9/12/2007	7.95	0.249
SJV93	MNWR SOUTH - DEADMAN CREEK WEST	9/12/2007	8.11	0.25
SJV94	ARENA PLAINS - ATWATER DRAIN	9/12/2007	7.64	0.279
SJV95	SNOBIRD - BEAR CREEK	9/12/2007	7.5	0.217
NA	ESC AT SNOBIRD ENTRANCE	9/12/2007	7.8	0.257

Table 8: Water Metrics (continued)

South of SJ River				
Transect ID	GENERAL LOCATION	Date	pH	EC (mS/cm)
SJV1	BIG WATER DRAIN AT SANTA FE RD.	8/23/2006	8.56	0.49
SJV3	AGATHA AT POSO	8/23/2006	8.28	0.333
SJV4	LOS BANOS CREEK NORTH	8/24/2006	8.63	0.952
SJV11	AGATHA CANAL AT CLCC	8/23/2006	7.92	0.894
SJV12	SAN LUIS CREEK EAST	8/24/2006	7.99	0.739
SJV16	MUD SLOUGH 2	8/23/2006	8.58	0.929
SJV17	LOS BANOS CREEK 2 (REF)	8/24/2006	7.98	0.717
SJV18	MUD SLOUGH DRIFT FENCE	8/23/2006	7.87	0.96
SJV21	BLUE GOOSE INTERIOR 1	8/24/2006	8.02	0.695
SJV27	SAN LUIS NWR DEAD MAN'S SLOUGH	8/24/2006	8.63	2.166
SJV29	SANTA FE CANAL AT KESTERSON	8/24/2006	8.36	0.665
SJV30	E3P MARSH AT KESTERSON	8/24/2006	8.13	0.865
SJV31	BEAVER POND AT KESTERSON	8/24/2006	8.24	0.672
SJV32	MOSQUITO DITCH SW	8/24/2006	8.2	0.706
SJV33	SAN LUIS CREEK WEST	8/24/2006	7.63	1.154
SJV34	POSO DRAIN AT MALLARD RD.	8/23/2006	7.86	1.142
SJV43	ALMADEN DITCH	8/23/2006	9.07	0.352
SJV44	HELM CANAL AT FROG POND	8/23/2006	8.06	0.354
SJV50	ALMOND DRIVE DITCH	8/23/2006	8.02	0.373
SJV51	FREEMONT AT BLUE GOOSE	9/13/2007	7.86	0.866
SJV55	NE SERVICE DITCH AT KESTERSON	9/12/2007	8.29	0.861
SJV56	SOUTH LIFT AT MARSH 3W	9/12/2007	7.81	1.028
SJV57	MUD SLOUGH AT KESTERSON	9/12/2007	8.37	1.899
SJV60	MOSQUITO REFERENCE	9/13/2007	7.97	0.683
SJV61	SALINAS SERVICE DITCH	9/13/2007	8.09	0.639
SJV64	HOLLISTER DRAIN AT SALINAS	9/13/2007	7.88	0.638
SJV65	MOSQUITO SOUTH	9/13/2007	8.02	0.637
SJV68	WEST SIDE DITCH AT GUN CLUB	9/12/2007	7.89	2.253
SJV70	EAGLE DITCH AT HOLLISTER	9/13/2007	7.97	0.636
SJV71	KESTERSON DITCH WEST	9/13/2007	7.91	0.669
SJV72	KESTERSON DITCH EAST	9/13/2007	7.89	0.644
SJV111	AGATHA CANAL AT BRITTO RD.	9/13/2007	7.97	0.773

Table 8: Water Metrics (continued)

South of SJ River (continued)

Transect ID	GENERAL LOCATION	Date	pH	EC (mS/cm)
SJV113	BENNETT DRAIN	9/13/2007	7.93	0.77
SJV114	POSO DRAIN	9/13/2007	7.88	1.335
NA	LOS BANOS CREEK AT SANTA FE	9/12/2007	8.15	1.197
NA	LOS BANOS CREEK AT GUN CLUB	9/12/2007	7.84	1.214
NA	LOS BANOS CREEK AT SALINAS	9/13/2007	7.85	0.681
NA	SAN LUIS SPILLWAY DITCH	9/13/2007	7.89	0.65
NA	SOUTH LIFT EAST AT SAN LUIS	9/12/2007	7.94	1.03

Mendota Wildlife Area

Transect ID	GENERAL LOCATION	Date	pH	EC (mS/cm)
SJV98	MWA - TULE 1 AT FRESNO SLOUGH	9/13/2007	8.24	0.847
NA	MWA EAST - E-W STAGGERED DRAIN	9/13/2007	8.03	0.963
NA	MWA EAST - HAMBURGER SLOUGH	9/13/2007	8.22	0.951
NA	MWA EAST - N-S DITCH	9/13/2007	8.31	0.984
NA	MWA - DITCH AT PUMP 6	9/13/2007	8.27	0.94
NA	MWA WEST - FRESNO SLOUGH BACKWATER	9/13/2007	8.63	0.866

Table 9: Statistical analysis of San Joaquin Valley water metrics (**H_o:** mean value of the water metric measured during 2006 equals the mean value of the water metric measured during 2007)

SJV pH 2006-2007 (pooled amongst all areas)
t-Test: Two-Sample Assuming Equal Variances

	2006	*2007*
Mean	8.206857191	8.040000001
Variance	0.124651557	0.063994452
Observations	35	37
Pooled Variance	0.093456474	
Hypothesized Mean Difference	0	
df	70	
t Stat	2.31477544	
P(T<=t) one-tail	0.01178165	
t Critical one-tail	1.66691448	
P(T<=t) two-tail	0.023563301	
t Critical two-tail	1.994437086	

SJV EC 2006-2007 (pooled amongst all areas)
t-Test: Two-Sample Assuming Equal Variances

	2006	*2007*
Mean	0.5458	0.74327027
Variance	0.178134576	0.207556647
Observations	35	37
Pooled Variance	0.193265927	
Hypothesized Mean Difference	0	
df	70	
t Stat	-1.90499004	
P(T<=t) one-tail	0.030445024	
t Critical one-tail	1.66691448	
P(T<=t) two-tail	0.060890047	
t Critical two-tail	1.994437086	

Table 10: Statistical analysis of North Grassland Water District[1] water metrics (**H_o:** mean value of the water metric measured during 2006 equals the mean value of the water metric measured during 2007)

North GWD pH 2006-2007
t-Test: Two-Sample Assuming Equal Variances

	2006	*2007*
Mean	8.188888921	7.97
Variance	0.120986875	0.022221
Observations	18	20
Pooled Variance	0.068860464	
Hypothesized Mean Difference	0	
df	36	
t Stat	2.567428414	
P(T<=t) one-tail	0.007272565	
t Critical one-tail	1.688297694	
P(T<=t) two-tail	0.014545129	
t Critical two-tail	2.028093987	

North GWD EC 2006-2007
t-Test: Two-Sample Assuming Equal Variances

	2006	*2007*
Mean	0.721777778	0.95515
Variance	0.068927477	0.198151
Observations	18	20
Pooled Variance	0.137128991	
Hypothesized Mean Difference	0	
df	36	
t Stat	1.939742021	
P(T<=t) one-tail	0.030138642	
t Critical one-tail	1.688297694	
P(T<=t) two-tail	0.060277284	
t Critical two-tail	2.028093987	

[1] GGS observations declined markedly in this region between 2006 and 2007

Table 11: Statistical analysis of water metrics north and south of the San Joaquin River (**H_o:** mean value of the water metric measured north of the SJ River equals the mean value of the water metric measured south of the SJ River)

