Giant Garter Snake
(*Thamnophis gigas*)

5-Year Review:
Summary and Evaluation

Photo: Eric Hansen

U.S. Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Sacramento, California

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5-YEAR REVIEW
Giant Garter Snake (*Thamnophis gigas*)

I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview:

The giant garter snake (*Thamnophis gigas*) is one of the largest garter snakes, reaching an average total length of at least 162 centimeters (63.7 inches). Once identified as a subspecies of the western terrestrial garter snake, the giant garter snake was accorded the status of a full species in 1987, and its taxonomy remains unchanged.

Endemic to the valley floor wetlands of the Sacramento and San Joaquin valleys in California, the giant garter snake inhabits marshes, sloughs, ponds, small lakes, low gradient streams and other waterways and agricultural wetlands. Habitat for the giant garter snake consists of (1) adequate water during the snake's active season, (2) emergent herbaceous wetland vegetation for escape and foraging habitat, (3) grassy banks and openings in waterside vegetation for basking, and (4) higher elevation upland habitat for cover and refuge from flooding. Giant garter snakes feed on small fishes, tadpoles, and frogs (G. Hansen 1988). They breed in March and April with females giving birth to live young from late July though early September (R. Hansen and G. Hansen 1990). Giant garter snakes typically either are inactive or greatly reduce their activities during the late fall and winter months (Wylie *et al*. 1997*a*). The historic range of the giant garter snake included natural wetlands from northern Butte County, California southward to Buena Vista Lake near Bakersfield in Kern County, California (G. Hansen and Brody 1980).

Methodology Used to Complete This Review:

This review was prepared by Sacramento Fish and Wildlife Office (SFWO) staff following the Region 8 guidance issued in March 2008. We used information from species survey and monitoring reports, the 1999 Draft Recovery Plan for the Giant Garter Snake, the 2006 giant garter snake 5 year review, peer-reviewed journal articles, documents generated as part of section 7 and section 10 consultations, grant proposals generated under the Central Valley Project Improvement Act/Habitat Restoration Project grant program, and the California Natural Diversity Database (CNDDB) maintained by the California Department of Fish and Game (CDFG). We interviewed recognized giant garter snake experts for their knowledge and suggestions for recommendations to assist in the recovery of the species. Survey data, peer-reviewed journal articles, the Draft Recovery Plan for the Giant Garter Snake, and personal communications with snake experts were our primary sources of information used to update the species status and threats sections of this review. We received no information from the public in response to our Federal Notice initiating this 5-year review. This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known at the time of listing or since the last 5-year review. We focus on current threats to the species that are attributable to the Act's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

Contact Information:

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Federal Register (FR) Notice Citation Announcing Initiation of This Review: A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register on May 25, 2011 (76 FR 30377). No comments were received.

Listing History:

<u>Original Listing</u>
FR notice: 58 FR 54053
Date listed: October 20, 1993
Entity listed: *Thamnophis gigas*, an animal species.
Classification: Threatened

<u>State Listing</u>
The giant garter snake (*Thamnophis gigas*) was listed by the State of California as a rare species on June 27, 1971 and reclassified as threatened on October 2, 1980.

Associated Rulemakings: Since the time of listing, no rulemakings, such as 4(d) rules or proposal or designation of critical habitat, have been completed.

Review History: One 5-Year status review was completed in September 2006.

Species' Recovery Priority Number at Start of 5-Year Review
The recovery priority number for the giant garter snake is 2C according to the Service's 2011 Recovery Data Call for the Sacramento Fish and Wildlife Office based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Endangered and Threatened Species Listing and Recovery Priority Guidelines, 48 FR 43098, September 21, 1983). This number indicates that the taxon is a species that faces a high degree of threat and has a high potential for recovery. The "C" indicates conflict with construction or other development projects or other forms of economic activity.

Recovery Plan or Outline

> **Name of plan:** Draft Recovery Plan for the Giant Garter Snake
> **Date issued:** 1999
> **Dates of previous revisions:** none

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) policy

The Endangered Species Act defines "species" as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. The 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species act (61 FR 4722, February 7, 1996) clarifies the interpretation of the phrase "distinct population segment" for the purposes of listing, delisting, and reclassifying species under the Act. Currently there are no designated DPS within the extant range of the giant garter snake.

Information on the Species and its Status

<u>Species Biology and Life History</u>
The giant garter snake (*Thamnophis gigas*) is one of the largest garter snakes, reaching a total length of at least 162 centimeters (63.7 inches) (USFWS 1993). Once identified as a subspecies of the western terrestrial garter snake, giant garter snake was accorded the status of a full species in 1987, and its taxonomy is unchanged today.

Endemic to the valley floor wetlands of the Sacramento and San Joaquin valleys in California, the snake inhabits marshes, sloughs, ponds, small lakes, low gradient streams and other waterways and agricultural wetlands. Habitat consists of (1) adequate water during the snake's active season, (2) emergent herbaceous wetland vegetation for escape and foraging habitat, (3) grassy banks and openings in waterside vegetation for basking, and (4) higher elevation upland habitat for cover and refuge from flooding. Giant garter snakes feed on small fishes, tadpoles, and frogs (G. Hansen 1988). They breed in March and April with females giving birth to live young from late July though early September (R. Hansen and G. Hansen 1990).

Although growth rates are variable, young typically more than double in size by one year of age. Sexual maturity averages 3 years for males and 5 years for females (USFWS 1993). Researchers have noticed significant differences in the size of giant garter snakes between different populations. The largest, most robust snakes have been observed in the newly discovered population at Yolo Bypass, discovered in 2005, and the population at Badger Creek in southern Sacramento County (E. Hansen 2001, 2006*a*).

A series of studies have been completed since the previous five year review that address and provide updates to the ecology, life history, and behavior of the giant garter snake. These studies are discussed in more detail in the section entitled "Species-specific Research and/or Grant-supported Activities". Briefly, the new studies reveal that:

A. Both the growth rates and the use of body energy reserves of male giant garter snakes differ from those of female giant garter snakes temporally. This reflects giant garter snake behavior where males are seeking mates early in the spring, while females are undergoing reproductive cycles in early and mid-summer.

B. Certain external factors, like water, air temperature and time of day, may be used to evaluate the probability of detection of giant garter snakes.

C. Factor analysis can be used to evaluate geographic areas having the best habitat characteristics for giant garter snakes, which can be used to evaluate where giant garter snakes are most likely to be found.

D. Maternal physical characteristics have an effect on reproductive output of giant garter snakes, including the size of litters and neonate body size.

