U.S. Fish & Wildlife Service

Revised Draft Recovery Plan for Giant Garter Snake (*Thamnophis gigas*)

Photo by David Kelly, U.S. Fish and Wildlife Service

Revised Draft Recovery Plan for the Giant Garter Snake

(*Thamnophis gigas*)

(2015)

Region 8
U.S. Fish and Wildlife Service
Sacramento, California

Approved: XXXXXXXXXXXXXXXXXXXX

Regional Director, U.S. Fish and Wildlife Service
Pacific Southwest Region, Region 8.

Date: XXXXXXXXX

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An electronic copy of this revised draft recovery plan will be made available at:
http://www.fws.gov/endangered/species/recovery-plans.html

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EXECUTIVE SUMMARY

The giant garter snake (*Thamnophis gigas*) was federally listed as a threatened species on October 20, 1993. Historical records suggest that the giant garter snake inhabited fresh water marshes, streams, and wetlands throughout the length of the Sacramento and San Joaquin valleys in Central California. Today only about 5 percent of its historical wetland habitat acreage remains. The 13 populations identified at listing were isolated from one another with no protected dispersal corridors. Nine populations are recognized in this revised draft recovery plan following an update of the thirteen populations described in the original listing. This change is based on recent surveys, which indicate that two populations were extirpated, and on genetic research, which lead to the grouping together of some of the populations.

The giant garter snake has specific habitat needs that include summer aquatic habitat for foraging, bankside basking areas with nearby emergent vegetation for cover and thermal regulation, and upland refugia for extended periods of inactivity. Perennial wetlands provide the highest quality habitat for the giant garter snake, and rice lands, with the interconnected water conveyance structures, serve as an alternative habitat in the absence of higher-quality wetlands. The loss and subsequent fragmentation of habitat is the primary threat to the giant garter snake throughout the Central Valley of California. Habitat loss has occurred from urban expansion, agricultural conversion, and flood control. Habitat fragmentation restricts dispersal and isolates populations of the giant garter snake increasing the likelihood of inbreeding, decreasing fitness, and reducing genetic diversity. These factors have ultimately resulted in the snake being extirpated from the southern one-third of its range in former wetlands associated with the historical Buena Vista, Tulare, and Kern lakebeds. In addition to habitat loss, the remaining Central Valley populations of the giant garter snake are subject to the cumulative effects of a number of other existing and potential threats, including: roads and vehicular traffic, climate change, and predation by non-native species.

Recovery Strategy: The strategy used to recover the giant garter snake is focused on protecting existing, occupied habitat and identifying and protecting areas for habitat restoration, enhancement, or creation including areas that are needed to provide connectivity between populations. Appropriate management is needed for all giant garter snake conservation lands to ensure that stable and viable populations can be maintained in occupied areas, and that colonization will be promoted in restored and enhanced unoccupied habitat. We defined nine recovery units that correspond directly to the nine geographically and genetically distinct populations, to aid in our recovery planning: Butte Basin, Colusa Basin, Sutter Basin, American Basin, Yolo Basin, Delta Basin, Cosumnes-Mokelumne Basin, San Joaquin Basin, and Tulare Basin.

Recovery Goal and Objective: The objective of this revised draft recovery plan is to reduce threats to and improve the population status of the giant garter snake sufficiently to warrant delisting. To achieve this goal we have defined the following objectives:

1. Establish and protect self-sustaining populations of the giant garter snake throughout the full ecological, geographical, and genetic range of the species.
2. Restore and conserve healthy Central Valley wetland ecosystems that function to support the giant garter snake and associated species and communities of conservation concern such as Central Valley waterfowl and shorebird populations.
3. Ameliorate or eliminate, to the extent possible, the threats that caused the species to be listed or are otherwise of concern, and any foreseeable future threats.

Recovery Criteria:

Factor A Criteria:

- Sufficient habitat is protected to support populations of giant garter snakes.
- Populations are connected with corridors of suitable habitat.
- Management plans and best management practices oriented to giant garter snake conservation are developed and implemented (and adaptively updated based on current research).
- Protected habitat is supplied with a reliable source of clean water during the critical active summer months.

Factor C Criteria:

- Threats due to disease are reduced or removed.

Factor E Criteria:

- Monitoring in recovery units demonstrates stable or increasing populations and evidence that the identified populations and their habitats are viable over a 20-year period including at least one 3-year drought.

Actions Needed:

1. Protect existing habitat, areas identified for restoration or creation, and areas that will provide connectivity between preserved areas of habitat.
2. Develop and implement appropriate management of habitat on public and private wetlands and conservation lands.
3. Improve water quality in areas occupied by the giant garter snake and affected by poor water quality conditions.
4. Ensure summer water is available for wetland habitats used by the snake.
5. Establish an incentive or easement program(s) to encourage private landowners and local agencies to provide or maintain giant garter snake habitat.
6. Monitor populations and habitat to assess the success or failure of management activities and habitat protection efforts.
7. Conduct surveys and research to identify areas requiring protection and management.
8. Conduct research focused on the management needs of the species, and on identifying and removing threats.
9. Establish and implement outreach and education, which includes the participation of landowners; interested public and stakeholders; and other Federal, State, and local agencies.
10. Reestablish populations within the giant garter snake's historical range.

Total Estimated Cost of Recovery: As described in the Act, we are required to estimate the cost of implementing all measures described in this recovery plan. In order to best provide for the conservation and recovery of the species and develop a reasonable cost estimate, we will maximize partnerships with Federal, State, and non-governmental partners. Due to the complexity of this plan and number of actions needed to accomplish recovery, we are continuing to develop the cost estimates for the actions described in this draft plan. We will provide a revised draft for further public review and comment once we have completed our cost estimates.

Date of Recovery: Delisting could be initiated by 2045 if recovery criteria have been met including: protection of habitat and creation of population corridors. These criteria are likely to take at least 10 years to achieve. Additionally, recovery requires that giant garter snake populations be self-

sustaining over the long-term. Therefore, a 20-year monitoring period is recommended to cover multiple generations (four to five generations) to provide a reliable estimate of population change. This monitoring period must also include one 3-year drought to ensure that giant garter snakes are no longer threatened by an insufficient water supply.

Recovery Criteria:

Factor A Criteria:

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- Populations are connected with corridors of suitable habitat.
- Management plans and best management practices oriented to giant garter snake conservation are developed and implemented (and adaptively updated based on current research).
- Protected habitat is supplied with a reliable source of clean water during the critical active summer months.

Factor C Criteria:

- Threats due to disease are reduced or removed.

Factor E Criteria:

- Monitoring in recovery units demonstrates stable or increasing populations and evidence that the identified populations and their habitats are viable over a 20-year period including at least one 3-year drought.

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I. BACKGROUND

A. OVERVIEW

The U.S. Fish and Wildlife Service listed the giant garter snake *(Thamnophis gigas)* as a threatened species on October 20, 1993 (Service 1993) under the Endangered Species Act of 1973 (Act), as amended. Critical habitat has not been designated for the giant garter snake. Since the 1993 listing rule, a threats assessment and review of the biological status were conducted in 5-year status reviews for the species in 2006 and 2012 (Service 2006a, 2012). We will conduct a new 5-year status review for release concurrent with the finalization of this revised draft recovery plan.

Recovery plans focus on restoring the ecosystems on which a species is dependent, reducing threats to the species, or both. A recovery plan constitutes an important Service document that presents a logical path to recovery of the species based on what we know about the species' biology and life history, and how threats impact the species. Recovery plans help to provide guidance to the Service, States, and other partners on ways to eliminate or reduce threats to listed species and measurable objectives against which to measure progress towards recovery. Recovery plans are advisory documents, not regulatory documents, and do not substitute for the determinations and promulgation of regulations required under section 4(a)(1) of the Act. A decision to revise the listing status of a species or to remove it from the Federal List of Endangered and Threatened Wildlife (50 CFR 17.11) or Plants (50 CFR 17.12) is ultimately based on an analysis of the best scientific and commercial data available to determine whether a species is no longer an endangered species or a threatened species.

The following discussion summarizes characteristics of giant garter snake biology, demography, distribution, population status, and threats that are relevant to recovery. Additional information is available in the 2012 5-year status review (http://ecos.fws.gov/speciesProfile/profile/speciesProfile?spcode=C057) and associated literature.

B. TAXONOMY AND DESCRIPTION

The giant garter snake was first described and named by Henry S. Fitch (1940) as *Thamnophis ordinoides gigas*. A study based on biochemical data (Lawson and Dessauer 1979) pointed toward the species-level distinctness of *T. gigas*. Rossman and Stewart (1987) used morphological characters to further examine and reevaluate the taxon and formally recognized the giant garter snake, *T. gigas*, as a full species. This recognition remains today.

The giant garter snake can be distinguished from the common garter snake (*T. sirtalis*) and the western terrestrial garter snake (*T. elegans*) by color pattern, scale numbers and/or size, and head shape. Dorsal (back or topside) background color of giant garter snakes varies from brown to olive with a cream, yellow, or orange dorsal stripe and two light-colored lateral stripes. Some individuals have a checkered pattern of black spots between the dorsal and lateral stripes. Background coloration, prominence of the checkered pattern, and the three yellow stripes are individually and geographically variable (R. Hansen 1980). The average body length for a male giant garter snake is 60 to 70 centimeters (23.6 to 27.5 inches) and 70 to 80 centimeters (27.5 to 31.5 inches) for a female (Wylie *et al.* 2010). A complete discussion of the taxonomy and appearance for this species can be found in the most recent 5-Year Status Review (Service 2012).

C. HABITAT DESCRIPTION

The giant garter snake is endemic to the wetlands of the Sacramento and San Joaquin Valleys of California, inhibiting the tule marshes and seasonal wetlands created by overbank flooding of the rivers and streams of the Central Valley (Fitch 1940; Central Valley Joint Venture 2006). Currently, less than 5 percent of the historical 1.8 million hectares (4.5 million acres) of wetlands, or approximately 90,000 hectares (222,394 acres) remain (Central Valley Joint Venture 2006). The giant garter snake now inhabits the remaining high-quality fragmented wetlands that include marshes, ponds, small lakes, low-gradient streams with silt substrates, and managed waterways. The loss of wetland ecosystems and suitable habitat has also resulted in the giant garter snake using highly modified and degraded habitats. Located among cultivated farm lands, these areas include irrigation ditches, drainage canals, rice fields, and their adjacent uplands. Since giant garter snake surveys were first conducted in the 1970s, results have demonstrated that active rice fields and the supporting water conveyance infrastructure consisting of a matrix of canals, levees, and ditches have served as alternative habitat that is commonly used by the giant garter snakes in the absence of suitable natural marsh habitat (G. Hansen 1988; G. Hansen and Brode 1980, 1993; Brode and G. Hansen 1992; Wylie 1998a; Wylie *et al.* 1997a; Wylie and Cassaza 2000; Halstead *et al.* 2010). The giant garter snake is primarily an aquatic species, but it also occupies upland terrestrial habitat, particularly during the winter inactive season. Although usually found in or adjacent to aquatic habitats, giant garter snakes have been observed in associated uplands up to hundreds of meters (hundreds of yards) distant from any water body (Wylie *et al.* 1997a; P. Coates, U.S. Geological Survey [USGS], pers. comm. 2011).

1. Habitat Components

There are three habitat components that appear to be most important to the giant garter snake (G. Hansen 1982, 1986, 1988, 1996a; Wylie *et al.* 1995, 1997a; Halstead *et al.* 2010):

1. A fresh-water aquatic component with protective emergent vegetative cover that will allow foraging (Figure 1),
2. An upland component near the aquatic habitat that can be used for thermoregulation and for summer shelter in burrows, and,
3. An upland refugia component that will serve as winter hibernacula.

Figure 1. Typical giant garter snake habitat in the Sacramento Valley. (Photo: USGS)

Aquatic Component. The giant garter snake has been recognized as requiring aquatic habitat since it was first described, and has been consistently observed and captured in association with aquatic habitats since accounts of the snake were first published (Fitch 1940; G. Hansen and Brode 1980). The aquatic component of the giant garter snake habitat has been regarded as a steadfast requirement for the survival of the snake, and researchers acknowledge the following qualitative requirements of ideal aquatic habitat for the giant garter snake (G. Hansen 1986; G. Hansen and Brode 1980; Wylie *et al.* 1995; Dickert 2002; E. Hansen 2002):

1. Water present from March through November.
2. Slow moving or static water flow with mud substrate.
3. Presence of emergent and bankside vegetation that provides cover from predators and may serve in thermoregulation.
4. The absence of a continuous canopy of riparian vegetation.
5. Available prey in the form of small amphibians and small fish.
6. Thermoregulation (basking) sites with supportive vegetation such as folded tule clumps immediately adjacent to escape cover.
7. The absence of large predatory fish.
8. Absence of recurrent flooding, or where flooding is probable the presence of upland refugia.

Upland Component. Although the giant garter snake is predominately an aquatic species, incidental observations and radio telemetry studies have shown that the snake can be found in upland areas near the aquatic habitat component during the active spring and summer seasons (G. Hansen 1986, 1988; Brode and G. Hansen 1992; E. Hansen 2002; Dickert 2003; Wylie and Cassaza 2000, 2001; Wylie *et al.* 1995, 1997a, 2002a, 2003a, 2004, 2005). Upland habitat (land that is not typically inundated during the active season and is adjacent to the aquatic habitat of the giant garter snake) is used for basking to regulate body temperature, for cover, and as a retreat into mammal burrows and crevices in the soil during ecdysis (shedding of skin) or to avoid predation (G. Hansen and Brode 1993; Wylie *et al.* 2003a). Giant garter snakes have been observed using burrows for refuge in the summer as much as 50 meters (164 feet) away from the marsh edge (Wylie *et al.* 1997a). Important qualities of upland habitat have been found by researchers (E. Hansen 2003a; Wylie *et al.* 2003a) to include:

1. Availability of bankside vegetative cover, typically tule (*Scirpus* sp.) or cattail (*Typha* sp.), for screening from predators.
2. Availability of more permanent shelter, such as bankside cracks or crevices, holes, or small mammal burrows.
3. Free of poor grazing management practices (such as overgrazed areas).

Upland Winter Refugia Component. During the colder winter months, giant garter snakes spend their time in a lethargic state. During this period, giant garter snakes over-winter in locations such as mammal burrows along canal banks and marsh locations, or riprap along a railroad grade near a marsh or roads (Wylie *et al.* 1997a; Wylie *et al.* 2002a). Giant garter snakes typically do not over-winter where flooding occurs in channels with rapidly moving water, such as the Sutter Bypass (B. Halstead, USGS, pers. comm. 2011). Over-wintering snakes use burrows as far as 200 to 250 meters (656 to 820 feet) from the edge of summer aquatic habitat (G. Hansen 1988; Wylie *et al.* 1997a; P. Coates, pers. comm. 2010).

2. Habitat types and quality

Table 1 shows four locations representing three different levels of habitat quality where trapping surveys were conducted and population estimates were completed. The habitat quality was rated as marginal for the seasonal wetland habitat at Colusa NWR (which was being managed for wintering waterfowl at the time), moderate for both the Natomas Basin and Gilsizer Slough (both have predominate rice agriculture), and high quality for Badger Creek (natural, perennial marsh). Of all known populated sites, the 240-hectare (593 acre) Badger Creek area is believed to best represent historical giant garter snake habitat, and was found to have the highest density of snakes of the four sites (Wylie *et al.* 2010). Wylie *et al.* (2010) found from their data analysis that giant garter snakes will persist in areas dominated by rice, by foraging in flooded rice fields after the rice plants have grown sufficiently to provide cover from predators. It appears that giant garter snakes do not tolerate seasonal wetlands managed for waterfowl if there is no aquatic habitat available during the active summer season. The Body Condition Index of snakes, a measure of the energy reserves of a snake (measured as a ratio of length to mass) was analyzed for the same four sites (Wylie *et al.* 2010). It was found that the snakes at Badger Creek had the highest Body Condition Index, indicating the best health, and that the snakes at the Colusa NWR had the lowest Body Condition Index.

Table 1. Comparative studies giving population estimates and densities for sites with varying giant garter snake habitat quality. (Wylie et al. 2010)

Location / Year	Trap-Days[A]	Captures Hand/trap	Captures Trap only	Abundance[B] N (95% CI)	Density[C] Snakes/Ha (95% CI)
Badger Creek 1997	18,376	103	103	118 (111-132)	8.0 (7.6 – 9.0)
Colusa NWR 1997	12,198	53	22	29 (22-53)	0.83 (0.63-1.5)
Gilsizer Slough 1996	17,136	88	67	177 (124-280)	3.1 (2.2 – 4.9)
Natomas Basin 1999	19,170	164	141	229 (199-276)	1.7 (1.5 – 2.1)

[A] Trap-Days = number of traps used at a site X the days they were used for trapping
[B] For abundance N = number of individual snakes, CI = Confidence Interval
[C] Snakes/Ha = Snakes per Hectare

Wylie *et al.* (2000a) reported that in wetlands managed specifically to benefit giant garter snakes, home range estimates were smaller than for those areas lacking comparable management, while Wylie (1998b) found that giant garter snakes may concentrate in the best available habitat when all other surrounding habitat has been eliminated or highly degraded.