SJV respective pH 2006-2007
t-Test: Two-Sample Assuming Equal Variances

	Northern pH	*Southern pH*
Mean	8.132963	8.0879487
Variance	0.1312524	0.0851167
Observations	27	39
Pooled Variance	0.1038593	
Hypothesized Mean Difference	0	
df	64	
t Stat	0.5579173	
P(T<=t) one-tail	0.2894237	
t Critical one-tail	1.669013	
P(T<=t) two-tail	0.5788473	
t Critical two-tail	1.9977296	

SJV respective EC 2006-2007
t-Test: Two-Sample Assuming Equal Variances

	Northern EC	*Southern EC*
Mean	0.2515556	0.8784872
Variance	0.0109379	0.188261
Observations	27	39
Pooled Variance	0.1162235	
Hypothesized Mean Difference	0	
df	64	
t Stat	-7.3454003	
P(T<=t) one-tail	2.298E-10	
t Critical one-tail	1.669013	
P(T<=t) two-tail	4.596E-10	
t Critical two-tail	1.9977296	

Table 12: Statistical analysis of water metrics north of the San Joaquin River and at Mendota Wildlife Area (**H_o:** mean value of the water metric measured north of the SJ River equals the mean value of the water metric measured at Mendota Wildlife Area)

SJV respective pH 2006-2007
t-Test: Two-Sample Assuming Equal Variances

	North pH	*MWA pH*
Mean	8.132963	8.2833335
Variance	0.1312524	0.0382267
Observations	27	6
Pooled Variance	0.1162483	
Hypothesized Mean Difference	0	
df	31	
t Stat	-0.9771694	
P(T<=t) one-tail	0.1680249	
t Critical one-tail	1.6955187	
P(T<=t) two-tail	0.3360498	
t Critical two-tail	2.0395134	

SJV respective EC 2006-2007
t-Test: Two-Sample Assuming Equal Variances

	North EC	*MWA EC*
Mean	0.2515556	0.9251667
Variance	0.0109379	0.0030782
Observations	27	6
Pooled Variance	0.0096702	
Hypothesized Mean Difference	0	
df	31	
t Stat	-15.177231	
P(T<=t) one-tail	3.362E-16	
t Critical one-tail	1.6955187	
P(T<=t) two-tail	6.724E-16	
t Critical two-tail	2.0395134	

Table 13: Statistical analysis of water metrics south of the San Joaquin River (GWD) and at Mendota Wildlife Area (**H_o:** mean value of the water metric measured south of the SJ River equals the mean value of the water metric measured at Mendota Wildlife Area)

SJV respective pH 2006-2007

t-Test: Two-Sample Assuming Equal Variances

	South pH	*MWA pH*
Mean	8.0879487	8.2833335
Variance	0.0851167	0.0382267
Observations	39	6
Pooled Variance	0.0796644	
Hypothesized Mean Difference	0	
df	43	
t Stat	-1.5785568	
P(T<=t) one-tail	0.0608835	
t Critical one-tail	1.6810707	
P(T<=t) two-tail	0.1217669	
t Critical two-tail	2.0166922	

SJV respective EC 2006-2007

t-Test: Two-Sample Assuming Equal Variances

	South EC	*MWA EC*
Mean	0.8784872	0.9251667
Variance	0.188261	0.0030782
Observations	39	6
Pooled Variance	0.1667281	
Hypothesized Mean Difference	0	
df	43	
t Stat	-0.2606894	
P(T<=t) one-tail	0.3977882	
t Critical one-tail	1.6810707	
P(T<=t) two-tail	0.7955765	
t Critical two-tail	2.0166922	

SUMMARY AND CONCLUSIONS

Potential Reasons for Decline

While habitat loss is the primary threat to the survival of GGS, other factors, such as insufficient water supply during the snakes' active season, degraded water quality, environmental contamination, and parasite infestation are also suggested as potential contributors to the species' ongoing decline (G. Hansen *in litt*. 1992; G. Hansen 1993; USFWS 1999, 2006). These factors, alone or in concert, may apply in the San Joaquin Valley where recent surveys indicate an alarming decline in GGS despite the presence of limited, but seemingly suitable aquatic habitat (Dickert 2003; E. Hansen *in litt.* 2006; G. Hansen 1996; Sloan 2004; Wylie 1999).

Water Management

Historic changes in wetland management practices on State, Federal, and private lands in the Grassland Wetlands of the San Joaquin Valley have coincided with significant declines of local GGS populations (Beam and Menges 1997; E. Hansen 2007; G. Hansen 1988, 1996; Paquin *et*. *al*. 2006; USFWS 2006). Wetland management for waterfowl on several State and Federal wildlife refuges entails flooding the wetlands during winter and spring months, and draining them in the summer when water is critical to GGS (Paquin *et*. *al*. 2006; USFWS 2006). In the past, private duck clubs maintained pastures for cattle during the summer, providing sufficient water for GGS in sloughs, canals, and other water features throughout the region (G. Hansen 1988; Paquin *et*. *al*. 2006; USFWS 2006). In the mid-1970's, however, duck clubs were encouraged to shift their focus from cattle grazing to moist soil management, which significantly reduced the amount of summer water in the area (G. Hansen 1988; Beam and Menges 1997; USFWS 2006), particularly that associated with shallow-flooded surface features such as stock ponds and wetlands (S. Lower, *pers. comm.*). This shift in management, beginning in the 1960's and continuing through the 1980's (S. Lower, *pers. comm.*), coincides with the observed onset of the GGS decline in SJV first documented from the 1970's to the 1980's (Hansen 1988).

Although aquatic habitat persists year-round within the majority of SJV ditches, drains, and canals, recent work suggests that channelized habitat without associated wetlands may be inadequate for GGS. Data collected range-wide suggest that GGS prefer channelized habitats associated with native marsh, managed marsh, or active rice agriculture and may in fact abandon otherwise suitable channelized features when wetland habitats are removed (Jones and Stokes 2008, *in prep.;* Wylie 2004). To test the null hypothesis that mean capture per unit effort within linear aquatic features (e.g., channels, ditches, and drains) adjacent to wetland features (e.g., native marsh, managed marsh, or rice agriculture) is equal to that of features without associated wetlands, data from regions of the Sacramento Valley supporting substantial populations of GGS (e.g., American Basin, Sutter Basin, Yolo Basin) were analyzed (2-sample t-test). All features included in the analysis were hydrologically connected, allowing GGS to move freely between them (i.e., habitat selection was not geographically hindered). Results indicate that mean capture per unit effort is significantly greater within linear aquatic features adjacent to wetlands ($p = 0.002123655$; $df = 78$). Though captures were far fewer than within the Sacramento Valley, an analysis of data from SJV produced similar results ($p = 0.0449944$; $df = 82$). Statistics are reported in Table 14. Though the life history parameters driving this association are unclear (though perhaps attributable to habitat and cover requirements for neonate and juvenile GGS), these results underscore the importance of shallow flooded wetlands during the GGS active season.

Regardless of management, the uncertain quantity and reliability of continued water deliveries to SJV water users potentially limits the ability to enhance habitat values by providing valuable summer surface water. In GWD, constraints emanating from the 2007 winter drought resulted in Level 4 summer water supplies totaling less than 50% of the district's total needs, leading to significant impacts to riparian habitats (S. Lower, *pers. comm.*) and unknown effects on aquatic species such as GGS. Though 2008 appears to be a normal water year, reductions in water exports may result in similar reductions in available water (S. Lower, *pers. comm.*). On December 14th, 2007, Judge Oliver W. Wanger of the U.S. District Court in Fresno finalized a decision (Case 1:05-cv-01207-OWW-GSA) made on August 31st to enforce potential limits on water pumped south from the San Francisco Bay Delta during critical winter and spring periods in order to protect the federally-protected delta smelt (*Hypomesus transpacificus*). Limits will remain in effect until a new biological opinion on the Long-Term Operational Criteria and Plan (OCAP) for coordination of the Central Valley Project and State Water Project is completed; Judge Wanger has directed the U.S. Fish and Wildlife Service to complete the biological opinion by September 15th, 2008. The extent of water restrictions and the potential impacts to water-dependent species within the San Joaquin Valley are not known.