E. Giant garter snake individuals vary in degree of parasite load, bacteria flora, and contaminant loads; however, none of these factors appears to be population limiting. Valley garter snakes (*Thamnophis sirtalis fitchii*) also demonstrated a wide variation in parasitic infection and contaminant loads, and show different hematology characteristics than the giant garter snake.

F. Various canal bank treatments may effect to some degree giant garter snake behavior and distribution.

G. Contaminant loads in livers and brains of giant garter snakes were analyzed for mercury and trace elements and correlated with tail samples to demonstrate that tail samples provide a reliable indication of mercury concentration in tissues.

H. The thermoregulatory behavior of males differs from females for various times of the season, particularly during mid-summer.

I. Data from 15 years of surveys conducted at four locations revealed abundance and densities of the giant garter snakes, the sex ratios, and sexual size dimorphism at the four sites, which showed that snake abundance varies with habitat quality.

J. Aggressive reduction in the excessive growth of non-native water primrose in some aquatic habitat may be necessary to restore the value of the habitat to giant garter snakes.

K. Predicted suitable habitat from GIS analysis can be used to locate appropriate areas to conduct reconnaissance surveys for locating giant garter snakes.

Spatial Distribution

The previous status review found that, of the 13 populations in the listing, the population at Burrell/Lanare in the San Joaquin Valley was probably extirpated and that several locality records in the San Joaquin Valley and within the Sacramento-San Joaquin Delta (Delta) were threatened with extirpation (USFWS 2006). Surveys conducted since 2006 strongly suggest that populations at Burrell/Lanare and at Liberty Farms in Yolo County have been extirpated (E. Hansen 2008*a*). The population at the Mendota Wildlife Area (WA) was found to still be extant when a single snake was found in a survey conducted in 2008, although follow-on surveys did not find any individual snakes (E. Hansen 2008*a*, Eric Hansen, pers. comm. 2011). Neither surveys nor habitat assessments have been conducted at the East Stockton Diverting Canal since listing, so the status of that population is uncertain. The other populations listed in the previous status review all appear to be extant and these populations will be discussed in this section. A reorganization of populations is considered necessary based on the results of two independent genetic studies which described watershed basins as distinct genetic groupings (Paquin 2006, Engstrom 2010). These studies will be discussed in detail in the section on genetics that follows. Briefly, we believe that all of the populations should now be grouped into the watershed basins in which they occur. The changes that occur as a result of this reorganization are that the Yolo Basin is now considered to be a single population, the three populations listed in the Delta are now combined into a single Delta Basin population, the Badger Creek population is now expanded into the Cosumnes-Mokelumne Watershed, and the two populations in the San Joaquin Valley are now identified by their respective watershed basins, the San Joaquin and Tulare basins. Table 1 shows the current status of the populations.

Table 1. The status of giant garter snake populations		
1993 Listing and the 1999 Draft Recovery Plan	2006 Status Review	2011 Status Review
Butte Basin	Butte Basin	Butte Basin
Colusa Basin	Colusa Basin	Colusa Basin
Sutter Basin	Sutter Basin	Sutter Basin
American Basin	American Basin	American Basin
Yolo Basin – Liberty Farms	Liberty Farms	Presumed Extirpated
Yolo Basin – Willow Slough	Willow Slough	Yolo Basin
Badger Creek – Willow Creek	Badger Creek	Cosumnes-Mokelumne Watershed
Sacramento Basin	Sacramento Basin	Delta Basin
Caldoni Marsh	Caldoni Marsh	Delta Basin
East Stockton – Diverting Canal and Duck Creek.	East Stockton – Diverting Canal and Duck Creek	Delta Basin
North and South Grasslands	North and South Grasslands	San Joaquin Basin
Mendota WA	Mendota WA	Tulare Basin
Burell and Lanare	Burell and Lanare	Presumed extirpated

The known range of the giant garter snake has changed little since the 1993 listing and since the 2006 status review. The current extant range of the giant garter snake is believed to extend from Chico in Butte County and southward to the Mendota WA in Fresno County (Kelly 2006, E. Hansen 2008*a*). Giant garter snake populations north of the Delta Basin are believed to be relatively stable compared to the San Joaquin Valley where the populations appear to be in a serious and notable decline. No sightings of giant garter snakes south of the Mendota WA within the historic range of the species have been made since the time of listing (Wylie and Amarello 2007, E. Hansen 2008*a*). A summary of recent surveys and sightings for each population since the previous status review follows:

(1) Butte Basin: The northernmost locality record of the giant garter snake is found 5 miles west of the city of Chico where at least four snakes have been found (Kelly 2006, Gallaway *in litt.* 2008). In 2009 and 2010, the United States Geological Survey (USGS) surveyed rice fields in Butte County near Butte Sink and found snakes near the City of Nelson and at the Butte Sink Wildlife Management Area (WMA) (Halstead *in litt.* 2011). Incidental observations of giant garter snakes were reported by refuge biologists at Llano Seco [Joe Silveira, Sacramento National Wildlife Refuge (NWR), pers. comm. 2009]. Surveys in 2008 to 2010 by USGS have found snakes at several new locations in southwest Butte County (Western Ecological Resource Center, Dixon Field Station 2011). Two sightings of giant garter snakes were reported in May and October of 2011 on the south perimeter of the Thermolito After-Bay just east of SR 99 (R. Martin *in litt.* 2012).

(2) Colusa Basin: USGS and USFWS National Wildlife Refuge (NWR) staff observed giant garter snakes at each of the Federal wildlife refuges (Colusa, Delevan, and Sacramento NWRs) that make up the Sacramento NWR Complex (Wylie *et al*. 2005, 2006). In addition, giant garter snakes occur outside of Refuge lands in the adjacent rice production areas. In 2010 giant garter snakes were found in Glenn County 6 miles southwest of the Chico Water Pollution Control

Plant (Swaim *in litt*. 2010). Giant garter snakes were found at the Colusa Basin Drainage Canal near the City of Knight's Landing by walking and trapping surveys from spring through summer during the years 2003, 2004, and 2006 (Wylie *et al*. 2008). This was part of a study on the effects of riprap used on the canal banks.

(3) Sutter Basin: A trapping survey in 2005 found giant garter snakes at Gilsizer Slough (Wylie 2008). At the Sutter Basin Conservation Bank, E. Hansen (2007*a*) caught 37 snakes in an investigation of snake use of surrounding ricelands. In 2007 six conservation areas in Yolo, Sutter, Colusa, and Sacramento Counties were surveyed but giant garter snakes were found only at the Gilsizer Slough South Conservation Bank in Sutter County (Wildlands 2008).