D. ECOLOGY AND DEMOGRAPHY

1. Ecology

Reproduction. Male giant garter snakes are believed to reach sexual maturity in an average of 3 years and females in an average of 5 years (USFWS 1993); therefore, we estimate that a generation is 5 years for the giant garter snake. The mating season is believed to extend from March, soon after emergence, into May (Coates *et al.* 2009). The giant garter snake usually gives birth in summer to early fall after a gestation period of 2 -3 months. R. Hansen and G. Hansen (1990) found that parturition (giving birth) for the female giant garter snakes taken into captivity occurred from late July through early September, and neonates (newly born young) emerge from the female fully developed. Litter size is variable with the giant garter snake, and averages between 17 and 23 young (R. Hansen and G. Hansen 1990; Halstead et al. 2011).

Thermal Ecology. Snakes are ectothermic animals, relying on external sources of heat to warm their bodies. Ectothermic animals regulate their body temperatures by daily behavioral activities such as basking in the sun or resting on a warm rock to heat their bodies, or by resting under vegetation or in the water to cool their bodies (Lincoln *et al.* 2001; Pough *et al.* 2001). A snake's ability to thermoregulate its body within narrow limits using external sources of heating and cooling are believed to play an important role in feeding and digestion, growth, reproduction, and in their vulnerability to predation, such as when basking without cover (Pough *et al.* 2001). Wylie *et al.* (2009a) found that giant garter snakes remain cool during hot days by remaining in underground burrows and warm themselves in cool weather by basking on canal banks.

Chemical Ecology. Chemical cues are detected by the vomeronasal system in snakes, which involves oral and nasal sensory inputs from the flicking action of the forked tongue (Pough *et al.* 2001). The ability of garter snakes to detect chemicals is important in reproduction, orientation and navigation, locating prey, and predator avoidance (Costanzo 1989a).

Daily Activity. The daily activity of giant garter snakes was described by G. Hansen and Brode (1993) as follows: (1) emergence from burrows after sunrise; (2) basking in order to warm bodies to activity temperatures, particularly during cool weather; and (3) foraging or courting activity for the remainder of the day. During radio-telemetry studies, giant garter snakes typically traveled little from day to day; however, total activity varied widely among individuals (Wylie *et al.* 1997a). Giant garter snakes usually remain in close proximity to wetland habitats but G. Hansen and Brode (1993) documented movements within the Natomas Basin, observing that giant garter snakes moved at least 400 meters (1,312 feet) between small lateral ditches and larger canals, and some giant garter snakes moved distances of greater than 800 meters (2,625 feet). Wylie *et al.* (2008) found that giant garter snakes at the Colusa Drain site in Yolo County traveled on average 100 meters (328 feet) per day during the 2006 active season and 45 meters (148 feet) per day during the 2007 active season, but decreased activity significantly during the fall and winter when daily travel was about 7 meters (23 feet).

Although Fitch (1940) and Van Denburgh and Slevin (1918) both described a strictly diurnal behavior (active during daylight only) for the giant garter snake, R. Hansen (1980) recorded a more flexible daily activity period in which he observed nocturnal activity of the giant garter snake.

Seasonal Activity. Around October 1, snakes move underground into mammal burrows, crevices, or other voids in the earth to avoid potentially lethal cool autumn and winter temperatures (G. Hansen 1988). Foraging, basking, and other activities are sporadic at this time and dependent upon weather conditions (G. Hansen and Brode 1993; Wylie *et al.* 1995). Giant garter snakes begin emerging from winter retreats around April 1 and are most active from early spring through mid-fall. Seasonal activity may begin earlier than April 1 (as early as March 1) in some years and in some locations (R. Hansen 1980; G. Hansen and Brode 1993; Wylie *et al.* 1997a). Giant garter snakes are typically active by April 15, having emerged from hibernacula, and are actively foraging (G. Hansen and Brode 1993). Giant garter snake activity peaks during April and May, and then activity is reduced during the mid- to late summer months (G. Hansen and Brode 1993).

Prey. Adult giant garter snakes feed primarily on a wide variety of native and non-native aquatic prey such as fish and amphibians, capturing all their food in the water (R. Hansen 1980). Research on several species of garter snakes suggests that diet varies with age and size, and prey availability varies seasonally and geographically (Rossman *et al.* 1996). Brode (1988) and G. Hansen (1988)

suggest the giant garter snake specializes in ambushing small fish underwater and giant garter snakes have been observed actively hunting for and capturing small fish in the wild (Fitch 1941; R. Hansen 1980; B. Halstead, pers. comm. 2011). They appear to take advantage of conditions that trap and concentrate prey items in small pools or near road culverts (Rossman *et al.* 1996) and have been observed on multiple occasions feeding on mosquito fish (*Gambusia affinis*) confined to small pools of water (R. Hansen 1980; G. Hansen and Brode 1993; G. Wylie, *in litt.* 2009).

Predators. A number of native mammals and birds are known, or are likely, predators of giant garter snakes, including raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), hawks and harriers (*Buteo* species, *Accipiter* species, *Circus cyaneus*), and great blue herons (*Ardea herodias*). Many areas supporting giant garter snakes have been documented to have abundant predators (R. Hansen 1980; G. Hansen and Brode 1993; Wylie *et al.* 1997a). However, predation is not believed to be a limiting factor in areas that provide abundant cover, high concentrations of prey items, and connectivity to a permanent water source (Wylie *et al.* 1997a).

2. Demographics

Demography, the quantitative description of a population (Krohne 2001), includes such parameters as population size, density, distribution, age structure, home range, and sex ratios. Demography provides insight into a population's age structure, growth rates and overall health, and is therefore important to wildlife management (Klemens 2000) and in measuring success in restoration of habitat and reintroductions of rare species. As a conservation tool, demographic parameters can be used to gauge the recovery of a species.

Population Size Estimates. The most fundamental of parameters used to define the demography of a population is the number of individuals in the population; these estimates are useful to wildlife managers in providing a means to determine the density of individuals in a population and to estimate the size of a self-sustaining population. Unfortunately, population counts for many animals cannot adequately estimate a population size because of the imperfect detectability of the animals (Mazerolle *et al.* 2007), such as individuals being inconspicuous, having extended periods of inactivity, having low densities, or exhibiting extensive and irregular movement (Parker and Plummer 1987; Wylie *et al.* 2010).

Table 2 displays some of the population estimates that have been published for the giant garter snake. Estimates are notably lacking for the San Joaquin Valley, and this is primarily due to low capture numbers that are insufficient for mark-recapture derived estimates (E. Hansen 2008b). Although estimates exist for some populations, inconsistent methods across years do not allow us to estimate a range-wide population size for the species. USGS is working to develop a range-wide population size estimate.

Population Density. Density is a measure of the number of individuals occupying a specific area. The measure of "ecological density" is important to species managers because it is the measure of the number of individuals per unit of appropriate habitat (Krohne 2001). Surveys from 16 different sites, trapped with varying frequency from 1999 to 2005, have shown a range of linear densities of giant garter snakes from 8 snakes per kilometer at Natomas Basin (Wylie and Cassazza 2000) to 126 snakes per kilometer at the Colusa NWR site T24 (Wylie *et al.* 2005).

Table 2. Some population estimates of giant garter snakes.

Location	Year	Trap-Days	Captures (Hand & trap)	Captures (Trap only)	Abundance N (95% CI)[A]	Author
Badger Creek	1997	18,376	103	103	**118** (111-132)	Wylie *et al.* 2010
Badger Creek	2002	14,973	63	63	**216** (137–383)	E. Hansen 2003a
Colusa NWR	1997	12,198	53	22	**29** (22-53)	Wylie *et al.* 2010
Colusa NWR	2002	Not Listed	128	128	**163** (42-186)	Wylie *et al.* 2002c
Gilsizer Slough	1996	17,136	88	67	**177** (124-280)	Wylie *et al.* 2010
Natomas Basin	1999	19,170	164	141	**229** (199-276)	Wylie *et al.* 2010
Volta WA	2003	15,900	28	28	**45** (31-59)	Dickert 2003
Volta WA	2006	5,131	7	7	Insufficient numbers caught for estimate	Sousa and Sloan 2007
Yolo WA	2005	13,700	41	41	**57** (45-84)	E. Hansen 2008a

[A] CI = Confidence Interval

In a later study, Wylie *et al.* (2010) used data acquired from previous studies to determine snake densities in four separate areas that represent a range of habitat from rice agriculture (Natomas Basin) to managed seasonal marsh (Colusa NWR and Gilsizer Slough) to managed natural perennial marsh (Badger Creek). The density estimates in this study were presented as number of snakes per unit area, such as a wetland or rice field instead of a linear value. Wylie *et al.* (2010) found that the highest densities of giant garter snakes were located in the natural marsh at Badger Creek (see Table 1), which is believed to represent the historical giant garter snake perennial marsh habitat (Wylie *et al.* 2010).

Home Range. Many animals confine their routine daily activities, such as foraging and mating, to a limited area which biologists call the home range (Pough *et al.* 2001; Lincoln *et al.* 2001). Researchers who have conducted years of surveys for the giant garter snake, including monitoring snakes by implanting Passive Integrated Transponder (PIT) tags (small electronic devices the size of a rice kernel that produce a unique number for each implanted snake when scanned by a hand-held device) have found that giant garter snakes demonstrate site fidelity, especially the females (E. Hansen, pers. comm. 2011; B. Halstead, pers. comm. 2011; P. Valcarcel, USGS, *in litt.* 2010).

Researchers with the USGS estimated the home range size of giant garter snakes at several study sites using telemetry data (Worten 1989; Seaman and Powell 1996). Table 3 shows the home range figures from those studies. Home range estimates from the studies averaged from 17 to 44 hectares (42 to 109 acres) for a sample of 105 individual snakes (Wylie and Casazza 2000; Wylie *et al.* 2002a, 2008). In localities where surrounding land use provides or complements the necessary components of giant garter snake habitat, for example in areas of rice cultivation, the home ranges for snakes were shown to be smaller than for localities where the snakes must travel some distance to find those same components (E. Hansen 2008a).

Table 3. Home range estimates from various surveys of giant garter snakes

Location and Date	N[A]	Median home range Ha (min-max)[B]	Author
Colusa NWR 1997	27	42 (1.3 – 1130)	Wylie *et al.* 2002a
Colusa NWR 2000	9	17 (1 – 33)	Wylie *et al.* 2002a
Colusa NWR 2001	13	24 (3 – 173)	Wylie *et al.* 2002a
Colusa Drain Mar – Sep 2006	22	41.2 (3 – 239)	Wylie *et al.* 2008
Colusa Drain Mar – July 2007	22	22.78 (5.3 – 59.9)	Wylie *et al.* 2008
Natomas Basin 1999 (Elverta)	7	44 (13 – 80)	Wylie and Casazza 2000
Natomas Basin 1999 (Fisherman's Lake)	5	37.2 (13 – 87)	Wylie and Casazza 2000

[A] N = number of snakes in study [B] Ha = hectares

At Badger Creek, an area considered to exemplify high quality giant garter snake habitat, one telemetry study of the movements (not including a calculation of home ranges) of 12 individual snakes revealed that the giant garter snakes did not move more than 300 meters (984 feet) from their point of capture along the marsh emergent vegetation, and that males traveled further than females (E. Hansen 2003a).

E. DISTRIBUTION AND POPULATIONS

1. Distribution

Giant garter snakes are endemic to California's Central Valley (Fitch 1940; G. Hansen and Brode 1980; Rossman and Stewart 1987). Historically, giant garter snakes inhabited the Sacramento and San Joaquin Valleys from the vicinity of Chico, in Butte County southward to Buena Vista Lake, near Bakersfield in Kern County, California. The eastern and western boundaries of the giant garter snake range from the foothills occurring along each side of the Central Valley - the Coast Range to the west and the Sierra Nevada to the east. Observations of individual giant garter snakes range in elevation from 3 to 12 meters (10 to 40 feet) in the southern Sacramento Valley. Although the boundaries of the giant garter snake's original distribution are undetermined, occurrence records coincide with the historical distribution of the large flood-basins, freshwater wetlands, and tributary streams of the Central Valley's Sacramento and San Joaquin watersheds (Figure 2; G. Hansen and Brode 1980).

Though the abundance of giant garter snakes in the Sacramento Valley has declined, the distribution of giant garter snakes in its northern range may still reflect its historical distribution. Giant garter snakes in the San Joaquin Valley, however, have suffered an extensive reduction in their abundance and distribution compared to historical times (R. Hansen 1980; Paquin *et al.* 2006; Wylie and Amarello 2007; E. Hansen 2008a). Giant garter snakes historically inhabited the extensive wetlands of the Tulare and Buena Vista lakes in the southern San Joaquin Valley and appear to have once been fairly abundant in this part of the San Joaquin Valley (G. Hansen and Brode 1980). Conversely, giant garter snakes have not been found in the northern reach of the San Joaquin Valley up to the Delta area. Here, the floodplain of the San Joaquin River and its associated wetland habitat constricts to a geologically narrow trough. The length of this 100-kilometer (62-mile) constriction is presumed to have historically separated the giant garter snake populations in Merced County from those of the eastern Sacramento/San Joaquin River Delta (Delta) in San Joaquin

County (G. Hansen and Brode 1980). It is believed that the extensive historical wetlands of the Delta were suitable for giant garter snakes and that they historically occupied this area (G. Hansen 1986, 1988).

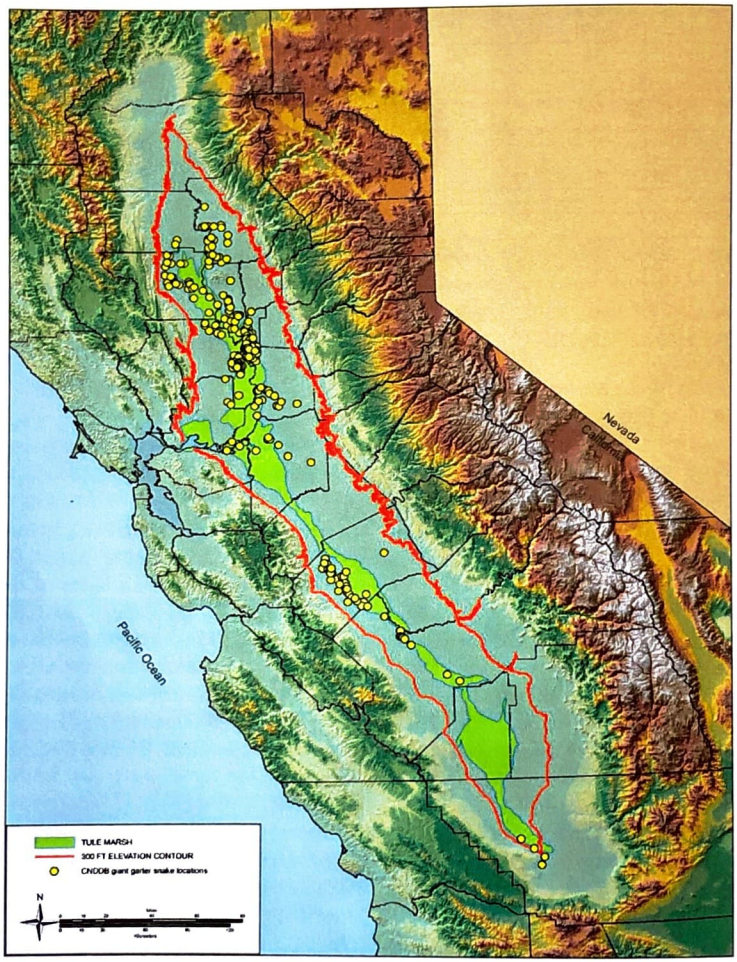

Figure 2. Distribution of historic tule marsh (lime green) and giant garter snake captures. (CNDDB, Kuchler)

2. Populations as Defined for this Recovery Plan

In this revised draft recovery plan we will continue to use, as closely as possible, the population definition from the listing rule (USFWS 1993), "a cluster of locality records in a contiguous habitat

area." Locality records are distinct locations where surveys were conducted and giant garter snakes were found (USFWS 1993). These populations were associated with the major watershed basins in the Central Valley because these basins were exclusively defined by geographic features (Bryan 1923) and contained habitat that appeared to be historically interconnected by wetland features. Recent genetic studies of the giant garter snake have confirmed the validity of these population boundaries by demonstrating that historically there was restricted gene flow between groups of individuals inhabiting these major watersheds (Paquin *et al.* 2006; Engstrom 2010). The currently recognized populations and distribution of the giant garter snake as they relate to the 13 populations described in the 1993 listing are summarized in Table 4.