Table 14: Statistical analysis of wetland significance (**H_o :** mean giant garter snake capture per unit effort within linear aquatic features (e.g., channels, ditches, and drains) adjacent to wetland (e.g., native marsh, managed marsh, or rice agriculture) equals the mean capture per unit effort within linear aquatic features where wetlands are not present)

Sacramento Valley 2007
t-Test: Two-Sample Assuming Equal Variances

	Dry	*Wet*
Mean	0.001143363	0.007365288
Variance	8.32472E-06	9.14363E-05
Observations	25	55
Pooled Variance	6.58635E-05	
Hypothesized Mean Difference	0	
df	78	
t Stat	-3.17840078	
P(T<=t) one-tail	0.001061827	
t Critical one-tail	1.664624645	
P(T<=t) two-tail	0.002123655	
t Critical two-tail	1.990847036	

San Joaquin Valley 2006-2007
t-Test: Two-Sample Assuming Equal Variances

	Dry	*Wet*
Mean	2.96296E-05	0.000600371
Variance	3.95062E-08	3.49763E-06
Observations	45	39
Pooled Variance	1.64205E-06	
Hypothesized Mean Difference	0	
df	82	
	-	
t Stat	2.035846652	
P(T<=t) one-tail	0.0224972	
t Critical one-tail	1.663649185	
P(T<=t) two-tail	0.0449944	
t Critical two-tail	1.989318521	

Water Quality

Selenium contamination and impaired water quality have been suggested as contributing factors in the decline of GGS, particularly in the southern portion of their range (USFWS 1993, USFWS 1999). Unfortunately, information regarding reptile toxicology is lacking, particularly for snakes (Burger *et al.* 2005; Campbell *et al*. 2005; Clark *et al.* 2000; Holem *et al.* 2006; Hopkins *et al.* 2002; Rainwater *et al.* 2005; USFWS 2003). No studies to date have specifically examined giant garter snake toxicology. One recent study used valley garter snakes (*Thamnophis sirtalis fitchi*) and western terrestrial garter snakes (*Thamnophis elegans elegans*) as surrogate species to determine the acute toxicity to giant garter snakes of select herbicides and a surfactant; though no mortality was observed, neither general pathology nor the effects of long-term exposure were assessed (Hosea *et al*. 2004). Research on other snake species, including eastern water snakes (*Nerodia* spp.), which occupy an ecological niche very similar to GGS (Rossman *et al*. 1996), demonstrates that bioaccumulation of trace elements, pesticides, and other contaminants does occur in snakes (Bishop and Rouse 2000; Clark *et al.* 2000; Campbell *et al.* 2005; Hopkins *et al.* 2002; K. Campbell and T. Campbell 2001, Ohlendorf *et al.* 1988; Rainwater *et al.* 2005; Santos *et al.*1999) and can result in adverse biological effects, including increased standard metabolic rates (Hopkins *et al.* 1999; USFWS 2006) and impaired locomotion (Hopkins *et al.* 2005). Impaired reproduction, weakened immune systems, and a number of other harmful effects have been demonstrated in a variety of organisms. While little data is available regarding the effects of specific contaminants, the bioaccumulative properties of selenium in the food web has been well documented in the Kesterson National Wildlife Refuge area (Ohlendorf *et. al.* 1986, Saiki and Lowe 1981, Saiki and May 1988, Saiki *et al.* 1991, USFWS 1993).

Selenium has been shown to cause hepatotoxicity (chemical-driven liver damage) and impaired embryo growth in contaminated American avocet (*Recurvirostra americana*) hatchlings collected from the Tulare Lake Basin (Hoffman *et al.* 2002). Lead intoxication caused increased kidney weight, altered mitochondrial structure and function, presence of renal intranuclear inclusion bodies, and depressed alanine dehydrogenase (a catabolic enzyme responsible for catalyzing *L*-alanine to pyruvate, generating cellular energy) activity in the blood, liver, and kidneys of London pigeons (*Columba livia*) (Hutton 1980). Organophosphate pesticide exposure has been shown to significantly decrease cholinesterase activity in the kidney and liver of changeable lizards (*Calotes versiclor*) (Khan 2003) and impair sprint velocities in western fence lizards (*Sceloporus occidentalis*) (Holem *et al.* 2006). Organochlorine pesticides biomagnify in the food chain, and can disrupt the immune system (Grasman and Fox 2001) and endocrine processes (Tanabe 2002). While the effects of these contaminants on reptiles are not fully understood, it is expected that toxicity thresholds for reptiles would be similar to those of fish and birds, particularly for an aquatic obligate, such as GGS, feeding exclusively on aquatic prey (USFWS 1993, 1999).

Of the ten giant garter snakes captured between 2006 and 2007, all were, sexually mature adults of significant size, and, by inference, significant age. No young were observed (Figure 7, Figure 8, Table 5). Contrasting sharply with populations documented within the Sacramento Valley demonstrating a relatively equal representation amongst size/age classes (E. Hansen 2005; Jones and Stokes 2005, 2006; Wylie et al. 1997, 2002, 2004), the adult-biased population in SJV follows a pattern typical of declining or senescing populations. While other factors, such as predation or low detectability of juvenile GGS, might explain this difference, impaired reproductive output might also play a role. Bioaccumulation of selenium and organochlorine pesticides in fish, frogs, fish-eating birds (Hothem and Ohlendorf 1989; Ohlendorf *et al*. 1986, 1988; Saiki and Lowe 1987; Saiki and May 1988; Saiki and Schmitt 1986; Saiki *et al*. 1991, 1992; 1993; USFWS 1999, 2006), and gopher snakes (*Pituophis catenifer*) (Ohlendorf *et al*. 1988) is well documented in the Grassland Ecological Area and surrounding areas of Merced County. As with other species, these compounds may impair reproduction and population recruitment in SJV GGS, resulting in population senescence.

Despite regional remediation efforts, selenium still poses a regional threat to wildlife, particularly in the south Grasslands. The U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Environmental Contaminants Division conducted a field investigation of sediment, aquatic invertebrates, and fish from wetlands in the Grasslands area and analyzed these constituents for selenium from five areas that receive water from different or mixed water sources and were representative of areas where eggs were collected by Hothem and Welsh (1994) in 1986 and 1987 (Beckon et al., 2007). Sediments are thought to serve as an important reservoir of selenium contributing to long-term cycling of selenium in aquatic ecosystems (Lemly and Smith 1987; Lemly 1997) long after influx of selenium has been stopped. The authors conclude that selenium concentrations in sediments and invertebrates are likely due to a continuing influx of selenium contamination that has not been fully abated in the area. The study’s findings included:

1. Of the 62 avian eggs sampled, 6.5 percent, exceeded the threshold of concern for avian eggs (6 µg/g dwt,). Those four eggs ranged from 6.0 to 6.9 µg/g.

2. Of the 74 whole body fish samples collected, 27 (36.5 percent) exceeded the threshold of concern for selenium in warmwater fish

(4 µg/g selenium). All 12 samples of striped bass (*Morone saxatilis*, all of them juveniles: 11 from Gadwall Canal at Santa Cruz Gun Club, and one from Camp 13 Ditch) exceeded the threshold of concern for selenium in warmwater fish.

3. Thirty-two samples of invertebrates were collected in the South Grasslands. Thirteen of these (40.6 percent) reached or exceeded the threshold of concern for invertebrates as diet for birds (3 µg/g dietary selenium). The most effective invertebrate bioaccumulators of selenium were European freshwater snails (*Physa*) and Siberian shrimp (*Exopalaemon modestus*). The later is a recently introduced species that evidently bioaccumulates selenium more effectively than other aquatic invertebrates in the area, such as red crayfish, that it seems to be replacing.