(4) American Basin: Giant garter snakes have been observed among the rice agricultural fields in the area within and around the Natomas Basin. The greatest number of surveys has occurred in the Natomas Basin. The Natomas Basin property that is managed by the Natomas Basin Conservancy has been monitored for giant garter snakes since 2000 (ICF Jones and Stokes 2010) and surveys show that giant garter snakes persist in the Natomas Basin and continue occupying both restored habitat and rice fields. Outside of the Natomas Basin other areas where giant garter snakes have been found include the area immediately north of the Natomas Cross Canal (E. Hansen 2003*a*, 2004*a*, 2005, 2006*b*, 2007*b*, and 2008*b*). The areas around Marysville and northward have not been comprehensively surveyed for the giant garter snake and the status of the snake in this region remains unknown.

(5) Yolo Basin: Giant garter snakes have been documented within the Yolo Bypass WA and adjacent rice-lands within the Yolo Bypass, and at Willow Slough Bypass in Yolo County (E. Hansen 2006*a*, 2007*c*, 2008*c*). Occurrences at Ridgecut Slough near the City of Dunnigan were also recently described by Wylie and Martin (2005*b*). A giant garter snake was found near the Pope Ranch Conservation Bank south of the Yolo Bypass WA during a habitat assessment (E. Hansen 2009*a*). In 2009, giant garter snakes were found during surveys conducted on the Conaway Ranch bordering Willow Slough (E. Hansen 2009*b*). The population at Liberty Farms that was listed as extant in 1993 appears to have been extirpated as snakes have not been found during recent surveys (USFWS 1993, E. Hansen 2008*c*). Wylie and Martin (2004, 2005*a*) conducted trapping surveys at 15 locations in Solano County for two consecutive years in order to confirm historic records. They did not find giant garter snakes at any of the 15 locations during the two seasons of survey (Wylie and Martin 2004, 2005*a*). Wylie and Martin (2005*a*) proposed that the lack of an adequate prey base and the surrounding "dry" agricultural fields (row crops) did not support otherwise suitable giant garter snake habitat at the Solano County sites. Subsequently, in the summer of 2010 a single giant garter snake was incidentally observed and photographed at Grizzly Island near the Suisun Marsh south of the City of Fairfield in Solano County (C. Wilkerson, *in litt*. 2010).

(6) Cosumnes-Mokelumne Watershed: Giant garter snakes have been detected at the Badger Creek sub-unit of the Cosumnes River Preserve, in the southern portion of Sacramento County (Wylie *et al.* 1997*b*; E. Hansen 2001, 2003*b*; E. Hansen *et al.* 2010). A baseline survey conducted in 2008 as part of a restoration study revealed a large population of snakes at the Badger Creek sub-unit area called "Snake Marsh" (E. Hansen *et al*. 2010).

(7) Delta Basin: The Delta Basin includes portions of Sacramento, Yolo, Solano, Contra Costa,

and San Joaquin counties. A large portion of the Sacramento-San Joaquin Delta area has not been comprehensively surveyed for the giant garter snake, primarily because the majority of land is privately owned. However, suitable habitat for the giant garter snake is known to exist in this area (G. Hansen 1986, 1988; California Department of Water Resources [DWR] 2010) although the presence of snakes in this area remains unknown. DWR conducted a trapping survey of various sites within the Delta that met habitat assessment criteria for the giant garter snake during the summer of 2009 (DWR 2010). No giant garter snakes were trapped or observed during that survey. However, Eric Hansen captured 3 giant garter snakes at White Slough WA, confirming the population cited in the listing rule was still extant during the summer of 2009 (E. Hansen 2011*a*), and 4 giant garter snakes (3 road mortalities) were photographed near Little Connection Slough (ESA *in litt.* 2010). This location is approximately 6 miles southwest of White Slough and represents the locality situated the furthest west into the delta where giant garter snakes are known to currently exist. There is a large gap in recorded occurrences of the giant garter snake between the White Slough / Empire Tract population in San Joaquin County southward to the Grasslands Ecological Area in Merced County, a distance of about 105 kilometers (65 miles).

(8) San Joaquin Basin: Giant garter snakes currently occur in the northern and central San Joaquin Basin within the northern and southern Grassland Wetlands. The Grassland Wetlands is a complex of protected lands in Merced County, which includes private lands managed under conservation easements, lands under the management of the Grassland Water District, and State- and Federally-owned and managed lands. Trapping surveys conducted by E. Hansen in 2006 and 2007 within the Grasslands Ecological Area both south and east of the San Joaquin River and in the Mendota WA resulted in only 10 captures in the two year study, with the majority of snakes being found in the Los Banos Creek corridor between the San Joaquin River and the city of Las Banos, a wetland supply channel for the private wetlands in the northern reach of the Grassland Ecological Area (E. Hansen 2008*a*). The CDFG trapped in the Volta and Los Banos WAs in 2006 in order to monitor the populations and collect tissue for the genetic study by Dr. Tag Engstrom of the California State University at Chico and found giant garter snakes only at the Volta WA (Sousa 2007). Historical locations in the San Joaquin Valley that had been characterized as suitable habitat for giant garter snake in a 1986-88 survey were revisited (G. Hansen 1988, Paquin *et al*. 2006). They found that the habitat of approximately 60 percent of the sites had been degraded, either through the loss of terrestrial cover or water. The small numbers of giant garter snakes found may reflect continued degradation of wetland habitat and the abundance of invasive predators. Dense populations of bullfrogs, which are known to prey upon young giant garter snakes (Wylie *et al*. 2003*a*), were observed during field surveys in the southern region. Low numbers of giant garter snakes in the San Joaquin Valley populations places these populations at high risk of extirpation (Paquin *et al*. 2006, E. Hansen 2008*a*).