Table 4. Populations of giant garter snakes at time of listing in 1993 and as currently assessed in 2015.

1993 POPULATIONS (At time of listing)	2015 POPULATIONS
Butte Basin	Butte Basin
Colusa Basin	Colusa Basin
Sutter Basin	Sutter Basin
American Basin	American Basin
Yolo Basin – Liberty Farms (currently presumed extirpated)	Yolo Basin
Yolo Basin – Willow Slough	
Badger Creek – Willow Creek	Cosumnes-Mokelumne Basin
Sacramento Basin	Delta Basin
Caldoni Marsh (now called White Slough WA)	
East Stockton: Diverting Canal and Duck Creek	
North and South Grasslands	San Joaquin Basin
Mendota WA	Tulare Basin
Burrell and Lanare (currently presumed extirpated)	

Additional description and status information is available for each basin in the most recent 5-Year Status Review for the giant garter snake (Service 2012).

F. REASONS FOR DECLINE AND THREATS TO SURVIVAL

The following discussion of threats to the giant garter snake is presented in a format that follows the five listing factors used in status reviews as described in section 4(a)1 of the Endangered Species Act. These are:

A. The present or threatened destruction, modification, or curtailment of its habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms; and
E. Other natural or manmade factors affecting its continued existence.

Since Federal listing in October 1993, the list of threats to the giant garter snake has changed and new threats analyses were presented in 5-year reviews for the giant garter snake completed in 2006

and 2012 (USFWS 2006a, 2012). A brief summary of the current significant threats addressed in this revised draft recovery plan follows; the 2012 5-year review should be consulted for a complete analysis.

1. Factor A: The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

At the time of listing, habitat loss as a result of urbanization and conversion of wetlands was recognized as the primary Factor A threat to the giant garter snake. Today, habitat loss and fragmentation due to urbanization and changes in the levels of rice production are the largest threat to the giant garter snake. In addition, we consider the following to be current threats: changes in water availability; levee and canal maintenance; water management and water delivery which do not account for the giant garter snake; water transfers; small populations; and invasive aquatic species.

2. Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

In the final listing rule, the Factor B threats included collection of specimens for private and scientific use, and harassment and collection of giant garter snakes by recreationists engaged in angling. Collection for private and scientific use is not considered to be a threat. However, threats from human encounters, primarily engaged in recreational activities is still considered a threat, but was moved to Factor E.

3. Factor C: Disease and Predation

In the final listing rule, predation by both native and non-native predators was considered a threat and that threat continues today; however, it is not believed to be significant. Native and non-native predators both prey upon giant garter snakes and compete with giant garter snakes for prey. Parasites found on giant garter snakes were discussed in the final listing, but their level of threat was determined to be unknown; the degree of threat from parasites remains unknown today.

4. Factor D. The Inadequacy of Existing Regulatory Mechanisms

At the time of listing (USFWS 1993), the state and federal regulatory mechanisms thought to have some potential to protect the giant garter snake included the California Endangered Species Act (CESA), the California Environmental Quality Act (CEQA), the National Environmental Protection Act (NEPA), and the Clean Water Act (CWA). In addition, this revised draft recovery plan recognizes the Endangered Species Act (ESA) as a Federal program that was designed to protect rare species of plants and animals.

5. Factor E. Other Natural or Manmade Factors Affecting its Continued Existence

At the time of listing, Factor E threats discussed included: fluctuations in the acreages of active rice fields due to changing market values and market demand (and due to changes in water availability), levee and canal maintenance, water management and water delivery during the winter for waterfowl that does not also provide summer water for the giant garter snake, water transfers, and fragmented habitat with small populations. These threats are still considered to be valid; however, these threats are now discussed in the Factor A section since they all directly relate to the loss or alteration of available habitat for the giant garter snake. Flooding and contaminants were also discussed in the listing rule and these remain valid Factor E threats; however, they are not considered significant threats. Giant garter snake mortalities from vehicular strikes on roads were discussed as a Factor A threat in the listing, but are now presented as a Factor E threat; however, it is not considered a

significant threat. Encounters with humans was described as a Factor B threat in the listing, but is now considered more relevant as a Factor E threat since threatening encounters may include those not related to recreation; however, it is not considered a significant threat. Since the final listing rule, drought and climate change, netting used in erosion control, and competition from non-native water snakes were identified as threats; however, the significance of these threats is unknown.

II. RECOVERY PROGRAM

A. RECOVERY STRATEGY

The strategy used to recover the giant garter snake is focused on protecting existing occupied habitat and identifying and protecting areas for habitat restoration, enhancement, or creation including areas that are needed to provide connectivity between populations. This approach is vital to reduce or eliminate the primary threat to the giant garter snake, which is the loss of habitat throughout the historical range of the species.

Appropriate management is needed for all giant garter snake conservation lands to ensure that stable and viable populations can be maintained in occupied areas, and that colonization will be promoted in restored and enhanced unoccupied habitat. An essential part of the management of habitat for giant garter snakes is to ensure that sufficient clean water is available to provide adequate aquatic habitat during the summer active season. Management plans must also incorporate sufficient monitoring to determine outcomes of specific actions and responses of the species to protection and management efforts. Such monitoring programs should be designed specifically to determine the success or failure of various actions, and provide for feedback such that protection and management actions can be modified in response to new data, research, and monitoring information.

Research on the ecology, behavior and life history of the giant garter snake will be needed to further define specific recovery tasks, management needs and goals, help assess threats and determine best methods to eliminate or ameliorate the threats, and to analyze aspects of population viability.

Repatriation, the introduction and augmentation of giant garter snakes into historically occupied areas, is needed in appropriate habitat in the San Joaquin Valley where recent surveys show dwindling population numbers. This will involve captive propagation hand in hand with a genetics management plan.

Implementation of recovery measures will place an emphasis on multiple species protection and management by developing and implementing conservation measures to restore and protect the processes that maintain healthy ecosystems. Species that may benefit from an ecosystem focus include the western pond turtle and Pacific flyway waterfowl and shorebirds. These species will benefit from implementation of the giant garter snake recovery plan through improvements in wetland and riparian habitats.

To assist in the achievement of the recovery of the giant garter snake, it is necessary to develop and implement incentive programs for private landowners to conserve giant garter snake habitat. Additionally, development and distribution of informational material to interested landowners and public lands managers will enlist and encourage the participation and cooperation of private citizens and public land managers in the recovery of the giant garter snake.

Definitions

Recovery Unit: We defined nine recovery units that correspond directly to the nine geographically and genetically distinct populations to aid in our recovery planning. A recovery unit is a special unit of the listed species' range that is geographically or otherwise identifiable and is essential to the

recovery of the entire listed species. Recovery Units are individually necessary to conserve genetic distinctiveness, demographic robustness, important life history stages, or other features necessary for the long-term sustainability of the entire listed species.

Management Unit: These subdivisions of recovery units are areas that might require different management, that might be managed by different entities, or that might encompass different populations. In this revised draft recovery plan, the management units are primarily administrative in that they serve to organize the recovery units into separate and approximately equal areas that will assist in managing the implementation of the recovery actions.

Locality Record: A small geographic area of giant garter snake habitat where occupancy by giant garter snakes was documented by positive trapping survey results or by confirmed visual encounters. The size of the area can range from less than an acre to hundreds of acres.

Population: A cluster of locality records in a contiguous habitat area. In this plan individual populations are defined by the watershed basins in which they reside, which are contiguous habitat areas.

Corridor: A canal, waterway, slough, channel, or creek that connects two or more areas known to support giant garter snakes. A corridor must have the necessary habitat components to provide suitable giant garter snake habitat (see section I.C.1 and I.C.2) in order to function as a viable dispersal and movement corridor.

Giant Garter Snake Recovery Units

The giant garter snake's historical range encompasses the majority of the Central Valley of California, with habitat characteristics, species status, degree of threats, and needed recovery actions varying across this large geographic area. We have approached recovery planning by dividing the giant garter snake's broad geographic range into nine recovery units corresponding directly to the nine genetically and geographically defined populations previously discussed in chapter 1E (Figure 3). This grouping of recovery units is appropriate also because of the limited movement of giant garter snakes from one watershed to another, which genetically and demographically isolates the giant garter snakes within the various watershed basins. These recovery unit assignments will assist in establishing recovery criteria and guiding recovery tasks.

In defining recovery units for the giant garter snake, we have followed the usage of watershed basins that were also used to define population boundaries, and we have additionally restructured the populations from 13 (from listing rule) to 9 based on recent surveys and giant garter snake genetic data (Paquin *et al.* 2006; Engstrom 2010). The boundaries of the recovery units were defined using the following inputs: California Wetland and Riparian Geographic Information System (GIS) database developed by Ducks Unlimited (Ducks Unlimited, Inc., 1997) for the Central Valley that identified wetlands and irrigated agriculture; California Natural Diversity Database occurrences for giant garter snakes (CNDDB 2011); the map of historical tule marsh habitat (Kuchler 1977); and hydrological maps that showed tributary streams and waterways that may provide giant garter snake habitat. The combined recovery units, therefore, represent the potential extent of giant garter snake habitat in the Central Valley as known at the time of listing and updated with recent surveys. Each unit has unique genetic composition that is essential to the recovery of the giant garter snake as a species.

The descriptions and maps of each of the recovery units below will provide greater detail on the locality and the amount of public and private conservation lands. There are no known unique threats in any of the recovery units, and all of the threats mentioned in section F can be found in all of the recovery units; however, the level that a single threat may pose to the giant garter snake differs between the recovery units.

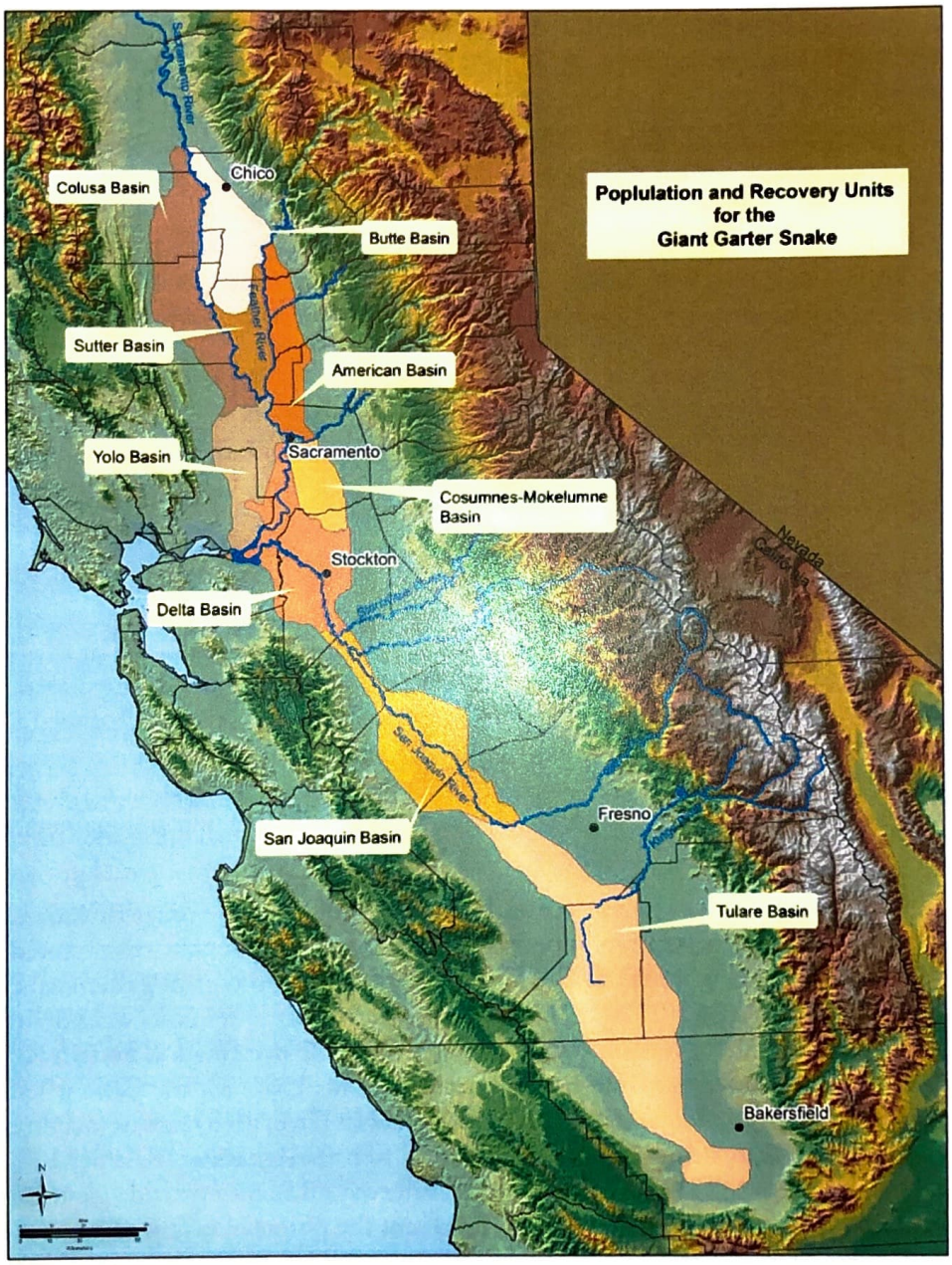

Figure 3. Populations and Recovery Units for the giant garter snake.

B. RECOVERY UNITS

1. Butte Basin Recovery Unit

The Butte Basin Recovery Unit encompasses the entire Butte Basin, extending from Red Bluff in the north to the Sutter Buttes in the south (Figure 4). The basin's watershed is dominated by the Sacramento River and includes those creeks that flow westward toward the Sacramento River. The Butte Basin consists of 193,892 hectares (479,118 acres), including portions of Tehama, Butte, Sutter, and Colusa counties. Three management units have been defined for the Butte Basin Recovery Unit: Llano Seco, Upper Butte Basin, and Gray Lodge/Butte Sink.

Within the Butte Basin, State and Federal conservation areas include: Gray Lodge WA, Upper Butte Basin WA, Butte Sink Wildlife Management Area, and several units of the Sacramento River NWR. In addition, approximately 4,047 hectares (10,000 acres) of privately owned lands are enrolled in the USFWS wetland easement program in the Butte Sink Wildlife Management Area. Currently there are no conservation banks in the Butte Basin designed for the giant garter snake.

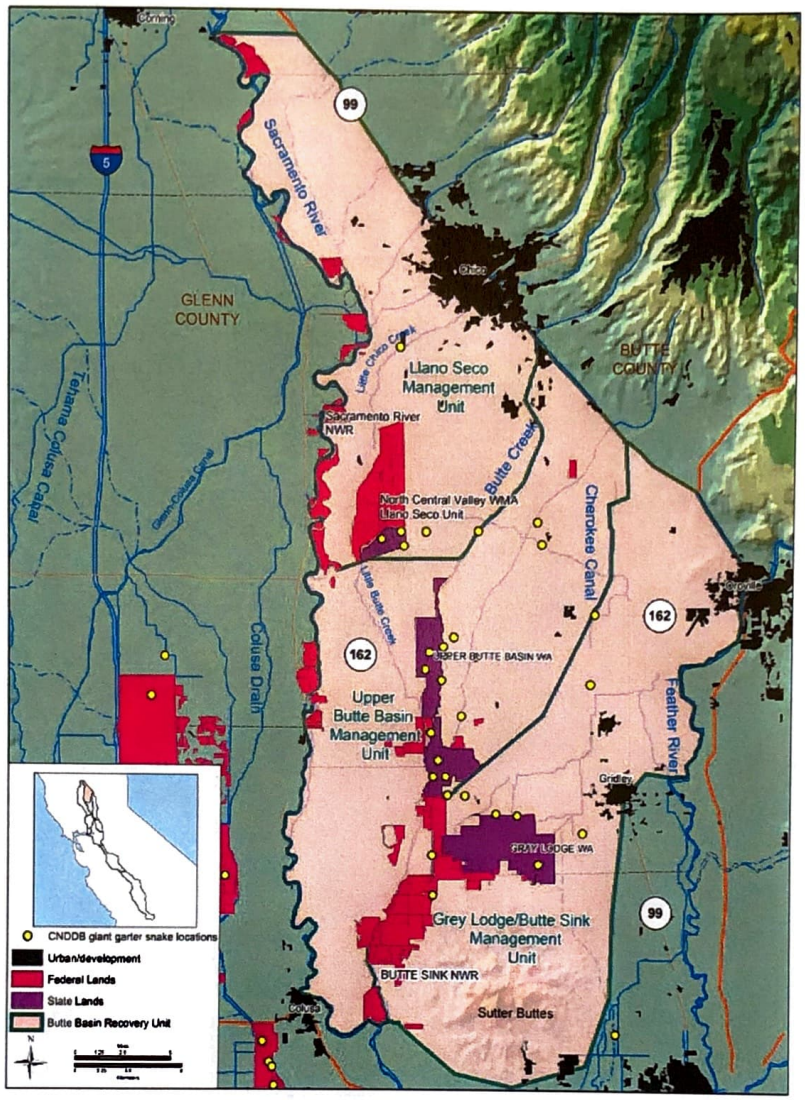

Figure 4. Butte Basin Recovery Unit

2. Colusa Basin Recovery Unit

The Colusa Basin extends from Red Bluff in the north to Cache Creek in the south (Figure 5). Its watershed is dominated by the Sacramento River. The Colusa Basin consists of 277,653 hectares (686,096 acres), including portions of the counties of Tehama, Glenn, Colusa, and Yolo. Three management units have been defined for the Colusa Basin Recovery Unit: Willows, Delevan and Colusa.