The U.S. Fish and Wildlife Service, Division of Natural Resources, Branch of Refuge Biology, Vancouver, WA, conducted follow-up collections during 2005 to determine Se concentrations in aquatic birds after long-term use (20 Years) of predominately freshwater for wetland management in the Grasslands (Paveglio and Killbride 2007). Selenium concentrations were higher for birds from the South Grasslands during 2005, which historically received more undiluted drainage water compared with the North Grasslands. Liver selenium concentrations for black-necked stilts from the South Grasslands were within ranges associated with the first incidence of reproductive impairment. Shovelers, coots, and black-necked stilts from the South Grasslands during 2005 were found to be significantly above the background level (at a 95% confidence level).

Water quality in the east side of the SJV, where the SMWD is located, is considerably better than west side of the Valley. In the east side of the Valley, salinity of source water as well as drainage water is considerably lower, and SMWD does not have the problems with high selenium and salt concentrations. In fact, SMWD is mostly deficient in selenium and selenium supplements may be required for cattle operations (R. Kelley personal communication). Impaired water quality, therefore, may not provide an adequate explanation for the possible lack of GGS northeast of the San Joaquin River. Though pH and EC levels were not statistically correlated with GGS distribution and relative density based on data collected during this study, sampling was limited, and the sample population (n) was very small. As such, this study provides only preliminary data. Further investigations are needed to determine the effects of pH and EC on GGS and their prey.

Predation

GGS are also threatened by the introduction of exotic species. Examinations of gut contents confirm that introduced bullfrogs (*Rana catesbeiana*) prey directly on juvenile GGS throughout their range (Dickert 2003, Treanor 1983, Wylie 2003). While the extent of this predation and its effect on population recruitment is poorly understood, estimates based on preliminary data from a study conducted at Colusa National Wildlife refuge suggests that 22% of neonate giant garter snakes may succumb to bullfrog predation (Wylie et al. 2003). Some suggest that bullfrog densities in SJV might exceed those in the Sacramento Valley by an order of magnitude (J. Beam, *pers. comm.*). Other studies of bullfrog predation on snakes have documented bullfrogs ingesting other species of garter snakes up to 80 cm (31.5 inches) long, resulting in a depletion of this age class within the population which experienced alternating resurgence and decline coinciding with fluctuations in the local bullfrog population (Bury and Wheelan 1984).

Introduced predatory game fishes such as black basses (*Micropterus* spp.), striped bass (*Morone saxatilis*), sunfish (*Lepomis* spp.), and channel catfishes (*Ictalurus* spp.) probably prey on giant garter snakes and compete with them for smaller prey (Hansen 1988, USFWS 1993). GGS appear absent from features supporting permanent populations of these species (USFWS 2006). Observations made during fish kills and episodic drying of ditches and canals throughout the study area (E. Hansen 2007) suggests that the composition and population structure of potential predatory fishes in SJV differ from those noted in the rice growing regions of the Sacramento Valley. Striped bass frequently exceeding 3-5 pounds were common to all permanent ditches and drains observed throughout the SJV study area. Striped bass are not observed where GGS persist in rice growing regions (E. Hansen 2005). In addition to striped bass, channel catfish and black basses from 2-8 pounds were not uncommon.

In rice growing regions, irrigation systems are dried down at the end of each growing season, preventing predatory fish from becoming large enough to consume GGS. Because much of the water conveyance infrastructure in SJV is also used to divert tile and surface drainage and to provide water for overwintering waterfowl, the water in SJV is more permanent. Subsequently, unlike their counterparts in rice growing regions, predatory fishes in SJV likely grow through multiple seasons and attain larger sizes. Because much of the available wetlands in SJV are drained for moist soil management during the GGS active season, GGS are likely forced to inhabit the permanent drainages and waterways that form the foundation of the irrigation system, perhaps exposing themselves to elevated rates of predation by these larger fish.

Pathology

The species' decline might also be attributed to pathological factors In 1992, George Hansen (*in*. *litt*.) documented parasite infestations in GGS from the American Basin in Sacramento County. Unidentified filarial nematode worms, possibly of the genus *Eustrongylides* (G. Wylie. *pers. comm.*) that have been identified in San Francisco garter snakes (*Thamnophis sirtalis tetrataenia*) (USFWS 1999), were observed in several captive-held snakes. Affected snakes developed lumps under the skin from which worms exited after burrowing their way out. Several neonates exhibiting the lumps died after lingering malaise, and those that survived showed lower growth rates then their unaffected siblings. Older infected snakes appeared to have difficulty breathing 1 to 2 days prior to death. The worms appear to be transferred from mother to young in vitro, and may contribute to low survival rates among neonates (E. Hansen *unpublished data*). Dietary transfer of *Eustrongylides* from mosquitofish to bullfrogs are documented under laboratory conditions, resulting in death of bullfrogs due to kidney, spleen, and liver hemorrhaging (Modzelewski and Culley 1974); both mosquitofish and bullfrogs are prey to GGS. At the time of the original report in 1992, George Hansen had not observed the parasites or the associated lumps in any GGS populations outside of the American Basin (*in litt*. 1992). Since 1992, however, lumps consistent with the parasitic infestation have been increasingly observed in GGS throughout their range (Dickert *pers. comm.*; Hansen *unpublished notes*; Wylie *pers*. *comm*.), and were observed to varying degrees in the majority of snakes observed during this study. Necropsies and surgeries have shown these parasites in a variety of organs and tissues (E. Hansen *unpublished notes*; G. Hansen *unpublished notes,* R. Wack, *pers. comm*.), making it difficult. to assess relative health based on visible, sub-cutaneous lumps. Pathology and population health has not been studied in this species.

Implications for Recovery

Recruitment

Successful recruitment of young is required to maintain stable populations. However, GGS observed during this study displayed an adult-biased size distribution typical of declining or senescing populations (Figures 7-8, Table 5). Although this sample is small (n=10) and may not accurately reflect the population's true age/size distribution, a skewed size distribution was also apparent in the sample collected by USGS in 1998. Of the 10 snakes captured, males ranged from 84-140 grams (mean = 114 grams) and females ranged from 136-790 grams (mean = 446.9 grams) (Wylie 1999), all of which are sexually mature adults. Though size classes for GGS observed by DFG are unavailable for this analysis, it is known that at least some neonates and sexually immature snakes are present at Volta Wildlife Area (Sloan 2004; DFG 2007). Regardless, the aforementioned studies may indicate that GGS population structure in SVJ differs from that which is typically observed in stable populations in the Sacramento Valley (E. Hansen 2005; Jones and Stokes 2005, 2006; Wylie et al. 1997, 2002, 2004). If the observed results in fact suggest poor representation within the younger age classes, the potential reduction in population recruitment could hinder GGS recovery in SJV.

Recolonization and Repatriation

Recovery potential may increase with habitat (e.g., water availability) and water quality improvements, allowing GGS to either recolonize or be reintroduced (repatriated) to portions of their former range. In 1996, drainage water containing high concentrations of selenium, salts, and other constituents from farms in the 97,000 acre Grassland Drainage Area formerly discharged into Salt Slough and other channels used to deliver water to GWD was diverted through a segment of the cement-lined San Luis Drain to Mud Slough, a tributary of the San Joaquin River. However, while it is true that water quality in Salt Slough and other wetland supply channels in the Grasslands has improved since the onset of the Grassland Bypass Project in 1996, there are several sources of selenium-tainted drainage still affecting water quality in these channels, especially in the south Grasslands. The sources of drainage in Grassland wetland channels include: unregulated runoff associated with heavy rainfall events, drainage flows from lands outside the Grasslands Project Area (direct discharges into Almond and Poso Drains in the South Grasslands), and drainage discharges into source waters (discharges into the Delta Mendota Canal) (Eppinger and Chilcott 2002). Discharges into the Delta Mendota Canal include those from sumps and check drains that discharge directly into the canal between O'Neil Forebay and Mendota Pool. These discharges cumulatively account for about 1,500 pounds of added selenium per year to the supply water (source: USBR 2003-2005, Monthly data reports of the Delta-Mendota Canal Water Quality Monitoring Program for Selenium and Salinity. Mid-Pacific Region, Sacramento, and Fresno California).