(9) Tulare Basin: The southern San Joaquin Valley includes portions of the counties of Fresno, Kings, Tulare, and Kern counties. Agricultural and flood control activities are presumed to have extirpated the giant garter snake from this portion of its historic range in the former wetlands associated with the historic Buena Vista, Tulare, and Kern lake beds (G. Hansen and Brode 1980; R. Hansen 1980; G. Hansen 1986, 1988). Surveys from 1998 to 2000 failed to detect giant garter snakes in the Mendota State WA, where two visual sightings occurred in 1995 (G. Hansen 1996, Wylie 1998, Dickert 2002). However, surveys in 2001 detected 14 snakes at Mendota State WA (7 female and 7 male), making this the southern-most currently known occurrence of

giant garter snakes (Dickert 2002). No snakes were detected in 2007 and only a single female was trapped in 2008 at the Mendota WA in spite of a routine trapping plan (E. Hansen 2008*a*). Surveys conducted in the southern San Joaquin Valley since the 1980s have demonstrated that the giant garter snake is probably extirpated south of the Mendota WA (Fresno County). Surveys, even at sites of historically recorded occurrences in the southern San Joaquin Valley, such as Burrell and Lanare, have all produced negative results (Hansen and Brody 1980; G. Hansen 1988, 1996; Wylie and Amarello 2007; E. Hansen 2008*a*). A recent survey of the historic documented localities of the giant garter snake in the southern San Joaquin Valley was conducted by the USGS in 2006 (Wylie and Amarello 2007). The areas covered by this survey included Buena Vista Lake bed, Fresno Slough, Kern NWR, King's River, and North King's River. No giant garter snakes were found during this survey.

Abundance

Estimates of population abundances of the giant garter snake have been conducted using mark recapture trapping methods. Researchers are able to estimate the size of a local population when certain assumptions about the population are granted, such as the population being closed meaning that there are no gains or losses to the population from factors such as mortalities, births, or migration. Table 2 (Page 10) presents some abundance estimates that have been published for a few areas with known occurrences of the giant garter snake.

Population abundance of the giant garter snake may also be estimated using density figures, such as the number of snakes per hectare. In a 2010 study, Wylie *et al.* 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 the number of snakes per unit area instead of the number of snakes per linear transect. The results from this study were derived using two different assumptions of passive sampling: one density calculation was derived using the assumption that each of the traps sampled equal areas of habitat while the other density calculations used the assumption that snake behavior delimited the boundary of the snake population. Although the studies were conducted during different years, weather and site conditions were noted to be virtually unchanged during the surveys.

Table 2. Some recent population estimates and actual capture numbers of giant garter snake population centers.		
Location/Year	Abundance (95% Confidence Interval)	Reference
Yolo Wildlife Area / 2005	57 (45-84)	E. Hansen 2008
Volta Wildlife Area / 2003	45 (31-59)	Dickert 2003
Volta Wildlife Area / 2006	Too few caught for estimate	Sousa and Sloan 2006
Badger Creek / 2008	170 *	E. Hansen *et al.* 2010
Badger Creek / 2009	195 *	E. Hansen *et al.* 2010
Conaway Ranch / 2009	46 (16-97) Sum of 3 areas	E. Hansen 2009
Natomas Basin / 2004	87 *	ICF International 2011
Natomas Basin / 2005	176 *	ICF International 2011
Natomas Basin / 2006	241 *	ICF International 2011
Natomas Basin / 2007	212 *	ICF International 2011
Natomas Basin / 2008	250 *	ICF International 2011
Natomas Basin / 2009	177 *	ICF International 2011
Natomas Basin / 2010	123 *	ICF International 2011
*These numbers are total number of individuals captured. Estimates of population size were not conducted. The estimates of population size are typically larger than the total number of individuals trapped.		

Wylie *et al.* (2010) found that the highest densities of giant garter snakes were located in the natural marsh at Badger Creek (8 snakes per hectare), which was up to an order of magnitude greater than estimates of snakes found in wetlands managed for waterfowl and agriculture (Colusa NWR) (Colusa NWR 0.83 snakes per hectare, Gilsizer Slough 3.1 snakes per hectare, and Natomas Basin 1.7 snakes per hectare). Badger Creek is believed to represent, more than any other populated site, the historic giant garter snake perennial marsh habitat (Wylie *et al.* 2010). The study also demonstrated that giant garter snake densities in these four regions were at or below the lowest densities reported in literature for other *Thamnophis* species (Rossman *et al.* 1996). It is unknown at this time if giant garter snake densities found from trapping may deviate from those of other garter snakes, for example due to overall differences in body sizes.

A summary of trapping surveys and the results of the surveys are presented as follows and grouped by recovery unit:

Butte Basin: Surveys in 2008 to 2010 by USGS have found snakes at several new locations in southwest Butte County including the Butte Basin WA (Western Ecological Resource Center, Dixon Field Station 2011). Estimates of giant garter snake density along a linear segment at three locations in southwest Butte County were 7 snakes per kilometer, 94 snakes per kilometer, and 91 snakes per kilometer (Western Ecological Resource Center, Dixon Field Station 2011).

Colusa Basin: Wylie *et al.* (2003*b*; 2005) located 109 and 75 giant garter snakes respectively, in the years 2003 and 2005 within the Colusa NWR. A continuous trapping effort was performed at the Colusa Basin Drainage Canal near the City of Knight's Landing by walking and trapping surveys from spring through summer during the years 2003, 2004, and 2006 with the following number of snakes captured: 82 in 2003, 46 in 2004, and 71 in 2006 (Wylie *et al*. 2008).

Sutter Basin: A trapping survey was performed in 2005 in support of a habitat manipulation study at Gilsizer Slough with 92 snakes trapped (Wylie 2008). At the Sutter Basin Conservation Bank, E. Hansen (2007*a*) caught 37 snakes in an investigation of snake use of surrounding ricelands. In 2007 six conservation areas in Yolo, Sutter, Colusa, and Sacramento counties were surveyed for the presence of giant garter snakes. Three of the surveys were visual surveys and two were trapping surveys. Giant garter snakes were found at Gilsizer Slough South Conservation Bank in Sutter County (Wildlands 2008).

American Basin: The Natomas Basin property that is managed by the Natomas Basin Conservancy has been monitored for giant garter snakes since 2000 (ICF Jones and Stokes 2010). Surveys across the Natomas Basin Conservancy lands since 2004 have revealed the following numbers of individuals captured per year indicated: 81 in 2004 , 176 in 2005, 241 in 2006, 212 in 2007, 250 in 2008, 177 in 2009, and 123 in 2010 (ICF Jones and Stokes 2011). Outside of the Natomas Basin other areas where giant garter snakes were trapped include the area immediately north of the Natomas Cross Canal, where during a multi-year trapping effort from 2002 to 2007 a relatively large occurrence was found (e.g., 100 snakes trapped two consecutive years using 300 traps) (E. Hansen 2003*a*, 2004*a*, 2005, 2006*b*, 2007*b*, and 2008*b*).