Within the Colusa Basin, Federal conservation areas include the Sacramento, Delevan and Colusa NWRs. In addition, about 2,226 hectares (5,500 acres) of private lands are enrolled in our wetland easement program in the area north and south of Delevan NWR. The Colusa Basin includes Dolan Ranch Conservation Bank (102-hectare, 252-acre), and the Ridge Cut Conservation Bank (75 hectare, 186 acre).

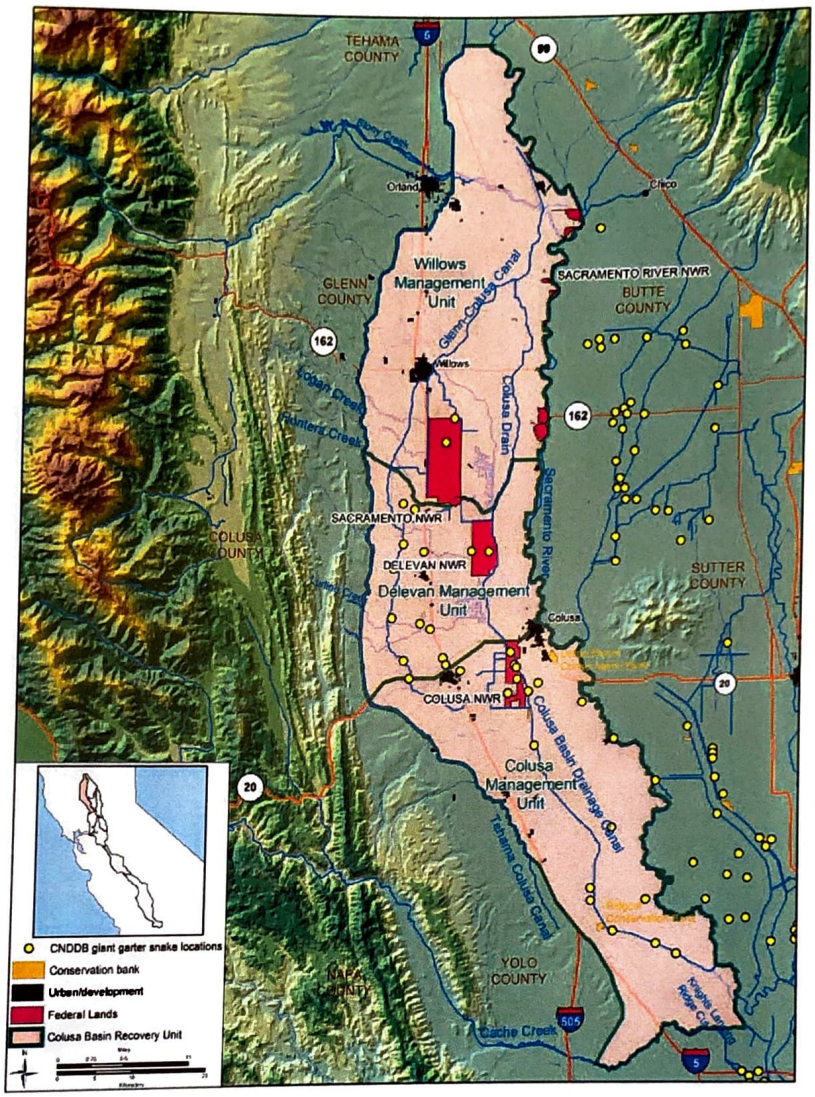

Figure 5. Colusa Basin Recovery Unit

3. Sutter Basin Recovery Unit

The Sutter Basin extends south from the Sutter Buttes to the confluence of the Feather and Sacramento rivers (Figure 6). The Sutter Basin consists of 97,048 hectares (239,810 acres), including portions of Butte and Sutter counties. Three management units have been defined for the Sutter Basin Recovery Unit: Sutter, Gilsizer Slough, and Robbins.

Within the Sutter Basin, Federal and State conservation areas include the Sutter NWR and the Sutter Bypass WA (east and west borrow channels of the Sutter Bypass, Tisdale Bypass, and Wadsworth Canal), and Feather River WAs. Also included are the Sutter Basin Conservation Bank

(174-hectare, 429-acre), the Gilsizer Slough South Conservation Bank (153 hectares, 379 acres), and the Tule Basin Giant Garter Snake Preserve (60.7 hectares, 150 acres).

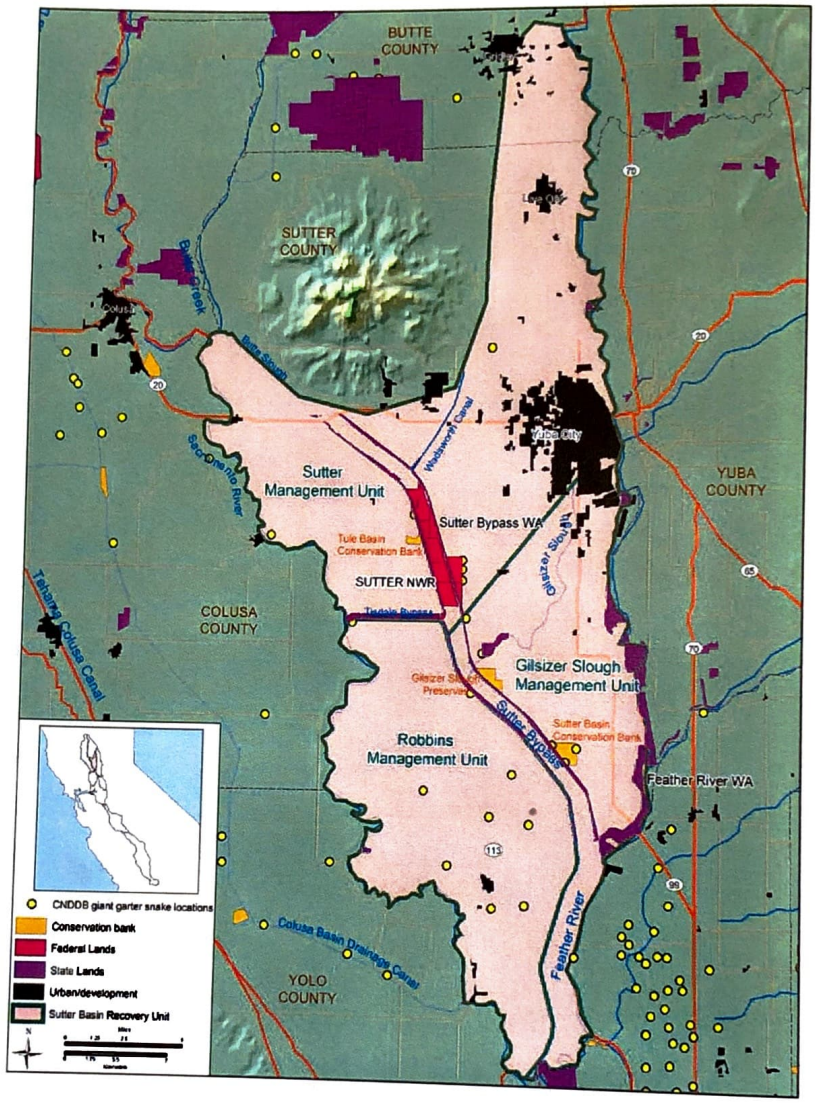

Figure 6. Sutter Basin Recovery Unit

4. American Basin Recovery Unit

The American Basin extends south from Oroville to the confluence of the Sacramento and American rivers (Figure 7). The Basin is about 152,204 hectares (376,104 acres), including portions of Butte, Yuba, Sutter, Placer, and Sacramento counties. Four management units have been defined for the American Basin Recovery Unit: District 10, Olivehurst, Nicolaus, and Natomas Basin.

Within the American Basin, the only public conservation lands are several units of the State Feather River WA along the Feather and Bear rivers. However, these conservation areas primarily provide riparian habitats that may not be suitable for the giant garter snake. There are no Federal wildlife refuges or State management areas within the American Basin. There are no conservation banks

specifically for the giant garter snake in the American Basin; however, several preserves have been established in the Natomas Basin as part of two HCPs and currently amount to 1,677 hectares (4,145 acres).

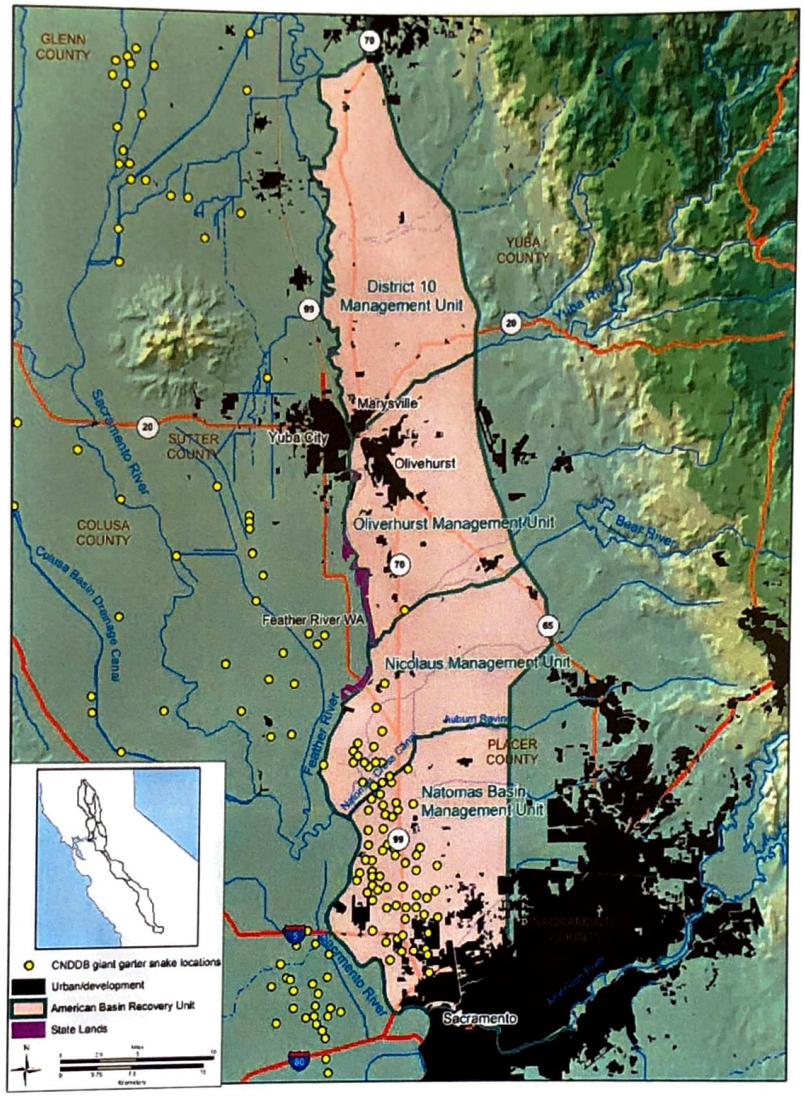

Figure 7. American Basin Recovery Unit

5. Yolo Basin Recovery Unit

The Yolo Basin extends from Cache Creek in the north to the Sacramento-San Joaquin River Delta in the south (Figure 8). The Yolo Basin includes portions of Yolo and Solano counties and is approximately 166,291 hectares (410,914 acres). Three management units have been defined for the Yolo Basin Recovery Unit: Ridgecut Slough, Willow Slough, and Yolo Bypass.

Within the Yolo Basin, conservation lands include the State Yolo Bypass WA, wetland easement areas within the Yolo Bypass, and the Jepson Prairie Preserve in Solano County. It also includes the Pope Ranch Conservation Bank (158 hectares, 390 acres).

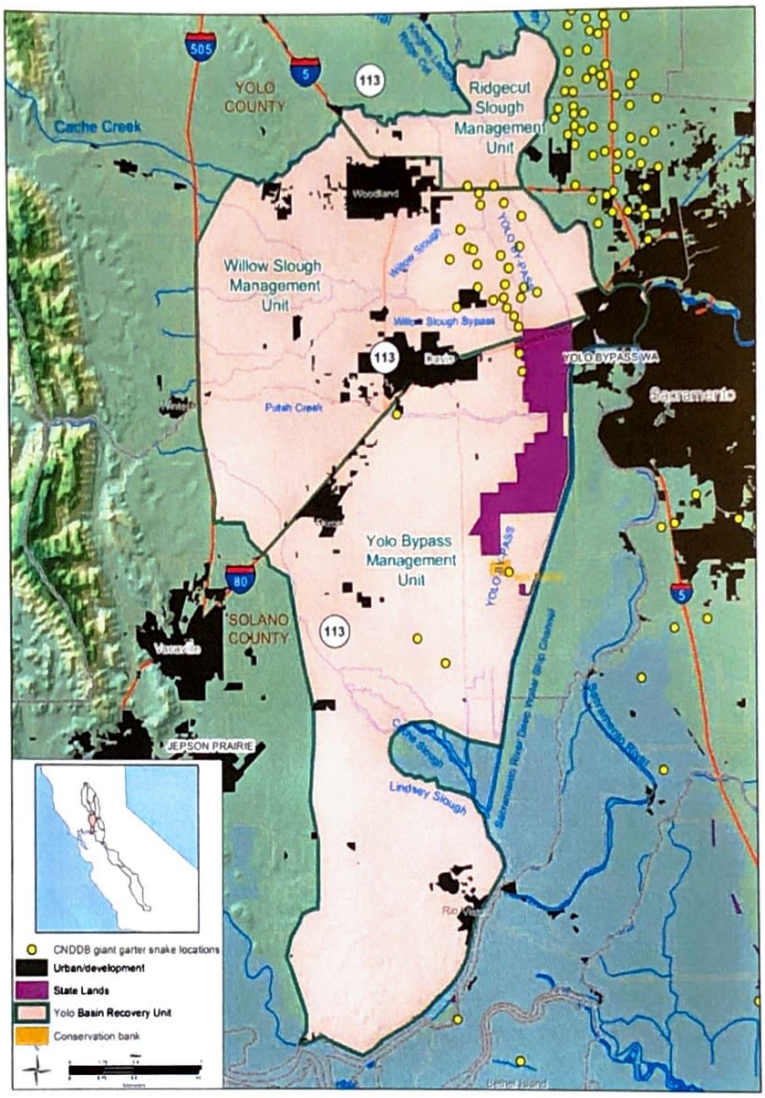

Figure 8. Yolo Basin Recovery Unit

6. Cosumnes-Mokelumne Basin Recovery Unit

The Cosumnes-Mokelumne Basin is bordered by the City of Sacramento and the Cosumnes River to the north, the foothills of the Sierra Nevada Mountains to the east, Interstate 5 to the west, and the Mokelumne River to the south (Figure 9). The Cosumnes-Mokelumne Basin consists of 95,085 hectares (234,960 acres). Noteworthy is that the locality record from Badger Creek (Snake Marsh), described as the best representative of undisturbed, historical wetlands which were once common throughout the Central Valley, is found in this watershed basin. There are no management units defined within this recovery unit because it encompasses a relatively small area and requires no geographic subdivision to assist in management.

Conservation land in the Cosumnes-Mokelumne Basin is mostly within the Cosumnes River Preserve, which is managed jointly by the CDFW, The Nature Conservancy, the BLM, and Ducks Unlimited. There are no conservation banks set up at this time in this recovery unit for the giant garter snake.