During the closure and cleanup of Kesterson Reservoir in 1988, contaminated soil was buried under 18" of clean topsoil. Although elevated levels of selenium continue to persist in biota at the former Kesterson Reservoir (Ohlendorf and Santolo 1994) subsequent monitoring shows a significant improvement in water quality throughout Grasslands RCD (http://www.fws.gov/sacramento/ec/grassland.htm). The removal of contaminants, the creation of permanent wetlands throughout the San Luis NWR, and the application of untainted water to the numerous private wetlands in Grasslands RCD may provide an opportunity to recover populations of GGS where local extirpations have occurred. When provided with ample water during the active season, GGS are demonstrated using newly-constructed wetlands (E. Hansen, *unpublished data*; Jones and Stokes 2005; Wylie et al. 2002). Recolonization, however, will depend upon successful recruitment within source populations and compatible water management. As was noted in the section on Water Management, management of private wetlands in the Grasslands Area has shifted from irrigated pasture to moist soil management. This management regime would likely not provide adequate water during the hot summer months, forcing GGS to move to nearby less desirable or drainwater contaminated agricultural lands and ditches.

Although GGS were not detected north of the San Joaquin River, the habitat features appear largely suitable and prey is comparable to that found where GGS are documented (Table 7). Theoretically, GGS could access SMWD and areas northeast of the San Joaquin River by traveling through the system of interconnected wetlands, pools, and swales associated with the Mud Slough, Salt Slough, and San Joaquin River drainages to the south (CNDDB 2006). In fact, long-time residents interviewed during the course of this study described seeing snakes matching the description of GGS on a fairly regular basis prior to the 1970's. Because water here is described as superior – at least historically – to that found south of the San Joaquin River, and because the Merced NWR now manages regional wetland habitat specifically for species conservation, this region may provide opportunities for GGS recovery by either facilitating the growth of undetected populations or by relocating snakes from other locations. Once again, recolonization would likely depend upon successful recruitment within source populations and upon compatible water management.

In general, habitat within the interior of SMWD is poor with regard to giant garter snakes. SMWD does not possess the rice agriculture that provides the stable network of ditches and drains that support permanent populations of giant garter snakes throughout the Central Valley, nor do they possess the abundant pools, wetlands, and low gradient streams supporting giant garter snakes in state-managed areas south and west of the San Joaquin River or present within the East Side Canal and Drainage Management Area. Soils are sandy, allowing water to quickly percolate through to subsurface levels. As a result, the majority of ditches do not possess the permanent water needed to support the populations of aquatic prey and emergent vegetation required by giant garter snakes. Although some features, such as Lake Honda, the Drainage Management Area, East Side Canal, and select pipeline locations provide suitable habitat conditions year-round, the system is largely fragmented by both dry open-ditch and previously piped segments. The limited habitat that does exist is isolated, providing little or no opportunity for giant garter snakes to migrate throughout the system to reach viable habitat as local conditions deteriorate. As such, suitability and recovery potential is greatest within the East Side Canal and Drainage Management Area as compared to laterals within the core of SMWD.

Recommendations

The rapid decline of GGS in the southern and Central San Joaquin Valley is well documented (G. Hansen and J. Brode 1980; E. Hansen 2007; G. Hansen 1988, 1996; Dickert 2003, 2005; Sloan, 2003, 2004; USFWS 1993, 1999, 2006; Williams 2004, Wylie 1999), and the decrease in captures at reference sites established since 2006 is alarming. Available data suggests that the age structure of local populations may also be skewed (E. Hansen 2007; Wylie 1999). To recover this species in SJV will require continued monitoring to seek unreported populations and to evaluate the persistence and trends associated with those that are known. This study established current baseline data throughout much of the known range of GGS in the Grasslands RCD using a standardized, repeatable trapping protocol. Because trap number and duration are standardized, results of subsequent studies executed according to these protocols can be compared across years, with less of the bias associated with comparing data collected by varying methods. To adhere to a standardized protocol will allow accurate comparisons through time, providing the data needed to assess the status of recovery in the region.

Standardized sampling of extant populations should be conducted at standard intervals to facilitate analyses of demographic characteristics such as age structure, fecundity, and survivorship, each of which may bear significantly on the species' decline in SJV. Though intensive demographic analyses have not been conducted for GGS, several models have been recently developed for studying other species within the genus *Thamnophis* (Stanford and King 2004; Lind *et al.* 2005). These and similar models require the continual monitoring of marked individuals through time, necessitating a commitment to a stable, long-term monitoring program.

In conjunction with monitoring GGS presence and demographic characteristics, future studies should seek to examine potential causes for this species' regional decline. SJV GGS populations are in rapid decline despite the presence of aquatic habitat, suggesting that causes other than habitat loss may play a role. Studies should target the interactions between water quality, water management, and pathology, to better understand and potentially reverse the observed population declines. Foremost, efforts should be made to ensure availability of summer water in areas where GGS are known to occur.

Combined with previous research, this study provides a foundation for future monitoring. Efforts to identify previously undocumented populations should continue in order to identify potential recovery opportunities. Standardized monitoring should continue in order to track GGS population trends and should include all known population clusters, including efforts to assess the status of concentrations of GGS in Fresno County.

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SJV Traplines 2006-2007

North of SJ River

Trap Line ID	Traps	Start Date	End Date	Trap Days	Start Location	End Location
SJV2						
Atwater Drain at Arena Plains	50	5/13/2006	5/28/2006	700	E. 702484 N. 4126755	E. 702886 N. 4126663
SJV5						
East Side Canal at Snowbird	50	5/19/2006	6/ 3/2006	750	E. 699760 N. 4127549	E. 700136 N. 4127412
SJV7						
Turner Slough	50	5/25/2006	6/ 9/2006	750	E. 686613 N. 4130804	E. 686796 N. 4130925
SJV8						
Arena Plains Wetland 1	50	5/28/2006	5/30/2006	100	E. 702512 N. 4127001	E. 702592 N. 4126804
SJV10						
East Side Canal at Hwy 140	50	5/31/2006	6/15/2006	750	E. 694757 N. 4131514	E. 694431 N. 4131728
SJV13						
Atwater Drain at Snowbird	50	6/ 3/2006	6/17/2006	700	E. 699834 N. 4127013	E. 700171 N. 4127256
SJV14						
Arena Plains Wetland 2	50	6/ 4/2006	6/19/2006	750	E. 702104 N. 4127666	E. 702094 N. 4127674
SJV19						
E Side Canal/Stevinson Ranch	50	6/15/2006	6/30/2006	700	E. 693726 N. 4132219	E. 693381 N. 4132476
SJV22						
Bear Creek at Snowbird	50	6/18/2006	7/ 3/2006	750	E. 698648 N. 4126182	E. 699014 N. 4126294
SJV23						
Arena Plains Wetland 3	50	6/19/2006	7/ 4/2006	750	E. 702049 N. 4127249	E. 702131 N. 4127447
SJV24						
Big Bottom Lake	50	6/ 9/2006	6/22/2006	400	E. 686457 N. 4130831	E. 686529 N. 4130964
SJV37						
Merced NWR 1	50	7/22/2006	8/ 6/2006	750	E. 712389 N. 4119143	E. 712640 N. 4119006