Yolo Basin: In 2009, 65 individual giant garter snakes were found during surveys conducted on the Conaway Ranch bordering Willow Slough (E. Hansen 2009*b*). In 2007, 51 individual giant garter snakes were trapped in the Davis Wetlands Complex and the Yolo Wildlife Area in Yolo County (E. Hansen 2008*c*). The population at Liberty Farms that was listed as extant in 1993 appears to have been extirpated as snakes have not been found during recent surveys (USFWS 1993, E. Hansen 2008*c*).
Cosumnes-Mokelumne Watershed: A baseline survey conducted in 2008 as part of a restoration study revealed a large population of snakes (172 individuals trapped in two months) at the Badger Creek sub-unit area called "Snake Marsh" (E. Hansen *et al*. 2010).

Delta Basin: DWR conducted a trapping survey of various sites within the Delta that met habitat assessment criteria for the giant garter snake during the summer of 2009 (DWR 2010). No giant garter snakes were trapped or observed during that survey. However, Eric Hansen captured 3 giant garter snakes at White Slough WA during the summer of 2009 (E. Hansen 2011*a*), and 4 giant garter snakes (3 road mortalities) were photographed near Little Connection Slough (ESA *in litt.* 2010).

San Joaquin Basin: Trapping surveys conducted by E. Hansen in 2006 and 2007 within the Grasslands Ecological Area both south and east of the San Joaquin River and in the Mendota WA resulted in only 10 captures in the two year study, with the majority of snakes being found in the Los Banos Creek corridor between the San Joaquin River and the city of Las Banos, a wetland supply channel for the private wetlands in the northern reach of the Grassland Ecological Area (E. Hansen 2008*a*). The CDFG trapped in the Volta and Los Banos WAs in 2006 in order to monitor the populations and collect tissue for the genetic study by Dr. Tag Engstrom of the California State University at Chico. A total of seven individual (4 females and

3 males) giant garter snakes were captured in that trapping effort, all from the Volta WA (Sousa 2007).

Tulare Basin: In 2006 USGS conducted surveys in the southern San Joaquin Valley at areas with historic occurrences of the giant garter snake. This included the following areas: Buena Vista (Lake Evans), Fresno Slough, Kern Refuge, and Kings River (Wylie and Amarello 2007). No giant garter snakes were found at these locations.

Habitat or Ecosystem

The giant garter snake is endemic to wetlands of California's Central Valley and inhabits marshes, sloughs, ponds, small lakes, low gradient streams, and other waterways and agricultural wetlands, such as irrigation and drainage canals, rice fields and the adjacent uplands (USFWS 1993).

Wylie *et al*. (2010) investigated four locations representing three different levels of habitat quality where trapping surveys were conducted and population estimates were completed for the giant garter snake. The habitat quality was rated as marginal for the pre-restored 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 historic 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 (BCI) of snakes, a measure of a snake's health based on linear regressions of body mass and length, was analyzed for the same four sites (Wylie *et al.* 2010). It was found that the snakes at Badger Creek had the highest BCI, indicating the best health, and that the snakes at the Colusa NWR had the lowest BCI. Snakes at the rice dominated sites had intermediate BCI scores. Although other vital metrics are needed to fully assess the habitat quality, such as survival and recruitment, the combination of BCI and density figures from this study strongly indicates that perennial marshes provide the highest quality giant garter snake habitat, rice agriculture is acceptable habitat, and seasonal winter wetlands provides the least suitable habitat of the three types (Wylie *et al.* 2010).

The Dixon Field Station of the USGS Biological Resources Division has been conducting a study of the life history and habitat use of the giant garter snake since 1995. Results of these studies have provided basic understanding of preferential habitat use by the giant garter snake. This information is used to define important habitat components for management of the giant garter snake and demonstrates that:

A. In the active summer season snakes predominately can be found in aquatic habitat,

B. Irrigation canals are commonly used by giant garter snakes,

C. Giant garter snakes use active rice fields in the summer,

D. Giant garter snakes are most often found under vegetative cover, and

E. In the summer, snakes are most often found under aquatic vegetative cover.

Studies, then, suggest that permanent wetlands with emergent vegetation harbor the greatest densities of giant garter snakes, and that wetlands that do not provide water during their active season (April to October) cannot support large populations of the giant garter snake (Wylie *et al*. 1997, 2000, 2002*a*, 2010).

USGS has recently conducted a landscape-level GIS analysis of habitat features for the giant garter snake in the Sacramento Valley, which was used to construct a habitat suitability model for the giant garter snake (Halstead *et al.* 2010). Giant garter snake location data was collected from trapping and visual surveys by the USGS over 20 years in the region, and this data was subjected to a factor analysis comparing habitat available in the Sacramento Valley to habitat at known giant garter snake locations (Halstead *et al.* 2010). Habitat suitability modeling has the potential to provide a valuable decision making tool for managers by showing those areas best suited for giant garter snake reconnaissance surveys, research, and potential conservation sites. For example, the USGS model shows a strong association of the giant garter snake with natural wetlands and aquatic agricultural habitats, including rice and associated water conveyances.

Changes in Taxonomic Classification or Nomenclature

No changes have occurred since the previous status report.

Genetics

Two genetic studies of the giant garter snake have been conducted recently. The first study of giant garter snakes included samples from six watersheds in the Sacramento Valley and found significant genetic variation between watersheds with low interpopulation and interregion gene flow (Paquin *et al*. 2006). This study was discussed in the previous five year review. In a subsequent study Dr. Tag Engstrom of California State University at Chico conducted a more intensive phylogeographic study analyzing samples taken from 466 individual giant garter snakes representing seven of the watersheds where giant garter snakes are still known to occur: Butte Basin, Colusa Basin, Sutter Basin, American Basin including Natomas Basin, Yolo Basin, Delta Basin, and north San Joaquin Basin (Engstrom 2010). Engstrom analyzed both mtDNA from the 466 individual samples and also microsatellite DNA (using 4 loci) from 98 samples. Results from Engstrom's study characterize the giant garter snake as a species with low genetic variability, which is evidenced by the low diversity of haplotypes across the species extant range. In addition, Engstrom's study, like Paquin's earlier study, demonstrated that the populations at Badger Creek and near-by White Slough have several unique haplotypes not found in any of the other populations that were concurrently analyzed. There are several possible historical events that could explain these genetic findings. The study also reveals that gene flow appears to be restricted across the major watershed basins, which lends support for naming these basins as separate populations

Species-specific Research and/or Grant-supported Activities

In addition to numerous trapping surveys throughout the range of the giant garter snake, a number of studies have been completed over the last five years that were published in scientific journals or released as "white papers", and include the following:

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. This study was conducted over three years where trapping surveys were used to determine the effects of three different bank stabilization treatments at the Colusa Basin drainage canal. The three treatments included soil over rock with native plants, soil and native plants without rock substrate and rock rip-rap. A control area with no treatment was also surveyed. In addition some snakes were radio tagged for a telemetry study. Results demonstrated that snakes used the control area more than all the three treatment areas and that home ranges were between 3 to 50 hectares. The study also demonstrated that snakes were actively moving into rice fields presumably for foraging and moved up to 100 meters from the aquatic habitat to find refuge in burrows or large cracks. At least one snake was shown to have moved up to 17 kilometers (10.5 miles) during the summer.