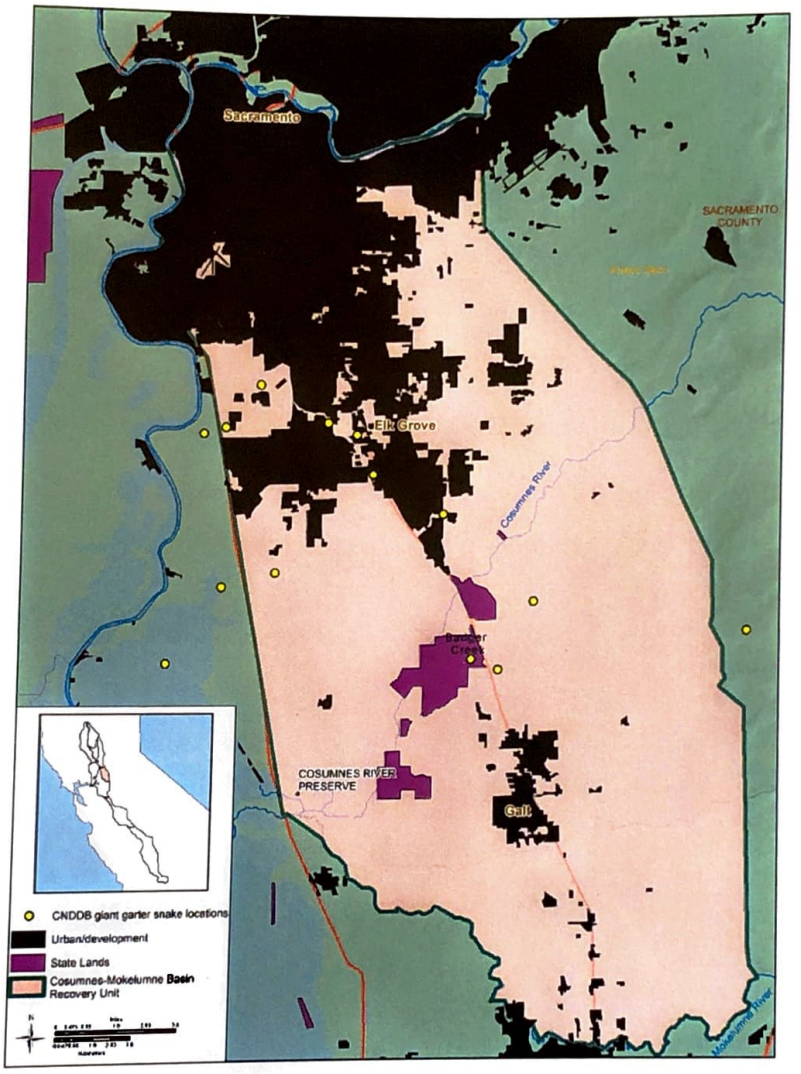

Figure 9. Cosumnes-Mokelumne Basin Recovery Unit

7. Delta Basin Recovery Unit

The Sacramento-San Joaquin River Delta (Delta Basin) extends from just south of the confluence of the Sacramento and American rivers south to the Stanislaus River (Figure 10). The Delta Basin contains about 283,078 hectares (699,502 acres) and includes portions of Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties. Four management units have been defined for the Delta Basin Recovery Unit: Stone Lakes, White Slough, Stockton, and Tracy.

Within the Delta, Federal and State conservation areas include the Federal Stone Lakes NWR, and the State's Sherman Island WA and White Slough WA. There are no conservation banks set up at this time in this recovery unit for the giant garter snake.

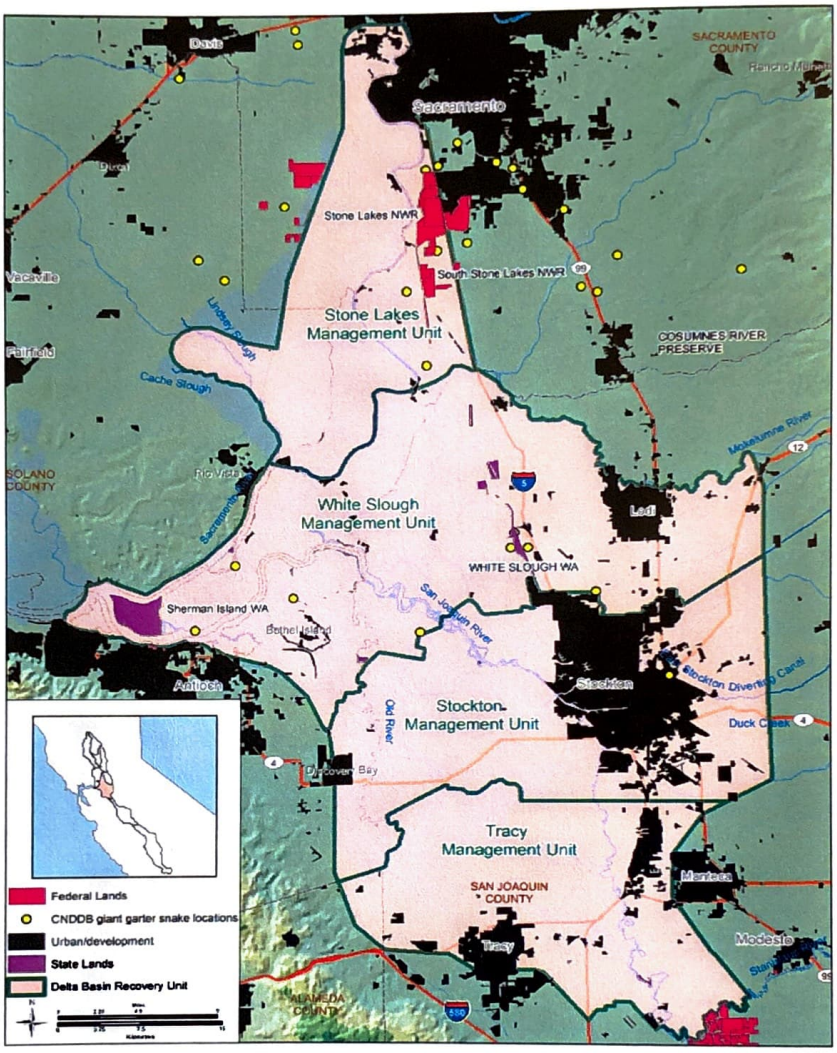

Figure 10. Delta Basin Recovery Unit

8. San Joaquin Basin Recovery Unit

The San Joaquin Basin extends from the Stanislaus River in the north to the San Joaquin River in the south and is bordered by the Coast Ranges on the west and the Sierra Nevada to the east (Figure 11). The San Joaquin Basin is 323,881 hectares (800,327 acres) and includes portions of Stanislaus, Merced, Fresno, and Madera counties. Four management units have been defined for the San Joaquin Basin Recovery Unit: San Joaquin River, San Luis/Volta, Brito, and Merced.

Within the San Joaquin Basin, Federal and State conservation areas include the San Joaquin River NWR, the San Luis NWR Complex, Merced NWR, and the North Grasslands WA, the Los Banos WA, and the Volta WA. Additional wetlands on private lands within the Grasslands Ecological Area are protected by conservation easements. The Grasslands Mitigation Bank is proposed for conservation of giant garter snakes.

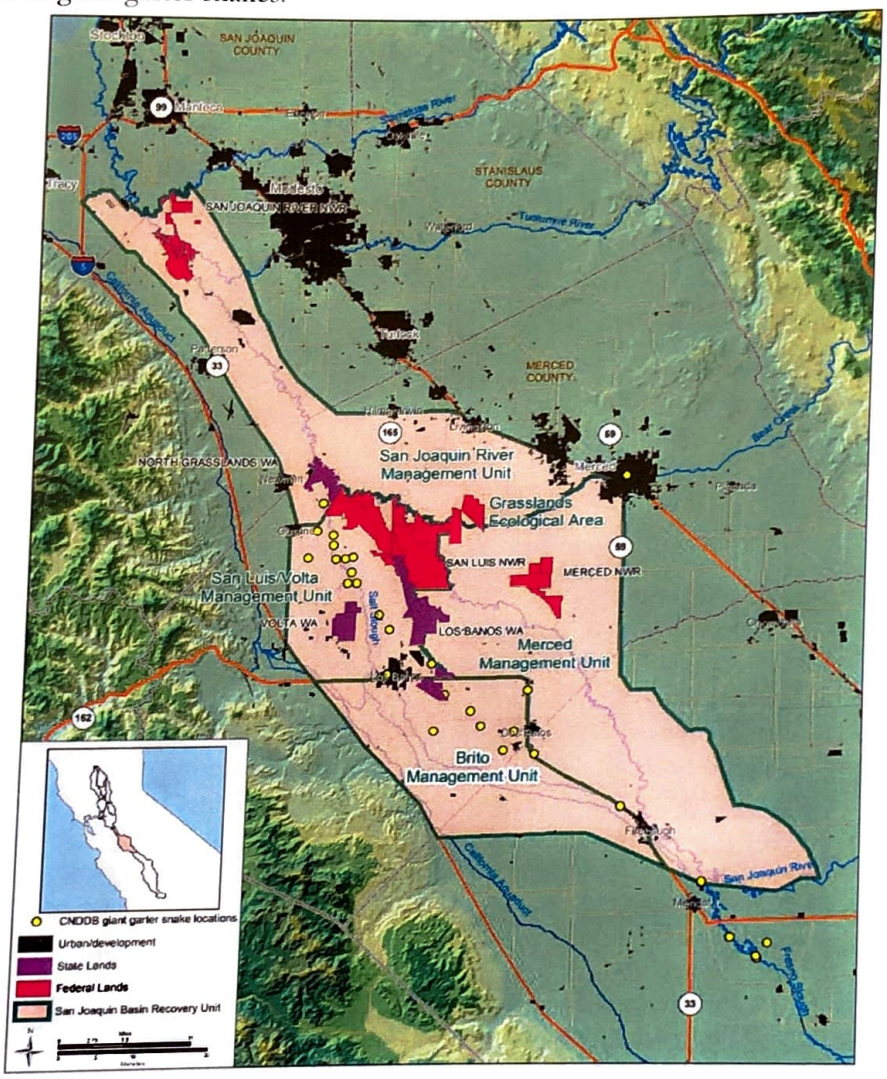

Figure 11. San Joaquin Basin Recovery Unit

9. Tulare Basin Recovery Unit

The Tulare Basin is the southern-most portion of the Central Valley and extends from the southern San Joaquin River south to the Buena Vista and Kern lakebeds (Figure 12). The Tulare Basin contains about 688,710 hectares (1,701,841 acres), and includes portions of Fresno, Kings, Tulare, and Kern counties. Four management units have been defined for the Tulare Basin Recovery Unit: Mendota, Burrell Lanare, Kern, and Buena Vista Lake.

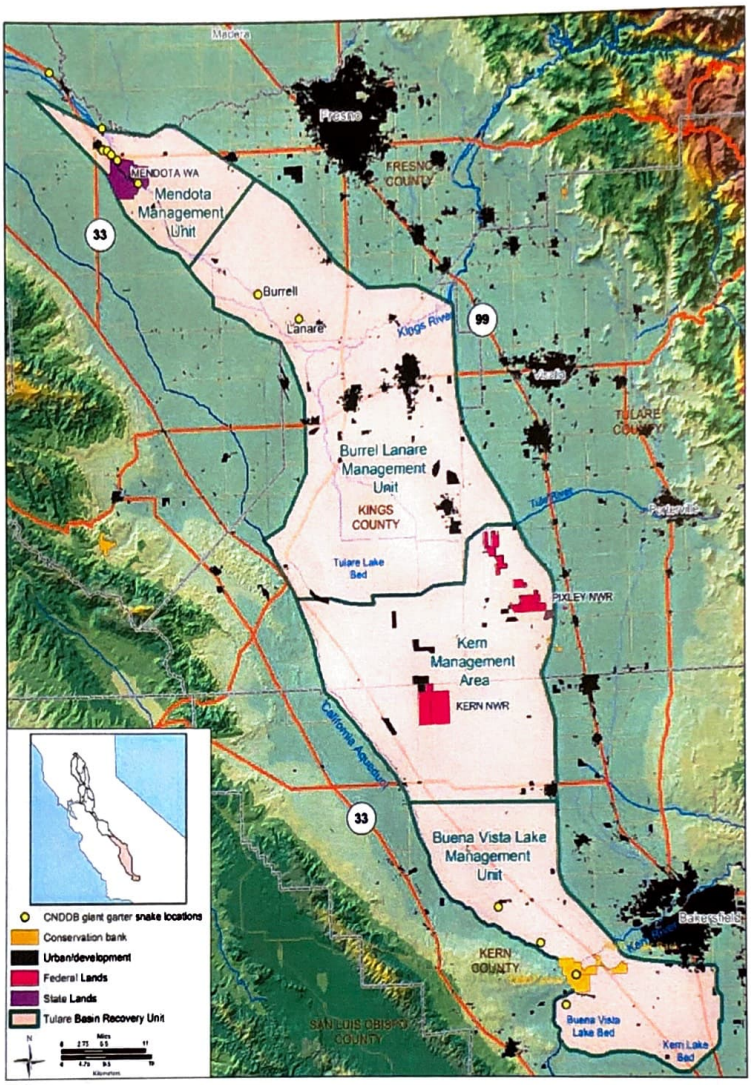

Figure 3. Tulare Basin Recovery Unit

Within the Tulare Basin, Federal and State conservation areas include the Kern and Pixley NWRs, and the Mendota WA. The Coles Levee Ecosystem Preserve and the Kern Water Bank are properties that will be preserved in perpetuity; however, these properties would require a great deal of restoration and reconfiguration to become appropriate habitat for giant garter snake populations. The 2,452-hectare (6,059-acre) Coles Levee Ecosystem Preserve was created by Aera Energy LLC and is managed by the CDFW. The Kern Water Bank HCP provided for a 1,322-hectare (3,267-acre) conservation bank. Additional wetlands on private lands occur within the Tulare Basin but will require habitat assessments and surveys to determine whether they provide potential habitat for the giant garter snake.

C. RECOVERY GOALS AND OBJECTIVES

The ultimate goal of this revised draft recovery plan is to recover the giant garter snake so that it no longer needs the protection of the Endangered Species Act and can be delisted (removed from the

list of Threatened and Endangered Species.). To achieve this goal the following objectives have been developed:

1. Protect existing and establish (and protect) self-sustaining populations of the giant garter snake throughout the full ecological, geographical, and genetic range of the species.

2. Restore and conserve healthy Central Valley wetland ecosystems that function to support the giant garter snake.

3. Ameliorate or eliminate, to the extent possible, the threats that caused the species to be listed or of concern and any foreseeable future threats.

D. RECOVERY CRITERIA

An endangered species is defined in the Endangered Species Act as a species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. When we evaluate whether or not a species warrants downlisting or delisting, we consider whether the species meets either of these definitions. A recovered species is one that no longer meets the Act's definitions of threatened or endangered. Determining whether a species should be downlisted or delisted requires consideration of the of the same five categories of threats which were considered when the species was listed and which are specified in section 4(a)(1) of the Endangered Species Act.

Recovery criteria are conditions that, when met, are likely to indicate that a species may warrant downlisting or delisting. Thus, recovery criteria are mileposts that measure progress toward recovery. Because the appropriateness of downlisting or delisting is assessed by evaluating the five threat factors identified in the Endangered Species Act, the recovery criteria below pertain to and are organized by these factors. These recovery criteria are our best assessment at this time of conditions that may indicate that the giant garter snake is ready to be delisted and removed from the list entirely. Because we cannot envision the exact course that recovery may take and because our understanding of the vulnerability of a species to threats is very likely to change as more is learned about the species and its threats, it is possible that a status review may indicate that delisting is warranted although not all recovery criteria are met. Conversely, it is possible that the recovery criteria could be met and a status review may indicate that delisting is not warranted; for example, a new threat may emerge that is not addressed by the recovery criteria below and that causes the species to remain threatened.

1. Recovery Criteria for Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range.

In order to ensure the long term recovery of the giant garter snake, threats to the species habitat must be reduced or removed in order to provide sufficient high-quality habitat and connections between populations. This will have been accomplished if: a) sufficient habitat of suitable quality is protected in each recovery unit, and b) blocks of habitat within each recovery unit are connected. The following provides specific descriptions as to how habitats would be sized and connected to reduce threats associated with habitat loss:

Specified areas in all recovery units with known populations of the giant garter snake are protected in perpetuity as suitable giant garter snake habitat and supplied with sufficient clean water during the

spring and summer to maintain necessary aquatic habitat. The protected areas are buffered from incompatible uses and are connected by corridors of suitable habitat.