Trap Line ID	Traps	Start Date	End Date	Trap Days	Start Location	End Location
North of SJ River (cont.)						
SJV38						
Merced NWR 2 Dead Man Creek	50	7/23/2006	7/31/2006	160	E. 710705 N. 4117205	E. 710386 N. 4117412
SJV39						
Merced NWR 3	50	7/24/2006	8/ 8/2006	750	E. 712380 N. 4119406	E. 712381 N. 4119010
SJV40						
East Side Canal 4	50	7/26/2006	8/10/2006	750	E. 702712 N. 4124990	E. 703025 N. 4124696
SJV41						
East Side Canal 5 Mariposa	50	7/27/2006	8/11/2006	750	E. 704295 N. 4121609	E. 704171 N. 4122001
SJV42						
East Side Canal 6	50	7/28/2006	8/12/2006	750	E. 701253 N. 4126414	E. 701568 N. 4126134
SJV45						
East Side Canal 7	50	8/ 4/2006	8/19/2006	700	E. 704724 N. 4119864	E. 704823 N. 4119802
SJV46						
Merced NWR 4	50	7/25/2006	8/ 9/2006	750	E. 711203 N. 4117480	E. 711012 N. 4117304
SJV48						
Modesto Properties Drake Ditch	50	8/ 2/2006	8/17/2006	750	E. 698479 N. 4127253	E. 698725 N. 4127585
SJV76						
East Side Canal 1	50	6/ 9/2007	6/23/2007	700	E. 703679 N. 4123529	E. 703537 N. 4123976
SJV77						
East Side Canal 2	50	6/10/2007	6/24/2007	700	E. 697751 N. 4129298	E. 697499 N. 4129666
SJV78						
East Side Canal 3	50	6/14/2007	6/28/2007	700	E. 698427 N . 4128227	E. 698173 N. 4128631
SJV79						
East Side Canal 4	50	6/15/2007	6/29/2007	700	E. 704383 N. 4120408	E. 704334 N. 4120859
SJV80						
Crane Ditch @ Modesto Properties	50	6/16/2007	7/ 1/2007	750	E. 698635 N. 4127491	E. 698846 N. 4127629
SJV82						
East Side Canal 5	50	6/20/2007	7/ 4/2007	666	E. 705138 N. 4119641	E. 704752 N. 4119836

North of SJ River (cont.)						
Trap Line ID	**Traps**	**Start Date**	**End Date**	**Trap Days**	**Start Location**	**End Location**
SJV83						
Merced NWR N – Ditch 1	50	6/21/2007	7/ 5/2007	699	E. 712379 N. 4119428	E. 712380 N. 4119008
SJV84						
Merced NWR N – Ditch 2	50	6/22/2007	6/23/2007	50	E. 712370 N. 4119804	E. 712375 N. 4119455
SJV85						
Merced NWR N – Duck Slough	50	6/23/2007	7/ 7/2007	650	E. 713149 N. 4120361	E. 712745 N. 4118592
SJV86						
Merced NWR N – Deadman Crk	50	6/23/2007	7/ 6/2007	697	E. 711777 N. 4118677	E. 711598 N. 4120248
SJV87						
Arena Plains – Bear Crk	50	6/24/2007	7/ 8/2007	700	E. 702770 N. 4125266	E. 702479 N. 4125405
SJV88						
Merced NWR S – E Side Bypass	50	6/28/2007	7/12/2007	700	E. 710610 N. 4115611	E. 710291 N. 4115933
SJV89						
Merced NWR N –NW Lake	50	6/29/2007	7/13/2007	700	E. 711651 N. 4120171	E. 711632 N. 4119899
SJV90						
Merced NWR S – W Ditch	50	6/30/2007	7/14/2007	697	E. 710278 N. 4116422	E. 710700 N. 4116563
SJV91						
Wally’s Ford @ Modesto Properties	50	7/ 1/2007	7/15/2007	700	E. 698103 N. 4126718	E. 697958 N. 4126862
SJV92						
East Side Canal 6	50	7/ 4/2007	7/18/2007	700	E. 693765 N. 4132204	E. 693402 N. 4132466
SJV93						
Merced NWR S – Deadman Crk	50	7/ 5/2007	7/19/2007	700	E. 711222 N. 4117579	E. 710945 N. 4117268
SJV94						
Arena Plains – Atwater Drain	50	7/ 7/2007	7/21/2007	700	E. 702879 N. 4126652	E. 702584 N. 4126726
SJV95						
Bear Crk @ SnoBird	50	7/ 8/2007	7/22/2007	625	E. 699146 N. 4126318	E. 699565 N. 4126234
SJV96						
East Side Canal 7	25	7/12/2007	7/22/2007	245	E. 692432 N. 4133396	E. 692544 N. 4133210

Appendix A. 2006-2007 SJV Trapline Dates and Locations (UTM Zone 10, NAD 1927)

South of SJ River Trap Line ID	Traps	Start Date	End Date	Trap Days	Start Location	End Location
SJV1						
Big Water Drain at Santa Fe Rd.	50	5/10/2006	5/25/2006	750	E. 700481 N. 4098720	E. 700339 N. 4098882
SJV3						
Agatha at Poso	50	5/17/2006	6/ 1/2006	750	E. 703981 N. 4096155	E. 703970 N. 4095817
SJV4						
Los Banos Creek North	50	5/18/2006	6/ 2/2006	750	E. 683676 N. 4119996	E. 683632 N. 4119991
SJV6						
Los Banos Creek SW	50	5/23/2006	6/ 7/2006	750	E. 685900 N. 4117306	E. 686096 N. 4116975
SJV9						
Mud Slough at Klamath Club	50	5/27/2006	6/11/2006	750	E. 697081 N. 4105105	E. 697362 N. 4105014
SJV11						
Agatha Canal at CLCC	49	6/ 1/2006	6/16/2006	735	E. 702504 N. 4098548	E. 702561 N. 4098140
SJV12						
San Luis Creek East	50	6/ 3/2006	6/17/2006	700	E. 686067 N. 4116972	E. 685587 N. 4116964
SJV15						
Los Banos Creek SE	50	6/ 7/2006	6/12/2006	250	E. 685929 N. 4117309	E. 685958 N. 4117413
SJV16						
Mud Slough 2	50	6/11/2006	6/26/2006	750	E. 696798 N. 4105789	E. 696852 N. 4105620
SJV17						
Los Banos Creek 2	50	6/12/2006	8/19/2006	3400	E. 686075 N. 4116991	E. 685905 N. 4117297
SJV18						
Mud Slough Drift Fence	50	6/10/2006	7/10/2006	1450	E. 696914 N. 4105934	E. 696941 N. 4105910
SJV20						
Clear Lake North	50	6/16/2006	6/23/2006	350	E. 701863 N. 4099225	E. 702346 N. 4099232
SJV21						
Blue Goose Interior 1	50	6/17/2006	7/ 2/2006	750	E. 690817 N. 4119518	E. 691151 N. 4119247

Appendix A. 2006-2007 SJV Trapline Dates and Locations (UTM Zone 10, NAD 1927)