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 270(2009): 285-293. This was an 11-year field study of body condition and growth rate of the giant garter snake across 13 study areas in the Central Valley of California. Findings from this study show that males likely allocated energy to search for mates, while females likely stored energy for embryonic development. Evidence from this study also indicates that males use more body energy reserves than females during hibernation, perhaps because of different body temperatures between sexes. Growth rates of male snakes were substantially lower during the mating period than during a non-mating period, which indicated that a trade-off existed between searching for mates and growth.

Wylie, G. D., R.L. Hothem, D.R. Bergen, L.L. Martin, R.J. Taylor, B.E. Brussee. 2009. Metals and trace elements in giant garter snakes (*Thamnophis gigas*) from the Sacramento Valley, California, USA. Archives of Environmental Contamination and Toxicology 56: 577-587. During a series of trapping surveys conducted from 1995 to the 2008, specimens of dead giant garter snakes were opportunistically collected from sites in northern California and were stored frozen for potential future analysis. Tissues from 23 snakes were analyzed for total mercury content and other trace elements in livers and concentrations of Mercury in brains and tail clips. Mercury concentrations (micrograms per gram, wet weight) ranged from 0.08 to 1.64 in livers, 0.01 to 0.18 in brains, and 0.02 to 0.32 in tail clips. In livers, the geometric mean concentrations (micrograms per gram, dry weight) of arsenic (25.7) and chromium (1.02) were higher than most values from studies of other snakes. Mercury concentrations in the tail clips were positively correlated with concentrations in livers and brains,with the most significant correlations occurring at the Natomas Basin. The results also indicate the value of using tail clips as a nonlethal bioindicator of contaminant concentrations.

Wylie, G.D., M.L. Casazza, B.J. Halstead, C.J. Gregory. 2009. Sex, season, and time of day interact to affect body temperatures of the giant garter snake. Journal of Thermal Biology 34: 183-189. This study examined multiple hypotheses regarding the differences in body temperatures of the giant garter snake using temperature-sensitive radio telemetry and an information-theoretic analytical approach. The results indicated that giant garter snakes selected body temperatures near 30 degrees Celsius, and that males and females had similar body temperatures most of the year, except during the midsummer gestation period. The study concluded that seasonal differences in the body temperatures of males and females may relate to both the costs associated with thermoregulatory behavior, such as predation, and the benefits associated with maintaining optimal body temperatures, such as successful incubation.

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. The results of this study were discussed in some detail under the genetics category above.

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. Factor analyses was used to assess the suitability of habitats for giant garter snakes and to map the locations of suitable habitat in the Sacramento Valley. Results showed that the niche for this species is composed of sites near rice agriculture with low stream densities. In the Sacramento Valley, suitable habitats occur primarily in the central portion of the valley floor.
The authors recommend that recovery planning for the giant garter snake will require an on-the-ground assessment of the current distribution and abundance of giant garter snakes, maintaining the few remaining natural wetlands and the practice of rice agriculture in the Sacramento Valley, and studying the effects of agricultural practices and land use changes on populations of the giant garter snake.

Hansen, E., H. McQuillen, S. Sweet, S. Gayla, and J, Marty. 2010 Response of the giant garter snake (*Thamnophis gigas*) to water primrose (*Ludwigia hexapetala*) removal at the Cosumnes River Preserve. Final report submitted to the CVPCP/HRP. December 29, 2010. This Central Valley Project Improvement Act (CVPIA) funded study and restoration effort occurred at Badger Creek in the Cosumnes preserve where densely growing water primrose were eliminating open water at this marsh that hosts one of the larger populations of giant garter snakes. Surveys demonstrated that giant garter snakes were not using areas that were covered in water primrose, but concentrated in areas with open water habitat available. Aggressive mechanical removal of primrose is documented, as well as dredging the open water areas to keep the marsh in its original state. From follow-up surveys and photos it appears that the restoration work was successful in restoring open water foraging habitat for the giant garter snake and attracting colonization into the newly restored habitat.

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.

Mark–recapture studies of four populations of the giant garter snake were conducted in order to obtain baseline data on the abundance and density of local populations. Four habitat types were sampled that ranged from natural, unmanaged marsh to constructed managed marshes and habitats associated with rice agriculture. Giant garter snake density was greatest in the natural wetland at Badger Creek and was an order of magnitude greater than in a wetland managed for waterfowl. Sex ratios found at all sites during the study were not significantly different from one to one, and females were longer and heavier than males. Females had greater body condition than males, and individuals at the least disturbed sites had significantly greater body condition than individuals at the managed wetland. The study demonstrates that the few remaining natural wetlands in the Central Valley are important, productive habitat for the giant garter snake, and should be conserved and protected. In addition the study suggests that wetlands constructed and restored for the giant garter snake should be modeled after the permanent, shallow wetlands representative of historic giant garter snake habitat.

<u>Halstead, B., G. Wylie, P. Coates, and M. Casazza. 2011. Bayesian adaptive survey protocols for resource management. Journal of Wildlife Management 75(2): 450-457.</u>
This study investigated the probability of detections in regard to various external factors noted during surveys of the giant garter snake, and promotes the use of Bayesian analysis in developing a standard survey protocol.

<u>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.</u> This study examined relationships of different reproductive characteristics of the giant garter snake in order to improve population modeling and conservation planning. Findings from this study show that neonates (newly born individuals) from larger litters had lower mass, and that the mass of neonates also was affected by random variation among mothers. The length of the mother did not affect the relative mass of litters; however, the data suggest that the longer mothers expended less reproductive effort per offspring than did the shorter mothers. The mean size of a litter varied among years, but little evidence existed for a relationship between the size of a litter or the mass of a litter and length of mother. The sex ratios of neonates did not differ from 1:1.