Habitat for the giant garter snake will be preserved in multiples of two block pairings of habitat. Each block pair will consist of one 240-hectare (539-acre) block of contiguous buffered perennial wetland habitat (existing, restored or enhanced) and one 639-hectare (1,578-acre) block of contiguous active ricelands separated by no more than 5 miles (8 kilometers)[1]. Alternatively, a pair of blocks may also consist of two 240-hectare (539-acre) blocks of buffered perennial wetlands. Between five and ten habitat block pairs may be prescribed for each of the recovery units depending on the size of the recovery unit and the available suitable habitat within the recovery unit. These block pairs should be evenly distributed among the management units. In addition, the habitat pairs must not be separated by more than 5 miles. Paired habitat blocks were selected because perennial wetlands are known to support core populations of the giant garter snake throughout a wide range of hydrologic conditions, while rice fields and the supporting infrastructure can provide habitat for robust populations of the giant garter snake while the rice fields are active. During periods of crop rotation the inactive or dry crop fields may provide some level of connectivity between perennial wetlands by keeping key irrigation canals full.

These pairs of contiguous perennial wetlands and ricelands must be buffered by 0.5 kilometer (.32 mile) of compatible habitat and the two blocks must be connected by a corridor of aquatic and upland habitat with a 0.8-kilometer (0.5-mile) minimum width. Corridor width is based on the distance a giant garter snake is known to travel in one day, which is 0.8 kilometer (0.5 mile) (G. Hansen and Brode 1993). All pairs of habitat blocks must be connected with the other pairs of habitat blocks within and between the management units by corridors of suitable habitat, and recovery units should be connected to one another by similar corridors.

A1 **Butte Basin Recovery Unit**: Minimum of six habitat block pairs with no less than two block pairs per management unit in the Butte Basin Recovery Unit. Additional protection along the following watercourses in the Butte Basin will provide for connectivity between existing populations of giant garter snakes and will protect habitat immediately on either side of the main watercourse at a minimum of 0.25 miles from each bank:

a. Little Chico Creek – 1,036 hectares (2,560 acres) abutting the Llano Seco Unit of the Sacramento NWR and continuing northeastward.
b. Butte Creek – 1,295 hectares (6,400 acres) abutting the Upper Butte Basin management unit and continuing northeastward.
c. Cherokee Canal – 3,108 hectares (7,680 acres) abutting Gray Lodge/Butte Sink management unit and continuing northeastward.

A2 **Colusa Basin Recovery Unit**: *Mini*mum of six habitat block pairs with no less than two block pairs per management unit in the Colusa Basin Recovery Unit. Additional protection along the following watercourses in the Colusa Basin will provide for connectivity between existing populations of giant garter snakes and will protect habitat immediately on either side

[1] The 240 hectare blocks of perennial wetlands is derived from Wylie *et al.* (2010), who reported that a self-sustaining Badger Creek population of giant garter snakes is supported by 240 hectares of perennial wetlands. This acreage of perennial wetlands is also close to acreages preserved in several giant garter snake conservation banks. The 639 hectare blocks of active ricelands are also derived from Wylie *et al.* (2010) by calculating the acreage of ricelands needed to support a giant garter snake population of equivalent size to the self-sustaining population at Badger Creek. This was done by dividing the target population density from Badger Creek (Wylie *et al.* 2010) by the giant garter snake density observed in rice fields (Wylie *et al.* 2010) and using this ratio to determine the target acreage of ricelands, which is 639 hectares. These values do not represent a minimum or maximum acreage for either perennial wetlands or ricelends, but represent target values.

of the main watercourse at a minimum of 0.25 miles from each bank. – 8,417 hectares (20,800 acres). Final protected canal length should extend at a minimum from the Glenn Colusa Canal in the north to the proximity of Ridge Cut Slough in the south.

A3 **Sutter Basin Recovery Unit**: Minimum of four habitat block pairs with no less than one block pair per management unit in the Sutter Basin Recovery Unit (areas with high flooding flows within the Sutter Bypass should be considered as unsuitable habitat). In order to provide connectivity between northern and southern populations additional protection should focus on the Sutter Bypass: 3,885 hectares (9,600 acres) comprising a continuous corridor along and outside of the western bank (levee) of the Sutter Bypass out to a width of 0.8 kilometers (0.5 miles) from the bank, and including the Tisdale Bypass 389 hectares (960 acres).

A4 **American Basin Recovery Unit:** Minimum of eight habitat block pairs with no less than one block pair per management unit in the American Basin Recovery Unit.[2]

A5 **Yolo Basin Recovery Unit**: Minimum of five habitat block pairs with no less than one block pair per management unit in the Yolo Basin Recovery Unit (areas with high flooding flows within the Yolo Bypass should be considered as unsuitable habitat).

A6 **Cosumnes-Mokelumne Basin Recovery Unit**: Minimum of two pairs of habitat blocks in the Cosumnes-Mokelumne Basin Recovery Unit.

A7 **Delta Basin Recovery Unit**: Minimum of ten habitat block pairs with no less than two block pairs per management unit in the Delta Basin Recovery Unit.

A8 **San Joaquin Basin Recovery Unit**: Minimum of ten habitat block pairs with no less than two block pairs per management unit in the San Joaquin Basin Recovery Unit.

A9 **Tulare Basin Recovery Unit**: Minimum of two habitat block pairs in the Mendota management unit in the Tulare Basin Recovery Unit.

All Recovery Units

A10 Corridors of aquatic habitat with a 0.8-kilometer (0.5-mile) width hydrologically connect adjacent habitat block pairs within Recovery Units.

A11 Corridors hydrologically connect adjacent Recovery Units.

A12 Management plans are developed, implemented, and updated as needed for 20 years for all habitat blocks and corridors preserved for the giant garter snake listed in Criteria A1 through A9. Management plans will address as a minimum the following: water management to provide summer aquatic habitat, use of pesticides, best grazing regimes, fallowing of rice fields, eradication of invasive plants, operations and maintenance of canals and flood control structures, control of non-native predators, monitoring of native predators, location and use of roads within the conservation areas)

A13 Water supplied for use on all giant garter snake preserves will have annual water delivery requirements identified. Garter snake preserves are supplied with water of sufficient quantity to support the aquatic habitat component of the giant garter snake on that property in perpetuity and will be free of contaminants or will contain contaminants at levels that

[2] This is in addition to the existing 3,541 hectares (8,750 acres) preserved in minimum blocks of 162 hectares (400 acres) with one 1,012 hectare (2,500 acre) reserve provided as compensation through the Natomas Basin HCP and the Metro Air Park HCP.

have been demonstrated to be harmless to giant garter snakes. Monitoring of annual water supplies and water quality standards reveals that water used to provide aquatic habitat is provided each year, and meets or exceeds quality standards over a 20-year monitoring program.

2. Recovery Criteria Factor B: Overutilization for commercial, recreational, scientific or educational purposes.

Overutilization for any purpose is not known to threaten the giant garter snake at this time. Therefore, no recovery criteria have been developed for this factor.

3. Recovery Factor C: Disease or Predation.

In order to ensure the long term recovery of the giant garter snake, threats to the species from disease or predation must be reduced or removed. This will have been accomplished if the following have occurred:

C1 Introduced snakes (*Nerodia* sp.) are either eradicated or reduced in numbers throughout the historical range of the giant garter snake to the point where the transmission of disease by these non-native snakes is no longer a threat (and competitive interactions are eliminated between introduced snakes and the giant garter snake).

C2 A management plan is developed and implemented to monitor for the effects of parasites and viruses on the giant garter snake and any discovered threats to the giant garter snake from parasites or viruses are controlled or ameliorated to an extent they are not a threat to the populations.

4. Recovery Factor D: Inadequacy of existing regulatory mechanisms.

If the threats under factors A, B, C and E are ameliorated or eliminated then additional regulatory mechanisms (beyond the existing ones) are not necessary.

5. Recovery Factor E: Other natural or manmade factors affecting its continued existence.

In order to ensure the long term recovery of the giant garter snake, the species must be protected from other natural or manmade factors known to affect its continued existence. This will have been accomplished if all of the preserved perennial marshes and ricelands host a stable population as determined from monitoring over a 20-year period that includes at least one consecutive 3-year period of dry or critically dry weather[3], and the following have occurred:

E1 These populations are protected from predicted alterations of habitat components due to climate change through the development of contingency plans that will provide resources to ensure habitat components are maintained at all preserves during adverse climatic

[3] There are multiple determinants of population dynamics of the giant garter snake. Populations of any species typically fluctuate over time depending on density dependent factors like births, deaths, emigrations, and immigration; and also may fluctuate as determined by a number of abiotic environmental factors, the level of resources, the life cycle of the species, and the influence of predators and parasites (Townsend *et al.* 2000). Thus a single year of population surveys is not an accurate portrayal of the stability of a population. Giant garter snake populations will similarly vary among years depending on annual weather patterns, local agricultural practices, degree of predation and recruitment, and other demographic factors. In order to determine whether giant garter snake populations are stable we use 20 years of monitoring as a period of time that will include multiple generations (4 or 5 generations based on the average of 5 years for females to reach sexual maturity) and reflect long-term trends in both demographics and local habitat suitability in response to weather and land use patterns (B. Halstead pers. comm. 2015, E. Hansen pers. comm. 2015).

conditions, such as extended periods of drought, or extended periods of above average temperatures.

E2 The density found during trapping is at least an average 8 snakes per hectare for buffered perennial wetlands and 3 snakes per hectare for active ricelands.

E3 The population estimate and density are used for a trend analysis over a 20-year period that demonstrates a 90 percent probability that the population is stable or increasing.

E4 The habitat requirements described in delisting criteria A/1 – A/9 are available during all surveys.

E5 The sex ratio is not significantly different than 1:1.

E6 Age structure analysis reveals that recruitment is occurring at a level that will prevent a senescent population.

E7 Road mortalities of giant garter snakes are reduced to a level that does not cause declines to populations.

III. RECOVERY ACTION NARRATIVE AND IMPLEMENTATION SCHEDULE

A. Recovery Action Narrative

This chapter lays out the elements of the recovery strategy, then tiers them down to individual recovery actions for implementation. Each most-detailed or stepped-down action has been assigned a priority according to our determination of what is most important for the recovery of giant garter snake. The priority numbers are defined as follows:

Priority 1: An action that must be taken to prevent extinction or to prevent a species from declining irreversibly.

Priority 2: An action that must be taken to prevent a significant decline in the species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Because situations change over time, priority numbers must be considered in the context of past and potential future actions at all sites. Therefore, the priority numbers assigned are intended to guide, not to constrain, the allocation of limited conservation resources.

1. Protect existing habitat, areas identified for habitat restoration or creation, and areas needed to provide connectivity between populations.

Protection of giant garter snake populations includes preserving and restoring the habitat necessary to maintain existing populations, providing for population increase, and ensuring that numbers and populations of giant garter snakes are self-sustaining and sufficient to maintain genetic diversity and adaptive potential of the species.

1.1 Protect, secure, and restore habitat distributed across the historical range of the giant garter snake. All habitat with known giant garter snake populations, based on locality record data, that is currently unprotected should be protected and secured. Habitat for the giant garter snake will be preserved in pairs of contiguous blocks of land as described in the recovery criteria above. (Priority 1)

1.2 Protect and secure corridors linking habitat blocks (within and between management units) and recovery units. Corridors for the giant garter snake need to be protected with an emphasis on accommodating movement that allows genetic exchange between giant garter snakes occupying habitat blocks and between management units and recovery units. (Priority 2)

1.3 Work with city and county governments to buffer areas identified for protection as habitat for the giant garter snake to minimize the effects of urban development on giant garter snakes and their habitat. Buffers may be secured and protected through acquisition, conservation or agricultural easements, through land use planning, or development of regional conservation plans. (Priority 2)

2. Develop and implement appropriate management of habitat on public and private wetlands and conservation lands, including specific practices for agricultural operations, water conveyance systems, and flood control systems that maintain either summer seasonal wetlands, perennial wetlands, or ricelands.

2.1. Service-approved management plans that incorporate adaptive management should be developed, approved, and implemented for habitat blocks and corridors. Management plans should include specific resource and habitat objectives and monitoring that ensure suitable habitat is restored and maintained, and include measures to minimize the impacts of habitat management activities on giant garter snakes and their habitat. (Priority 1)

2.2 Develop and periodically update best management guidelines for giant garter snake habitat occurring outside of conservation lands that: (1) minimize the risk of physical injury to giant garter snakes from ground disturbing activities, use of heavy equipment, and vehicle use; (2) minimize the amount and frequency of habitat disturbance; and (3) allow establishment and/or maintenance of habitat for giant garter snakes. Guidelines should be developed for ricelands, canals and ditches, flood control structures, water transfers, and private wetlands. (Priority 1)

2.3. Work with California Department of Transportation and the Federal Highway Administration to minimize effects of roadway expansion and increased use associated with urbanization by incorporating protective measures into project planning to minimize the effects of roads to giant garter snakes and giant garter snake habitat. (Priority 2)

3. Improve water quality in areas occupied by the giant garter snake and affected by poor water quality conditions.

3.1 Work with appropriate agencies to ensure the improvement of water quality within known-contaminated water bodies occupied by the giant garter snake. Review the Clean Water Act (303(d)) list of impaired water bodies in California produced by the USEPA to determine which impaired water bodies supply water to any known giant garter snake habitat and work with appropriate federal and state authorities to promote improvement of water quality in those waters. (Priority 2)

3.2 Study the effects of selenium, mercury, and other contaminants on giant garter snakes and their prey. (Priority 3)

3.3 Investigate, develop and implement a means to supply uncontaminated water to State and Federal wildlife refuges (such as Grasslands Ecological Area, Volta WA). (Priority 1)

4. Ensure summer water is available for wetland habitats used by the snake.

Explore, develop and implement methods to assure quantity and timing of water deliveries to meet habitat objectives for all conservation lands developed and protected for the giant garter snake. The USFWS, CDFW, and other species experts will work with the USBR, the Army Corps of Engineers, and local municipal water agencies to assure adequate water will be available to support the giant garter snake habitat and management needs at those locations where populations exist.

4.1. Identify total water requirements to maintain and/or restore habitats according to management plans developed under recovery action 2 on all conservation lands identified in recovery action 1. (Priority 1)

4.2. Evaluate the current, existing water supply and determine whether additional water is necessary to meet habitat needs and management goals determined and identified in recovery action 4.1 for each of the conservation lands identified in recovery action 1. For areas where additional water needs have been identified, secure sufficient water to fully develop or manage habitat for the giant garter snake. (Priority 1)

5. Establish an incentive or easement program(s) to encourage private landowners and local agencies to provide or maintain giant garter snake habitat.

The ultimate goal of incentive programs is to assist landowners in maintaining agricultural practices (*e.g.*, rice cultivation) and wetland habitats that benefit this species.

5.1 Develop agricultural incentives for landowners. Work with nonprofit organizations (such as land trusts) to assist private landowners in conserving and recovering the giant garter snake through economic and other incentive programs. Agricultural incentives should be developed and made available to landowners and water districts and users who conserve giant garter snakes on their property or who may provide suitable habitat. (Priority 1)

6. Monitor populations and habitat to assess success or failure of management activities and habitat protection efforts.

Monitoring is needed to establish population trends, to determine if and when additional management actions should be performed, and to determine the efficacy of management actions. A standardized protocol developed under recovery action 7.2 is needed to ensure consistency of monitoring performed by different entities and at different times.

Monitoring must be based on multiple biological and physical factors, not just on number of individuals captured. Monitoring should document changes in habitat quantity and quality over time. During development of monitoring plans, the development and implementation of population viability analyses should be considered and incorporated where possible using data collected during monitoring programs (see recovery actions 8.4.1 through 8.4.4).