South of SJ River (cont.) Trap Line ID	Traps	Start Date	End Date	Trap Days	Start Location	End Location
SJV25						
Blue Goose at Hwy 165	50	6/23/2006	6/25/2006	100	E. 691375 N. 4119299	E. 691545 N. 4118861
SJV26						
Blue Goose Interior 2	50	6/26/2006	7/11/2006	750	E. 689702 N. 4120166	E. 689429 N. 4120461
SJV27						
San Luis Refuge Dead Man Slough	50	7/ 2/2006	7/17/2006	700	E. 693146 N. 4120309	E. 693183 N. 4120508
SJV28						
Mosquito Ditch NE	50	7/11/2006	7/26/2006	700	E. 686106 N. 4116472	E. 686115 N. 4116915
SJV29						
Santa Fe Canal at Kesterson	50	7/ 7/2006	7/22/2006	700	E. 684387 N. 4125836	E. 684379 N. 4126333
SJV30						
E3P Marsh at Kesterson	50	7/ 8/2006	7/23/2006	700	E. 685176 N. 4125949	E. 685112 N. 4126180
SJV31						
Beaver Pond at Kesterson	50	7/ 9/2006	7/24/2006	750	E. 684413 N. 4126448	E. 684336 N. 4126454
SJV32						
Mosquito Ditch SW	50	7/12/2006	7/27/2006	750	E. 686092 N. 4116054	E. 686097 N. 4116449
SJV33						
San Luis Creek West	50	7/13/2006	7/28/2006	750	E. 683362 N. 4116995	E. 683552 N. 4116992
SJV34						
Poso Drain at Mallard Rd.	50	7/16/2006	7/30/2006	700	E. 703924 N. 4096169	E. 704283 N. 4095930
SJV35						
Agatha Canal at Clear Lake 2	50	7/17/2006	7/31/2006	700	E. 702840 N. 4097864	E. 703296 N. 4097574
SJV36						
Agatha Canal at Clear Lake 3	50	7/20/2006	8/ 4/2006	750	E. 703705 N. 4097315	E. 703311 N. 4097564
SJV43						
Almaden Ditch	50	7/30/2006	8/14/2006	750	E. 701409 N. 4094738	E. 701813 N. 4094820
SJV44						
Helm Canal at Frog Pond Club	50	7/31/2006	8/15/2006	750	E. 701861 N. 4090354	E. 702323 N. 4090321

Appendix A. 2006-2007 SJV Trapline Dates and Locations (UTM Zone 10, NAD 1927)

South of SJ River (cont.) Trap Line ID	Traps	Start Date	End Date	Trap Days	Start Location	End Location
SJV47						
Los Banos Creek / Salinas Drift Fence	25	7/21/2006	8/18/2006	700	E. 685892 N. 4117318	E. 685887 N. 4117339
SJV49						
Los Banos Creek Drift Fence 2	25	8/ 5/2006	8/18/2006	325	E. 685870 N. 4117297	E. 685889 N. 4117295
SJV50						
Almond Drive Ditch	50	8/ 6/2006	8/ 8/2006	100	E. 696915 N. 4096725	E. 697307 N. 4096725
SJV51						
Blue Goose	50	5/ 1/2007	5/15/2007	700	E. 690769 N. 4119535	E. 690463 N. 4119618
SJV52						
SNLNWR South-Sousa	50	5/ 2/2007	5/16/2007	700	E. 698793 N. 4116294	E. 698360 N. 4116289
SJV53						
SNLNWR – Barracks Ditch	50	5/ 3/2007	5/22/2007	950	E. 695977 N. 4116210	E. 695965 N. 4116624
SJV54						
SNLNWR South - Winton	50	5/ 4/2007	5/18/2007	700	E. 697519 N. 4116280	E. 697084 N. 4116223
SJV55						
Kesterson - Freitas	50	5/ 5/2007	5/19/2007	700	E. 688143 N. 4124826	E. 688288 N. 4124398
SJV56						
SNLNWR South – SW Marsh	50	5/ 8/2007	5/17/2007	450	E. 696424 N. 4116178	E. 696004 N. 4116149
SJV57						
Kesterson – Mud Slough	50	5/ 9/2007	5/23/2007	700	E. 685221 N. 4127077	E. 685131 N. 4127034
SJV58						
SNLNWR WEST - BEAR	50	5/10/2007	5/24/2007	700	E. 691930 N. 4126106	E. 692266 N. 4125809
SJV59						
SNLNWR WEST – Bear Crk	50	5/11/2007	5/25/2007	700	E. 694117 N. 4122595	E. 693768 N. 4122334
SJV60						
Mosquito Ditch @ Salinas Club	50	5/12/2007	8/10/2007	3720	E. 686084 N. 4116966	E. 685913 N. 4117312
SJV61						
Salinas Service Ditch	50	5/15/2007	5/30/2007	750	E. 684400 N. 4116967	E. 684826 N. 4116971

South of SJ River (cont.) Trap Line ID	Traps	Start Date	End Date	Trap Days	Start Location	End Location
SJV62						
SALINAS Service Ditch	50	5/16/2007	5/31/2007	750	E. 685238 N. 4116958	E. 685647 N. 4116959
SJV63						
Drift Fence @ Salinas Club	25	5/20/2007	6/24/2007	818	E. 685888 N. 4117297	E. 685873 N. 4117293
SJV64						
Hollister Drain West	50	5/23/2007	6/ 6/2007	700	E. 686157 N. 4117300	E. 686159 N. 4117306
SJV65						
Mosquito Ditch	50	5/25/2007	6/ 8/2007	700	E. 686095 N. 4116511	E. 686100 N. 4116927
SJV66						
Mosquito Peripheral Ditch	50	5/26/2007	6/ 9/2007	700	E. 686083 N. 4116996	E. 685945 N. 4117335
SJV67						
Ingomar Drain at Salinas	50	5/27/2007	6/10/2007	700	E. 685165 N. 4116941	E. 685584 N. 4116931
SJV68						
West Side Drain @ Gustine	50	5/30/2007	6/ 5/2007	300	E. 681247 N. 4121271	E. 681231 N. 4121702
SJV69						
West Side Drain @ Gustine	50	5/31/2007	6/14/2007	700	E. 681189 N. 4123311	E. 681197 N. 4123104
SJV70						
Eagle Ditch @ Hollister	50	6/ 1/2007	6/15/2007	700	E. 685279 N. 4120764	E. 685648 N. 4120515
SJV71						
Kesterson Ditch @Meadowlark	50	6/ 2/2007	6/16/2007	700	E. 688829 N. 4118789	E. 688597 N. 4118551
SJV72						
Kesterson Ditch @HayWire	50	6/ 3/2007	6/17/2007	700	E. 687888 N. 4117970	E. 687458 N. 4117956
SJV73						
Brood Ponds @Meadowlark	50	6/ 6/2007	6/20/2007	700	E. 688591 N. 4119145	E. 688581 N. 4119142
SJV74						
Los Banos Creek @ Gustine	50	6/ 7/2007	6/21/2007	620	E. 682414 N. 4123400	E. 682403 N. 4123399
SJV75						
Eagle Ditch @ Hollister	50	6/ 8/2007	6/22/2007	700	E. 684551 N. 4121206	E. 684852 N. 4120879

South of SJ River (cont.) Trap Line ID	Traps	Start Date	End Date	Trap Days	Start Location	End Location
SJV81						
Hollister Lake	50	6/17/2007	6/30/2007	640	E. 685251 N. 4120538	E. 684987 N. 4120671
SJV97						
Agatha Extension	50	7/21/2007	8/ 4/2007	628	E. 703887 N. 4096080	E. 704018 N. 4095709
SJV111						
Agatha Canal @ CWLCC 1	50	8/18/2007	8/25/2007	349	E. 702499 N. 4098610	E. 702442 N. 4099068
SJV112						
Agatha Canal @ CWLCC 2	50	8/19/2007	8/26/2007	332	E. 703962 N. 4097120	E. 703997 N. 4096639
SJV113						
Bennett Drain @ Britto Rd	50	8/24/2007	9/ 7/2007	700	E. 704447 N. 4096752	E. 704053 N. 4096916
SJV114						
Poso Drain @ Mallard Rd	50	8/25/2007	9/ 8/2007	700	E. 703972 N. 4096161	E. 704284 N. 4095934