<u>Hansen, E., R. Wack, R. Poppenga, K. Strohm, D. Bunn, C. Johnson, and R. Scherer. 2011. Comparative pathology, health, and contaminant exposure within San Joaquin Valley and Sacramento Valley giant garter snake (*Thamnophis gigas*) populations. Draft of study funded by the CVPIA and provided to the USFWS.</u> In this study giant garter snakes were captured in four representative habitats and sampled for a comprehensive medical evaluation conducted by a veterinarian that included screening for parasites, bacterial and viral infections, blood chemistry, and contaminant loads in tissues; and compared with valley garter snakes captured from the same locations. The studied showed that blood chemistries were very different between species and established baseline values for hematology for future reference. Parasitology revealed that oral trematodes were found in Sacramento Valley snakes but not found at all in snakes from the San Joaquin Valley while subcutaneous nematodes were found in snakes from all sampled sites. Protozoan parasites were also found in snakes from all sampled sites. Results of contaminants in tissues revealed that giant garter snakes had higher blood selenium levels than valley garter snakes, while females had lower selenium loading than males, and that selenium levels were

rated from lowest to highest in the following order of sites: Badger Creek, Natomas, Los Banos, and Mendota. Blood mercury levels among giant and valley garter snakes appeared to be strongly influenced by site with the four tested sites ordered from lowest to highest blood mercury levels as follows: Badger Creek, Mendota, Natomas, and Los Banos. The study concludes that while health parameters varied for both snake species among the sampling sites, the results of the study did not provide strong evidence of adverse health effects resulting from environmental contaminants.

<u>Western Ecological Resource Center, Dixon Field Station. 2011. Distribution of the giant garter snake in Butte County, California. Report to the U.S. Bureau of Reclamation, Habitat Restoration Program. Data summary of field observations from May 2008 – September 2010.</u> This study was funded by the Habitat Restoration Program of the Central Valley Project Improvement Act (CVPIA) program. Surveys were conducted in southwest Butte County, California at the following sites: Howard Slough, Upper Butte Basin Wildlife Area, and several duck clubs and rice fields in the vicinity of the Upper Butte Basin Wildlife area. The study determined that much of the Butte Basin west of Hwy 99 contains suitable habitat for the giant garter snake, and that suitable habitat is positively associated with a dense network of canals in close proximity to rice fields, wetlands, and open water. However, rivers and streams do not appear to provide suitable habitat. Detections of giant garter snake occurred at new and historically recorded occurrences of the giant garter snake and validated the GIS analysis published in Halstead *et al*. 2010 (above). This finding indicates that habitat suitability analysis will be a helpful tool in the future to locate the best habitat for conducting reconnaissance trapping surveys for the giant garter snake. Unfortunately, the study was unable to identify variables, such as habitat factors, that explain occupancy using current occupancy models. Ad hoc population estimates revealed several areas with densities similar to those found in previous studies for areas with perennial wetlands (3 snakes per hectare).

Five-Factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act. Each of the threats sections was updated with information gathered since the previous status review. Older information has been removed, with the exception of certain descriptive details which were deemed important to understanding the background and nature of the specific threat. Various threats were moved from one section to another in order to conform with the best descriptive heading for that particular issue. These moves are discussed in the initial explanation section of each factor

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The 2006 status review listed the following as Factor A threats to the giant garter snake: urbanization, flood control and canal maintenance, grazing and agricultural practices, wetland management for waterfowl, the introduction and eradication of invasive non-native plants, and natural gas exploration. Natural gas exploration and grazing have been moved to the Factor E threat section. In addition the threat listed in the last status review as water management under the category of factor E, which discussed the lowering water table effect on aquatic habitat, has been moved to the category of Factor A threat under the section of "water transfers". The section on agricultural practices in Factor E of the 2006 status review was combined into the section of Agricultural Practices in Factor A in this status review, and the Factor E section on Fragmentation and Population Isolation was moved to Factor A. Outside of these administrative changes there are no new threats discovered since the previous status review.

Urbanization

Urbanization continues to be one of the greatest threats to the giant garter snake throughout much of its extant range. Environmental impacts associated with urbanization are loss of habitat, introduction of non-native species with a resulting loss of biodiversity, alteration of natural fire regimes, fragmentation of habitat due to road construction, and degradation of habitat due to pollutants. Within the current range of the giant garter snake, cities that are rapidly expanding and, in some instances, intruding upon or otherwise impacting giant garter snake habitat include, but are not limited to: Chico, Woodland, Yuba City/Marysville, Sacramento, Galt, Stockton, Gustine, Los Banos, Merced, and Fresno. Urbanization increasingly threatens the viability of giant garter snake populations as urban landscapes encroach on ever-diminishing habitat for this listed species, including eliminating rice agriculture that serves as an alternative habitat for the giant garter snake.

Current projections reveal that during the next century urbanization in the state of California will increase from 20,000 square kilometers in 2009 to about 65,300 square kilometers in 2100 (Sansted *et al*. 2009). From 1982 to 2007 a total of 1,767,200 acres of farmland were lost to urban development in California (Farmland Information Center 2011), and current forecasts by the American Farmland Trust predict a loss of close to another one million acres of Central Valley farmland to urbanization by the year 2050 if current trends in land use continue (American Farmland Trust 2007). This trend includes a loss of potential and occupied giant garter snake habitat, both through the reduction in acreage of rice agriculture and the loss of associated wetlands. Further, viable rice production is subject to influences from encroaching urban and residential development. Potential changes in adjacent land use are likely to occur throughout the region, as demonstrated by the growth of northern California's population.

Since the previous status review, the Service has issued three section 10(a)(1)(B) permits (HCPs or Habitat Conservation Plans) for projects anticipated to impact the giant garter snake, which include the San Joaquin County multi-species HCP, the East Contra Costa County HCP, and the PG&E San Joaquin Vally HCP. In addition, eight other HCPs which include areas within the range of the giant garter snake are currently being developed and include: Butte County, South Sacramento, Solano County, Yolo County, Yuba/Sutter County, Placer County, PG&E Statewide Operations and Maintenance, and PG&E Bay Area. Since the previous status review in 2006, the Service also conducted 155 formal section 7 consultations where the giant garter snake was a species of concern. The majority of these consultations were for projects that would affect the Sacramento Valley area populations.