6.1 Develop and incorporate into management plans, monitoring programs for giant garter snake habitat and presence and abundance on all lands preserved for the giant garter snake. (Priority 1)

7. Conduct surveys and research to identify areas requiring protection and management.

7.1 Develop habitat assessment protocols to measure the suitability of giant garter snake habitat and conduct habitat assessments, habitat suitability analysis and mapping, and conduct surveys using the most recent protocols within the recovery units to assess giant garter snake populations and where the best habitat exists for potential conservation. (Priority 1)

8. Conduct research focused on the management needs of the species, and on identifying and removing threats.

8.1. Conduct research on the habitat requirements of the giant garter snake.

8.1.1. Determine habitat use and prey requirements of neonatal, juvenile, and adult giant garter snakes and examine the use of upland habitats by the giant garter snake to determine the amounts and types of upland habitats required to support giant garter snakes. (Priority 1)

8.1.2. Examine occurrence in and use of riparian habitats by the giant garter snake to determine if additional areas require management for the giant garter snake. (Priority 2)

8.1.3 Determine buffer requirements for protecting giant garter snakes and their habitat from incompatible uses, such as urban development and roadways. (Priority 2)

8.1.4 Examine use of corridors between conservation lands to determine use and effectiveness of protecting corridors. (Priority 1)

8.1.5 Examine response of giant garter snakes to managed marsh restoration to determine effectiveness of restoration efforts and to modify restoration techniques as necessary to benefit the giant garter snake. (Priority 1)

8.2 Conduct research on life history and population characteristics of giant garter snakes.

8.2.1 Determine the movement patterns of giant garter snakes, including home ranges, daily and annual movements, and dispersal abilities over a broad range of size classes, among different habitat types, across the giant garter snake's range. (Priority 2)

8.2.2 Determine demographic information on reproductive and mortality rates, clutch sizes, fecundity, age and size at sexual maturity, and population sizes and densities among different habitat types and across the giant garter snake's range. (Priority 1)

8.2.3 Determine movement of giant garter snake in response to changes to various external conditions (such as changes in habitat conditions or management). (Priority 2)

8.3 Determine genetic relatedness among populations of giant garter snakes within and between recovery units and identify landscape features that serve as barriers to dispersal. (Priority 2)

8.4 Conduct population viability analyses.

Population viability analysis (PVA) is the use of quantitative methods to analyze the environmental and demographic factors that affect the survival of populations. Population viability analyses may be used to refine recovery criteria and tasks in a number of ways. (Priority 2)

8.5 Conduct research on threats and propose actions to ameliorate those threats. Research is needed to determine extent of threats and to develop methods to ameliorate those threats.

8.5.1 Study the effects of introduced predators on giant garter snake populations, and develop and implement a management program to monitor affected populations. (Priority 2)

8.5.2 Determine the effects of flooding on the survival of the giant garter snake. Although giant garter snakes evolved in the Central Valley and likely are adapted to withstand some flooding of habitats, reclamation and flood control activities have altered the timing, duration, and severity of floods. (Priority 2)

8.5.3 Determine how to minimize the effects of water transfers to the giant garter snake and its habitat and develop and implement guidelines for water transfers that minimize the effects of transfers to the giant garter snake and its habitat. (Priority 1)

8.5.4 Determine the effects of erosion control netting products on snake movement, and recommend ways to ameliorate negative effects if found. Determine which products have the least chance of negatively affecting the giant garter snake and provide a list of these products for consideration during section 7 consultations. (Priority 2)

8.5.5 Collaborate with the California Climate Change Center to investigate the effects of climate change on the giant garter snake and its habitat. Information developed will, in part, inform development of adaptive management guidelines that should be implemented throughout the range of the giant garter snake. (Priority 2)

9. Establish and implement outreach and education, which includes the participation of landowners, interested public and stakeholders, and other Federal, State, and local agencies.

9.1 Distribute guidelines for land use practices compatible with giant garter snake conservation to landowners and agencies and distribute to appropriate land managers and partners (farmers, ranchers). (Priority 1)

9.2. Develop and distribute informational material on the habitat and management needs of the giant garter snake to interested and affected private landowners. (Priority 2)

9.3 Develop and distribute outreach and education materials for public and conservation land managers. (Priority 2)

9.4 Form a Recovery Implementation Team that cooperatively implements specific recovery actions necessary to recover the giant garter snake. (Priority 1)

10. Re-establish populations within the giant garter snake's historical range.

Since giant garter snakes have been extirpated over a portion of their range and several populations are now at risk of extirpation, repatriation may be necessary for recovery of the giant garter snake. Specific sites for repatriation are not currently identified; however the first sites will be in the San Joaquin Basin Recovery Unit or Tulare Basin Recovery Unit since these populations are more at risk than in the Sacramento Valley.

The first step is to research the possibility of conducting translocations to either augment populations with low numbers of individuals or to reintroduce individuals into historically occupied areas. If translocation is deemed unfeasible or undesirable, then a controlled propagation program must be conducted in a manner that will, to the maximum extent possible, preserve the genetic and ecological distinctness of the listed species, and minimize risks to existing wild populations.

10.1 Identify suitable repatriation sites based on results of surveys and habitat assessments including analysis of the habitat and management requirements necessary to successfully reintroduce giant garter snakes and current threats at potential reintroduction sites. The historical range of the giant garter snake in the San Joaquin Basin and the Tulare Basin Recovery Units should be assessed and surveyed for suitable repatriation sites or areas and to verify that no giant garter snakes already inhabit potential repatriation sites. (Priority 2)

10.2 Develop and implement and implement a captive propagation and repatriation plan (including genetics management plan) for specific sites if repatriation is determined to be necessary to prevent local extirpations and feasible. (Priority 2)

B. Implementation Schedule

The implementation schedule that follows outlines actions for this revised draft recovery plan. It is a guide for meeting the objectives discussed in Chapter III of this revised draft recovery plan. This schedule describes and prioritizes recovery actions, provides an estimated time table for performance of recovery actions, and indicates the responsible agencies. These actions, when accomplished, should further the recovery and conservation of the covered species.

Total Estimated Cost of Recovery and Date of Recovery: In order to best provide for the conservation and recovery of the species and develop a reasonable cost estimate, we will maximize partnerships with Federal, State, and non-governmental partners. Due to the complexity of this plan and number of actions needed to accomplish recovery, we are continuing to develop the cost estimates for the actions described in this draft plan. Delisting could be initiated by 2045 if recovery criteria have been achieved in the next 30 years. The core of the recovery strategy, protection of habitat and corridors, is likely to take a minimum 10 years to achieve, but may take significantly longer. Following the protection of habitat, an additional 20-year monitoring period is recommended to cover multiple generations (four to five generations) to ensure that giant garter snake populations are self-sustaining. Because recovery plans are guidance and planning documents, they do not obligate partners to carry out actions, nor do they provide funds to carry out actions.

We believe that considerable positive conservation can occur by working with agencies and landowners to conduct recovery actions and working toward acquisition of the highest priority areas. The Service will establish a Recovery Implementation Team (RIT) upon completion of a final recovery plan. The RIT will be a broad-based group of stakeholders and will help to identify the highest priority tasks for early implementation. The RIT will monitor the success of early implementation efforts and, depending on the giant garter snake's progress toward recovery, determine if all of the measures outlined in the plan are necessary. Therefore, we believe that the recovery measures outlined is this plan are a comprehensive approach for recovery of the giant garter snake; however, recovery may be achieved without all measures in this plan being implemented, resulting in a decrease in cost and time to recovery.

Key to Acronyms used in the Implementation Schedule

Definition of recovery action durations:
Continual - A recovery action that will be implemented on a routine basis once begun.
Ongoing - A recovery action that is currently being implemented and will continue until action is no longer necessary.
Unknown - Either recovery action duration or associated costs are not known at this time.

Responsible parties:
BLM - U.S. Bureau of Land Management
BRD - Biological Resources Division (USGS)

CITY – Local City
CDFW - California Department of Fish and Wildlife
CDOT - California Department of Transportation
COE - U.S. Army Corps of Engineers
COUN – Local County
CDPR - California Department of Parks and Recreation
CPP - Conservation program participant (easements, incentives)
CRIA - California Rice Industry Association
DPR - California Department of Pesticide Regulations
DWR - California Department of Water Resources
FCD – Local Flood Control District
FHWA - Federal Highways Administration
MVCD - Mosquito and Vector Control District
NCWA - Northern California Water Association
NGO - Non-government Organization
NRCS - Natural Resources Conservation Service
PLO - Private landowner or party
RB/DWR - Reclamation Board/California Department of Water Resources
(includes levee and reclamation districts)
RCD - Resource Conservation District
SJCOG – San Joaquin Council of Governments
SWRCB - State Water Resources Control Board
USBR - U.S. Bureau of Reclamation
USEPA - Environmental Protection Agency
USFWS - U.S. Fish and Wildlife Service
WD – Local Water District

The most likely lead responsible party is listed in bold in the following Implementation Schedule.

Implementation Schedule for the Giant Garter Snake											
Recovery Action Information					Cost estimate in $1,000 units						
Priority	**Action Number**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2015**	**2016**	**2017**	**2018**	**2019**	**Comments/Notes**
1	1.1	Protect, secure, and restore habitat distributed across the historical range of the giant garter snake.	Ongoing	**USFWS**, CDFW NGO, PLO, CPP, RCD, SJCOG, USBR, CDPR, RB/DWR	TBD	TBD	TBD	TBD	TBD	TBD	
2	1.2	Protect and secure corridors linking habitat blocks (within and between management units) and recovery units. Corridors for the giant garter snake need to be protected with an emphasis on accommodating movement that allows genetic exchange between giant garter snakes occupying habitat blocks and between management units and recovery units.	Ongoing	USFWS, CPP, **NGO,** CDFW	TBD	TBD	TBD	TBD	TBD	TBD	
2	1.3	Work with city and county governments to buffer areas identified for protection as habitat for the giant garter snake to minimize the effects of urban development on giant garter snakes and their habitat.	Continual	USFWS, CIT, **COUN**	TBD	TBD	TBD	TBD	TBD	TBD	
2	2.1	Service-approved management plans that incorporate adaptive management should be developed, approved, and implemented for habitat blocks and corridors.	Continual	**USFWS, CDFW, NGO,** PLO, CPP. **BLM**	TBD	TBD	TBD	TBD	TBD	TBD	
1	2.2	Develop and periodically update best management guidelines for giant garter snake habitat occurring outside of conservation lands that: (1) minimize the risk of physical injury to giant garter snakes from ground disturbing activities, use of heavy equipment, and vehicle use; (2) minimize the amount and frequency of habitat disturbance; and (3) allow establishment and/or maintenance of habitat for giant garter snakes. Guidelines should be developed for ricelands, canals and ditches, flood control structures, water transfers, and private wetlands.	Continual	**USFWS**, CDFW, BRD**, CRIA,** NCWA	TBD	TBD	TBD	TBD	TBD	TBD	
2	2.3	Work with California Department of Transportation and the Federal Highway	Ongoing,Continual	USFWS, CDFW, **CDOT**, FHWA	TBD	TBD	TBD	TBD	TBD	TBD	

Implementation Schedule for the Giant Garter Snake											
Recovery Action Information					**Cost estimate in $1,000 units**						
Priority	**Action Number**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2015**	**2016**	**2017**	**2018**	**2019**	**Comments/Notes**
		Administration to minimize effects of roadway expansion and increased use associated with urbanization by incorporating protective measures into project planning to minimize the effects of roads to giant garter snakes and giant garter snake habitat.									
2	3.1	Work with appropriate agencies to ensure the improvement of water quality within known-contaminated water bodies occupied by the giant garter snake.	2 years	**USFWS**, USEPA, CDFW	TBD	TBD	TBD	TBD	TBD	TBD	
3	3.2	Study the effects of selenium, mercury, and other contaminants on giant garter snakes and their prey.	4 years	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
1	3.3	Investigate, develop and implement a means to supply uncontaminated water to State and Federal wildlife refuges (such as Grasslands Ecological Area, Volta WA).	5 years	USFWS, CDFW, BRD, USBR, USEPA, **DWR**, **FCD**	TBD	TBD	TBD	TBD	TBD	TBD	
1	4.1	Identify total water requirements to maintain and/or restore habitats according to management plans developed under recovery action 2 on all conservation lands identified in recovery action 1.	Ongoing	**USFWS**, CDFW, CPP	TBD	TBD	TBD	TBD	TBD	TBD	
1	4.2	Evaluate the current, existing water supply and determine whether additional water is necessary to meet habitat needs and management goals.	Ongoing	**USFWS**, CDFW, CPP, USBR, WD, SWRCB	TBD	TBD	TBD	TBD	TBD	TBD	
1	5.1	Develop agricultural incentives for landowners. Work with nonprofit organizations (such as land trusts) to assist private landowners in conserving and recovering the giant garter snake through economic and other incentive programs. Agricultural incentives should be developed and made available to landowners and water districts and users who conserve giant garter snakes on their property or who may provide suitable habitat.	Ongoing	USFWS, CDFW, **NRCS**, USBR, DWR, CRIA, NCWA	TBD	TBD	TBD	TBD	TBD	TBD	
1	6.1	Develop and incorporate into management plans, monitoring programs for giant garter snake habitat and presence and abundance on all lands preserved for the giant garter snake.	Ongoing, Continual	**USFWS**, **CDFW**, USBR, CPP, BRD, **NGO**	TBD	TBD	TBD	TBD	TBD	TBD	

Implementation Schedule for the Giant Garter Snake											
Recovery Action Information					**Cost estimate in $1,000 units**						
Priority	**Action Number**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2015**	**2016**	**2017**	**2018**	**2019**	**Comments/Notes**
1	7.1	Develop habitat assessment protocols to measure the suitability of giant garter snake habitat and conduct habitat assessments, habitat suitability analysis and mapping, and conduct surveys using the most recent protocols within the recovery units to assess giant garter snake populations and where the best habitat exists for potential conservation.	Ongoing	**USFWS**, CDFW, BRD	TBD	TBD	TBD	TBD	TBD	TBD	
1	8.1.1	Determine habitat use and prey requirements of neonatal, juvenile, and adult giant garter snakes and examine the use of upland habitats by the giant garter snake to determine the amounts and types of upland habitats required to support giant garter snakes.	3 years	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
2	8.1.2	Examine occurrence in and use of riparian habitats by the giant garter snake to determine if additional areas require management for the giant garter snake.	5 years	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
2	8.1.3	Determine buffer requirements for protecting giant garter snakes and their habitat from incompatible uses, such as urban development and roadways.	2 years	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
1	8.1.4	Examine use of corridors between conservation lands to determine use and effectiveness of protecting corridors.	2 years	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
1	8.1.5	Examine response of giant garter snakes to managed marsh restoration to determine effectiveness of restoration efforts and to modify restoration techniques as necessary to benefit the giant garter snake.	10 years	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
2	8.2.1	Determine the movement patterns of giant garter snakes, including home ranges, daily and annual movements, and dispersal abilities over a broad range of size classes, among different habitat types, across the giant garter snake's range	Ongoing	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
1	8.2.2	Determine demographic information on reproductive and mortality rates, clutch sizes, fecundity, age and size at sexual maturity, and	Ongoing	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	

Implementation Schedule for the Giant Garter Snake											
Recovery Action Information					Cost estimate in $1,000 units						
Priority	Action Number	Description	Duration	Responsible Parties	Total Costs	2015	2016	2017	2018	2019	Comments/Notes
		population sizes and densities among different habitat types and across the giant garter snake's range.									
2	8.2.3	Determine movement of giant garter snake in response to changes to various external conditions	2 years	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
2	8.3	Determine genetic relatedness among populations of giant garter snakes within and between recovery units and identify landscape features that serve as barriers to dispersal.	Ongoing	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
2	8.4	Conduct population viability analyses.Population viability analysis (PVA) is the use of quantitative methods to analyze the environmental and demographic factors that affect the survival of populations. Population viability analyses may be used to refine recovery criteria and tasks in a number of ways.	Ongoing	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
2	8.5.1	Study the effects of introduced predators on giant garter snake populations, and develop and implement a management program to monitor affected populations	5 years	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
2	8.5.2	Determine the effects of flooding on the survival of the giant garter snake. Although giant garter snakes evolved in the Central Valley and likely are adapted to withstand some flooding of habitats, reclamation and flood control activities have altered the timing, duration, and severity of floods.	5 years	USFWS, CDFW, **BRD**, USBR, COE, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
1	8.5.3	Develop guidelines for water transfers that minimize the effects of transfers to the giant garter snake and its habitat and develop and implement guidelines for water transfers that minimize the effects of transfers to the giant garter snake and its habitat.	5 years	USFWS, CDFW, **BRD**, USBR, NGO, RB/DWR.	TBD	TBD	TBD	TBD	TBD	TBD	
2	8.5.4	Determine the effects of erosion control netting products on snake movement, and recommend ways to ameliorate negative effects if found. Determine which products have the least chance of negatively affecting	2 years	USFWS, CDFW, **BRD**, USBR, NGO, COE, CDOT	TBD	TBD	TBD	TBD	TBD	TBD	