Mendota Wildlife Area Trap Line ID	Traps	Start Date	End Date	Trap Days	Start Location	End Location
SJV98						
Mendota WA – Tule 1	50	7/25/2007	8/22/2007	1400	E. 742485 N. 4063333	E. 742300 N. 4063744
SJV99						
Mendota WA – Tule 2	50	7/26/2007	8/27/2007	1600	E. 742383 N. 4063781	E. 742550 N. 4063357
SJV100						
Mendota WA – Tule 3	50	7/27/2007	8/30/2007	1700	E. 742738 N. 4063067	E. 742538 N. 4063306
SJV101						
Mendota WA – Tule 4	50	7/28/2007	8/29/2007	1600	E. 742569 N. 4063345	E. 742864 N. 4063161
SJV102						
Mendota WA – Tule 5	50	7/29/2007	8/12/2007	700	E. 741499 N. 4063909	E. 741111 N. 4063907
SJV103						
Mendota WA – Slough 6	50	8/ 2/2007	8/16/2007	700	E. 739576 N. 4063641	E. 739573 N. 4063625
SJV104						
Mendota WA – Ditch 7	50	8/ 3/2007	8/16/2007	645	E. 739283 N. 4064678	E. 739486 N. 4065107

Mendota Wildlife Area (cont.) Trap Line ID	Traps	Start Date	End Date	Trap Days	Start Location	End Location
SJV105						
Mendota WA – Ditch 8	50	8/ 4/2007	8/18/2007	693	E. 739976 N. 4062671	E. 739942 N. 4063163
SJV106						
Mendota WA - Ditch 9	50	8/ 5/2007	8/16/2007	543	E. 738995 N. 4062748	E. 738766 N. 4062328
SJV107						
Mendota WA - East	50	8/ 9/2007	8/23/2007	696	E. 740914 N. 4066955	E. 740447 N. 4066927
SJV108						
Mendota WA - East	50	8/10/2007	8/24/2007	700	E. 740472 N. 4067367	E. 740928 N. 4067198
SJV109						
Mendota WA - Ditch 12	50	8/11/2007	8/25/2007	700	E. 741036 N. 4067600	E. 740918 N. 4067296
SJV110						
Mendota WA - Ditch 13	50	8/12/2007	8/26/2007	699	E. 740053 N. 4067072	E. 740327 N. 4067398

Appendix B. Photographs of 2006-7 SJV Traplines Corresponding to Appendix A

North of SJ River 2006

1. SJV2

2. SJV5

3. SJV7

PHOTO NOT AVAILABLE

4. SJV8

PHOTO NOT AVAILABLE

5. SJV10

6. SJV13

North of SJ River 2006 (continued)

7. SJV14

8. SVJ19

9. SJV22

10. SJV23

11. SJV24

12. SVV37

North of SJ River 2006 (continued)

13. SJV38

16. SJV41

14. SJV39

17. SJV42

15. SJV40

18. SJV45

North of SJ River 2006 (continued)

19. SJV46

20. SJV48

North of SJ River 2007

21. SJV76

22. SJV77

23. SJV78

24. SJV79

25. SJV80

26. SJV82

North of SJ River 2007 (continued)

27. SJV83

30. SJV86

28. SJV84

31. SJV87

29. SJV85

32. SJV88

North of SJ River 2007 (continued)

33. SJV89

34. SJV90

35. SJV91

36. SJV92

37. SJV93

38. SJV94

North of SJ River 2007 (continued)

39. SJV95

40. SJV96

South of SJ River 2006

41. SJV1

44. SJV6

42. SJV3

45. SJV9

43. SJV4

46. SJV11

South of SJ River 2006 (continued)

47. SJV12

50. SJV17

48. SJV15

51. SJV18

49. SJV16

52. SJV20

South of SJ River 2006 (continued)

53. SJV21

56. SJV27

PHOTO NOT AVAILABLE

54. SJV25

57. SJV28

PHOTO NOT AVAILABLE

55. SJV26

58. SJV29

South of SJ River 2006 (continued)

59. SJV30

62. SJV33

60. SJV31

63. SJV34

61. SJV32

64. SJV35

South of SJ River 2006 (continued)

65. SJV36

66. SJV43

67. SJV44

68. SJV47

PHOTO NOT AVAILABLE

69. SJV49

70. SJV50

South of SJ River 2007

71. SJV51

72. SJV52

73. SJV53

74. SJV54

75. SJV55

76. SJV56

South of SJ River 2007 (continued)

77. SJV57

78. SJV58

79. SJV59

80. SJV60

81. SJV61

82. SJV62

South of SJ River 2007 (continued)

83. SJV63

84. SJV64

85. SJV65

86. SJV66

87. SJV67

88. SJV68

South of SJ River 2007 (continued)

89. SJV69

90. SJV70

91. SJV71

92. SJV72

93. SJV73

94. SJV74

South of SJ River 2007 (continued)

95. SJV75

96. SJV81

97. SJV97

98. SJV111

99. SJV112

100. SJV113

South of SJ River 2007 (continued)

101. SJV114

Mendota Wildlife Area 2007

102. SJV98

105. SJV101

103. SJV99

106. SJV102

104. SJV100

107. SJV103

Mendota Wildlife Area 2007 (continued)

PHOTO NOT AVAILABLE

108. SJV104

111. SJV107

109. SJV105

112. SJV108

110. SJV106

113. SJV109

Mendota Wildlife Area 2007 (continued)

114. SJV110

SJV 2006-2007 GGS Captures*

Date	PIT	Sex	Mass (g)	SVL (mm)	Easting	Northing	Quadrangle	Township	Range	Section	Quarter
5/19/2006	466C4D142C	F	297	685	E. 703925	N. 4095952	DOS PALOS	T. 11	R. 11 E.	12	NE
5/24/2006	466C594568	M	107	640	E. 685918	N. 4117242	INGOMAR	T. 9	R. 10 E.	6	NE
6/1/2006	466D191B02	F	331	790	E. 685921	N. 4117287	INGOMAR	T. 9	R. 10 E.	6	NE
6/1/2006	46730F6A25	F	469	895	E. 685923	N. 4117297	INGOMAR	T. 9	R. 10 E.	6	NE
6/4/2006	4851485A62	M	130	635	E. 685853	N. 4116965	INGOMAR	T. 9	R. 10 E.	6	NE
6/14/2006	46731F1732	M	114	640	E. 685642	N. 4116968	INGOMAR	T. 9	R. 10 E.	6	NE
6/22/2006	465B552149	M	169	665	E. 686040	N. 4117040	INGOMAR	T. 9	R. 10 E.	5	NW
6/26/2006	48312D3600	M	145	657	E. 685912	N. 4117280	INGOMAR	T. 9	R. 10 E.	6	NE
5/15/2007	985120030583004	M	147	685	E. 684615	N. 4116978	INGOMAR	T.9	R. 10 E.	6	NW
6/26/2006	483B7172480	F	551	890	E. 685376	N. 4120696	SAN LUIS RANCH	T. 8	R. 10 E.	33	NE

*First capture only

PI - Eric C. Hansen

YEAR	Individual	Total Labor	% Benefits	Personnel total (salary + benefits)	Travel	Operating Expenses	Total Direct Costs	Overhead Rate (% of Total Direct Costs)	Indirect Costs	Total by Task
2007	Project Manager	$ 9,905.28	25	$12,381.60						
	Principal Investigator	$ 57,792.50	25	$72,240.60						
	Technician	$ 30,994.20	25	$38,742.80						
					$9319.77	$4406.39	$137,091.14	15.000%	$20,563.70	**$157,655**
TOTALS		**$ 98,691.98**		**$123,365**	**$9319.77**	**$4406.39**	**$137,091.14**		**$20,563.70**	**$157,655**

Approximate Hourly Breakdown by Task

Field Hours (Task 1)	1375
Project Management, Data Analysis, and Report Hours (Task 2)	150

Timeline

Task 1	May 1 to September 8, 2007
Task 2	May 1, 2007 to April 15, 2008