Implementation Schedule for the Giant Garter Snake											
Recovery Action Information					Cost estimate in $1,000 units						
Priority	**Action Number**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2015**	**2016**	**2017**	**2018**	**2019**	**Comments/Notes**
		the giant garter snake and provide a list of these products for consideration during section 7 consultations.									
2	8.5.5	Collaborate with the California Climate Change Center to investigate the effects of climate change on the giant garter snake and its habitat. Information developed will, in part, inform development of adaptive management guidelines that should be implemented throughout the range of the giant garter snake.	Ongoing	USFWS, CDFW, **BRD**, USBR, NGO	TBD	TBD	TBD	TBD	TBD	TBD	
1	9.1	Distribute guidelines for land use practices compatible with giant garter snake conservation to landowners and agencies and distribute to appropriate land managers and partners (farmers, ranchers)	Continual	**USFWS**, CDFW, BRD, USBR, COE, NRCS, RB/DWR, CRIA, NCWA	TBD	TBD	TBD	TBD	TBD	TBD	
2	9.2	Develop and distribute informational material on the habitat and management needs of the giant garter snake to interested and affected private landowners.	Continual	**USFWS**, CDFW	TBD	TBD	TBD	TBD	TBD	TBD	
2	9.3	Develop and distribute outreach and education materials for public and conservation land managers.	Continual	**USFWS**, CDFW	TBD	TBD	TBD	TBD	TBD	TBD	
1	9.4	Form a Recovery Implementation Team that cooperatively implements specific recovery actions necessary to recover the giant garter snake.	Continual	**USFWS**, BRD, NGO, CDFW	TBD	TBD	TBD	TBD	TBD	TBD	
2	10.1	Identify suitable repatriation sites based on results of surveys and habitat assessments including analysis of the habitat and management requirements necessary to successfully reintroduce giant garter snakes and current threats at potential reintroduction sites. The historical range of the giant garter snake in the San Joaquin Basin and the Tulare Basin Recovery Units should be assessed and surveyed for suitable repatriation sites or areas and to verify that no giant garter snakes already inhabit potential repatriation sites.	unknown	USFWS, **BRD**, NGO, CDFW	TBD	TBD	TBD	TBD	TBD	TBD	
2	10.2	Develop and implement and implement a	unknown	**USFWS**, BRD, CDFW,	TBD	TBD	TBD	TBD	TBD	TBD	

Implementation Schedule for the Giant Garter Snake											
Recovery Action Information					**Cost estimate in $1,000 units**						
Priority	**Action Number**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2015**	**2016**	**2017**	**2018**	**2019**	**Comments/Notes**
		captive propagation and repatriation plan (including genetics management plan) for specific sites if repatriation is determined to be necessary to prevent local extirpations and feasible.		NGO							
Total Cost: TBD											

IV. LITERATURE CITED

Brode, J. 1988. Natural history of the giant garter snake (*Thamnophis couchii gigas*). Pages 25-28, *In* Proceedings of the conference on California herpetology, H. F. DeListe, P. R. Brown, B. Kaufman, and B. M. McGurty (eds). Southwestern Herpetologists Society, Special Publication No. 4.

Brode, J. and G. Hansen. 1992. Status and future management of the giant garter snake (*Thamnophis gigas*) within the southern American Basin, Sacramento and Sutter counties, California. California Department of Fish and Game, Inland Fisheries. Division.

Bryan, K. 1923. Geology and Groundwater Resources of Sacramento Valley, California. Water – Supply Paper 495. Prepared for the U.S. Geological Survey and in cooperation with the Department of Engineering of the State of California. Washington: Government Printing Office. 313 pp.

Central Valley Joint Venture. 2006. Central Valley Joint Venture Implementation Plan – Conserving bird habitat. U.S. Fish and Wildlife Service, Sacramento, CA.

[CNDDB] California Department of Fish and Game, Natural Diversity Data Base. 2011. Natural Heritage Division. State of California. Available at : http://www.dfg.ca.gov/biogeodata/cnddb/>. Accessed March 18, 2011.

Coates, P.S., G.D. Wylie, B.J. Halstead, and M.L. Casazza. 2009. Using time-dependent models to investigate body condition and growth rate of the giant garter snake. Journal of Zoology.

Costanzo, J. P. 1989a. Conspecific scent trailing by garter snakes (*Thamnophis sirtalis*) during autumn. Further evidence for use of pheromones in den location. Journal of Chemical Ecology 15(11): 2531-2538.

Dickert, C. 2002. San Joaquin Valley Giant Garter Snake Project 2001. Unpublished report. California Department of Fish and Game, Los Banos, California.

Dickert, C. 2003. Progress report for the San Joaquin Valley giant garter snake conservation project – 2003. Unpublished report. California Department of Fish and Game, Los Banos, California.

Ducks Unlimited, Inc. 1997. California Wetland and Riparian Geographic Information System Project. Final Report for California Department of Fish and Game, Natural Heritage Division; California Wildlife Conservation Board; and U.S. Bureau of Reclamation. 41pp.

Engstrom, T. 2010. Genetic analysis of giant garter snake (Thamnophis gigas) populations in the San Joaquin and Sacramento Valleys. Prepared for the Central Valley Project Conservation Program/Habitat Restoration Program.

Fitch, H. S. 1940. A biogeographical study of the *ordinoides* Artenkreis of garter snakes (genus *Thamnophis*. University of California Publications in Zoology. 44:1-150.

Fitch, H. S. 1941. The feeding habits of California garter snakes. Department of Fish and Game 27:2-32.

Halstead, B.J., G.D. Wylie, and M.L. Casazza. 2010. Habitat suitability and conservation of the giant garter snake (*Thamnophis gigas*) at the landscape scale. Copeia 2010(4): 591-599.

Halstead, B.J., G.D. Wylie, M.L. Casazza, and P.S. Coates. 2011. Temporal and maternal effects on the reproductive ecology of the giant garter snake (*Thamnophis gigas*). Southwestern Naturalist 56(1): 29-34.

Hansen, E. 2002. Year 2001 investigations of the giant garter snake (*Thamnophis gigas*) in the greater American Basin: Sutter County, California. Prepared for the Sacramento Area Flood Control Agency by Eric Hansen. January 30, 2002.

Hansen, E. 2003a. Year 2002 investigations of the giant garter snake (*Thamnophis gigas*) at the Cosumnes River preserve. Prepared for the Nature Conservancy by Eric Hansen. March 15, 2003.

Hansen, E. 2008a. 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 extension to northern Fresno County. Prepared for the U.S. Fish and Wildlife Service by Eric Hansen. April 15, 2008.

Hansen, E. 2008b. Results of year 2007 giant garter snake (*Thamnophis gigas*) surveys, Yolo County, CA. Prepared for the U.S. Fish and Wildlife Service by Eric Hansen. February 12, 2008.

Hansen, G.E. 1982. Status of the giant garter snake *Thamnophis couchi gigas* along portions of Laguna and Elk Grove Creeks, Sacramento County, California. Report by George E. Hansen, Consulting Environmental Biologist.

Hansen, G. E. 1986. Status of the giant garter snake *Thamnophis couchi gigas* (Fitch) in the Southern Sacramento Valley During 1986. Final report for California Department of Fish and Game, Standard Agreement No. C-1433. Unpublished. 31 pp.

Hansen, G. E. 1988. Review of the status of the giant garter snake (*Thamnophis couchi gigas*) and its supporting habitat during 1986-1987. Final report for California Department of Fish and Game, Contract C-2060. Unpublished. 31 pp.

Hansen, G. E. 1996a. Status of the giant garter snake (*Thamnophis gigas*) in the San Joaquin Valley in 1995. Final report for California Department of Fish and Game, Standard Agreement No. FG4052IF. Unpublished 31 pp.

Hansen, G. E. and J. M. Brode. 1980. Status of the giant garter snake, *Thamnophis couchi gigas* (Fitch). California Department of Fish and Game. Inland Fisheries Endangered Species Program Special Publication Report No. 80-5. 14 pp.

Hansen, G. E. and J. M. Brode. 1993. Results of relocating canal habitat of the giant garter snake (*Thamnophis gigas*) during widening of State Route 99/70 in Sacramento and Sutter counties, California. Final report for Caltrans Interagency Agreement 03E325 (FG7550) (FY 87/88-91-92). Unpublished. 36 pp.

Hansen, R. W. 1980. Western aquatic garter snakes in central California: an ecological and evolutionary perspective. Masters thesis, Department of Biology, California State University, Fresno. 78 pp.

Hansen, R.W. and G. E. Hansen. 1990. *Thamnophis gigas.* Reproduction. Herpetological Review 21(4):93-94.

Klemens, M. W. 2000. Turtle conservation. Smithsonian Institution. Washington D.C. 334 pp.

Krohne, D. T. 2001. General ecology. Brooks/Cole. Pacific Grove, CA, 479 pp.

Kuchler, A. W. 1977. The map of the natural vegetation of California. Pp. 909-938 + supplement, *in* Terrestrial vegetation of California (M. G. Barbour and J. Major, eds.). John Wiley and Sons, NY, 1002 pp.

Lawson, R. and H. C. Dessauer. 1979. Biochemical genetics and systematics of garter snakes of the *Thamnophis elegans-couchii-ordinoides* complex. Occasional Papers of the Museum of Zoology, Louisiana State University, Baton Rouge, Louisiana, No. 56. 24 pp.

Lincoln, R., G. Boxshall, and P. Clark. 2001. A dictionary of ecology, evolution and systematics. Cambridge University Press, New York, NY, 361 pp.

Mazerolle, M.J., L. L. Bailey, W. L. Kendall, J. A. Royle, S. J. Converse, and J. D. Nichols. 2007. Making Great Leaps Forward: Accounting for Detectability in Herpetological Field Studies. Journal of Herpetology 41(4): 672–689.

Paquin, M. M., G. D. Wylie, and E. J. Routman. 2006. Population structure of the giant garter snake *Thamnophis gigas.* Conservation Genetics. 7:25-36.

Parker, W. S. and M. V. Plummer. 1987. Population ecology. In: R. A. Seigel, J. T. Collins, and S. S. Novak, editors. Snakes: ecology and evolutionary biology. McGraw-Hill, New York. Pages 253–301.

Pough, F.H., R.M. Andrews, J.E. Cadle, M.L. Crump, A.H. Savitzky, K.D. Wells. 2001. Herpetology. Prentice Hall, Upper Saddle River, NJ. 612 pp.

Rossman, D. and G. Stewart. 1987. Taxonomic reevaluation of *Thamnophis couchii* (Serpentes: Colubridae). Occasional Papers of the Museum of Zoology, Louisiana State University, Baton Rouge, Louisiana. No. 63. 25 pp.

Rossman, D. A., N. B. Ford, and R. A. Seigel. 1996. The garter snakes: evolution and ecology. University of Oklahoma Press, Norman. 331 pp.

Seaman, D.E. and R.A. Powell. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. Ecology 77(7): 2075-2085.

Sousa, C. and J. Sloan. 2007. San Joaquin Valley giant garter snake trapping 2006. Los Banos WA Publication Number 30. California Department of Fish and Game.

Townsend, C.R., J.L. Harper, M. Begon. 2000. Essentials of Ecology. Blackwell Sciences, Malden, MA, 553 pp.

U.S. Fish and Wildlife Service. 1983. Endangered and Threatened Species Listing and Recovery Priority Guidelines. Federal Register 48:43098 - 43105.

U.S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants; determination of threatened status for the giant garter snake. Federal Register 58:54053-54066.

U.S. Fish and Wildlife Service. 1994a. USFWS. 1994. Endangered and Threatened Wildlife and Plants: Notice of Interagency Cooperative Policy on Information Standards Under the Endangered Species Act. Federal Register 59:34271-34273.

U.S. Fish and Wildlife Service. 1997. Programmatic Formal Consultation for U.S. Army Corps of Engineers 404 Permitted Projects with Relatively Small Effects on the Giant Garter Snake within Butte, Colusa, Glenn, Fresno, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Sutter and Yolo Counties, California. Sacramento Fish and Wildlife Office 1-1-97-F-149, dated November 13, 1997.

U.S. Fish and Wildlife Service. 1999a. Announcement of Safe Harbor Policy. Federal Register 64 (32717-32726).

U.S. Fish and Wildlife Service. 1999b. Safe Harbor Agreements and Candidate Conservation Agreements with Assurances. Federal Register 64:32706-32716.

U.S. Fish and Wildlife Service. 2000. Policy regarding controlled propagation of species listed under the Endangered Species Act. Federal Register 65:56916-56922.

U.S. Fish and Wildlife Service. 2006a. Giant Garter Snake *(Thamnophis gigas)* 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California. 46 pp.

U.S. Fish and Wildlife Service. 2012. Giant Garter Snake *(Thamnophis gigas)* 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California. 62 pp.

Van Denburgh, J., and J. R. Slevin. 1918. The garter snakes of western North America. Proceedings of the California Academy of Science, Fourth Series 8(6):181-270.

Worton, B. J. (1989). Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* **70**, 164–168.

Wylie, G. D. 1998a. Giant Garter Snake Project 1998 Progress Report. Preliminary report, U. S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California

Wylie, G. D. 1998b. Results of the 1998 Survey for Giant Garter Snakes in and Around the Grasslands Area of the San Joaquin Valley. U. S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California.

Wylie, G. D. and M. L. Casazza. 2000. Investigations of the Giant Garter Snakes in the Natomas Basin:1998-1999. Unpublished report, USGS, Biological Resources Division, Dixon Field Station, California.

Wylie, G. D. and M. L. Casazza. 2001. Investigations of Giant Garter Snakes in the Natomas Basin: 2001 Field Season. U. S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California.

Wylie, G. D. and M. Amarello. 2007. Surveys for the current distribution and abundance of giant garter snakes (*Thamnophis gigas*) in the southern San Joaquin Valley. Prepared for the Bureau of Reclamation by the U.S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California.

Wylie, G. D., T. Graham, and M.L. Casazza. 1995. National Biological Service. Giant garter snake study progress report for the 1995 field season.. Preliminary report, U. S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California.

Wylie, G. D., M. L. Casazza, and J. K. Daugherty. 1997a. 1996 Progress report for the giant garter snake study. Preliminary report, U.S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California.

Wylie, G. D., M. L. Casazza, and N. M. Carpenter. 2000a. Monitoring giant garter snakes at Colusa NWR: 2000 report. Dixon Field Station, Biological Resources Survey, U.S. Geological Survey, Dixon, California.

Wylie, G. D., M. L. Casazza, L. Martin, and E. Hansen. 2000b. Investigations of giant garter snakes in the Natomas Basin: 2000 field season. Dixon Field Station, Biological Resources Survey, U.S. Geological Survey, Dixon, California. December 21, 2000.

Wylie, G. D., M. L. Casazza, and N. M. Carpenter. 2002a. Monitoring giant garter snakes at Colusa NWR: 2001 progress report. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon, California.

Wylie, G. D., M. L. Casazza, and L. L. Martin. 2002c. The distribution of giant garter snakes and their habitat in the Natomas Basin: a report for the U.S. Fish and Wildlife Service. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon, California.

Wylie, G. D., M. L. Casazza, and L. L. Martin. 2003a. Giant garter snake surveys in the Natomas Basin: 2000 - 2002. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon, California. September 2003.

Wylie, G. D., M. L. Casazza, and L. L. Martin. 2004. Monitoring giant garter snakes in the Natomas Basin: 2003 results. Prepared for the U.S. Fish and Wildlife Service by the U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon, California.

Wylie, G. D., M. L. Casazza, L. L. Martin, and N. M. Carpenter. 2005. Identification of key GGS habitats and use areas on the Sacramento NWR Complex. Prepared for the U.S. Fish and Wildlife Service and the U.S. Bureau of Reclamation by the U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon, California.

Wylie, G. D., L. L. Martin, and M. Amarello. 2008. Results of monitoring for giant garter snakes (*Thamnophis gigas*) for the bank protection project on the left bank of the Colusa Basin Drainage Canal in Reclamation District 108, Sacramento River Bank Protection Project, phase II. Prepared for the U.S. Army Corps of Engineers by the U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon, California.

Wylie, G.D., M.L. Casazza, B.J. Halstead, and C.J. Gregory. 2009a. Sex, season, and time of day interact to affect body temperatures of the giant garter snake. Journal of Thermal Biology 34: 183-189.

Wylie, G.D., M.L. Casazza, C.J. Gregory, and B.J. Halstead. 2010. Abundance and sexual size dimorphism of the giant garter snake (*Thamnophis gigas*) in the Sacramento Valley of California. Journal of Herpetology 44(1): 94-103.

PERSONAL COMMUNICATIONS

Coates, P. 2010, 2011. U.S. Geological Survey, Biological Resources Division, Dixon, California.

Halstead, Brian. 2011, 2015. U.S. Geological Survey, Biological Resources Division, Dixon, California.

Hansen, Eric. 2011, 2015. Consulting herpetologist, Sacramento, California.

IN LITT. REFERENCES

Valcarcel, P. 2010. E-mail from Patricia Valcarcel of the U.S. Geological Survey, Biological Resources Division, Dixon, California to David Kelly, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office.

Wylie, G. 2009. E-mail to David Kelly, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office.