Fragmentation and Population Isolation

Habitat loss throughout the range of the giant garter snake has resulted in fragmented and isolated habitat remnants (see further discussions of projects resulting in habitat fragmentation under Habitat Destruction and Urbanization in III.C.2.a and in the final rule to list the species (USFWS1993)). In general, occurrences of species confined to small habitat areas are likely vulnerable to extirpation from random, unpredictable environmental, genetic, and demographic events (Schonewald-Cox *et al*. 1983). When an occurrence becomes extirpated, habitat fragmentation reduces the chance of recolonization from any remaining populations. In addition, the breeding of closely related individuals can cause a genetic reduction in fitness, inbreeding depression, and a loss of genetic diversity (Meffe and Carroll 1994).

While we know giant garter snake habitat has been, and continues to be, fragmented by roads and urban development, we have no data that indicate whether or not random environmental, genetic and demographic events have adversely affected giant garter snake at this time. Continued isolation of giant garter snake occurrences increases the likelihood that such effects will be important in the future.

Despite the steady loss and degradation of giant garter snake habitat, some habitat has also been protected, restored, or created. Acquisition and restoration of giant garter snake habitat has been conducted in the Natomas Basin, as part of the Natomas Basin Habitat Conservation Plan and the Metro Air Park Habitat Conservation Plan. Of the total amount of giant garter snake habitat existing in the Natomas Basin (24,567 acres of ponds seasonally wet areas, rice fields and canals), 8,512 acres of giant garter snake habitat have been permitted to be lost through the two HCPs (USFWS *in litt*. 2003). Upon full implementation of the two HCPs, at least 6,562.5 acres of habitat (2,187.5 acres of managed marsh and 4,375 acres of rice) will be protected and managed for the snake (USFWS *in litt.* 2003). As of December 2010 the Natomas Basin Conservancy has acquired 4,116 acres of reserve lands for the snake and other covered species that include managed marsh, upland habitat, and rice land (ICF International 2011). These preserved lands fall into three consolidated reserve areas within the Natomas Basin: North Basin Reserve, Central Basin Reserve, and Fisherman's Lake Reserve (ICF International 2011). Surveys in the preserves over the last ten years show that giant garter snakes continue to occupy suitable habitat in the Natomas Basin although overall, the trend in capture numbers since 2006 is a decreasing trend (ICF International 2011).

A restored wetland area on the Colusa NWR showed increased numbers of snakes during the 2005 trapping season (Wylie *et al*. 2006). The USGS determined that, with the provision of a stable source of summer water in the restored area, these restoration efforts resulted in a decrease in reliance by the radio-marked snakes on adjacent rice fields for summer water. This resulted in possible decreased exposure to risk factors such as traveling greater distances and crossing roads (Wylie *et al*. 2006). Home ranges and movements were also reduced in recent years, likely because the giant garter snakes did not have to travel as far for food and shelter (Wylie *et al.* 2000, 2006).

The 158-hectare (391-acre) Pope Ranch Conservation Bank within the Yolo Bypass south of the WA was created to sell credits for giant garter snake mitigation requirements and all of the credits have been sold. The bank consists of over 81 hectares (200 acres) of seasonal and perennial marsh habitat for the snake, as well as close to 20 hectares (50 acres) of upland habitat, and has a management plan specifically designed for the giant garter snake. Land use surrounding the Pope Ranch Conservation Bank is all agriculture. Individual snakes have been trapped at Pope Ranch; however the size of the population at this bank does not appear to be large (Wildlands 2008).

The Ridge Cut Conservation Bank is located in the Yolo Bypass area about 7 miles north of the City of Woodland in Yolo County (40 miles north of the Pope Ranch Conservation Bank). This bank consists of a 75 hectare (186 acre) mosaic of seasonal and perennial wetland marsh, open water and upland habitat for the giant garter snake. Land use surrounding the bank is mostly agricultural (rice and row crop) with the eastern edge of the bank bordering the Colusa Basin Drainage Canal and southern edge by Oat Creek. Both of these water courses as well as the canals supporting surrounding agriculture provide a wide area of habitat and corridors for movement from the conservation bank to other habitat areas in the Yolo Basin. Ridge Cut Conservation Bank is within a 971-hectare (2,400-acre) parcel which has mostly been entered into the Wetland Reserve Program. As discussed earlier giant garter snakes were recently trapped at this site (Wiley and Martin 2005*b*).

Dolan Ranch, a 251-acre conservation bank in Colusa County, has sold all available giant garter snake credits, ensuring that the habitat on both sites is managed for the benefit of the species and protected in perpetuity. Although the giant garter snake has not yet been observed on either bank, known occurrences of the snake are located approximately 5 miles from Dolan Ranch Conservation Bank (CNDDB 2011).

The 174 hectare (429 acre) Sutter Basin Conservation Bank is located in south Sutter County just west of Highway 99, between the eastside of the Sutter Bypass and Sawtelle Avenue. The Sutter Conservation Bank is about four miles south of the Gilsizer Slough habitat corridor and is adjacent to a number of CDFG and Duck's Unlimited waterfowl habitat easements. The Sutter Basin Conservation Bank manages the perennial marsh, seasonal wetland, and upland habitat for the giant garter snake. Surveys have shown that giant garter snakes inhabit the areas surrounding the conservation bank and that the bank can provide connectivity to other areas of good quality giant garter snake habitat in the Sutter Basin (E. Hansen 2011*b*).

The Gilsizer Slough South Conservation Bank is located about 12 miles southwest of Yuba City in Sutter County and consists of 117 hectares (288 acres) of high quality perennial marsh, open water, and upland habitat for the snake. This conservation bank is managed almost exclusively for the giant garter snake and snakes have been found at this bank since the early 1990s (Westervelt Ecological Services 2010). Land use surrounding Gilsizer Slough South Conservation Bank is predominately agricultural and provides a suitable buffer and some connectivity. The Gilsizer Slough Preserve for giant garter snakes (162 acres) abuts the conservation bank. The southwest boundary of the conservation bank abuts the levee for the Sutter Bypass.

Flood Control and Canal Maintenance
Ongoing maintenance of artificial or natural aquatic habitats for purposes of flood control and agriculture may result in direct mortality to giant garter snakes (G. Hansen 1988, Brode and Hansen 1992, CDFG 1992, Hansen and Brode 1993). Maintenance activities may also fragment and isolate available habitat, prevent dispersal of giant garter snakes among habitat units, and reduce the availability of cover and giant garter snake prey. Much of the remaining giant garter snake habitat is subject to flood control and canal maintenance activities, subjecting the snake to on-going risks of mortality and injury and the effects of habitat degradation. Since the last status

review it appears that flood control and canal maintenance remain potential threats to the giant garter snake.

Maintenance activities may include weed eradication, which destroys surface cover, and rodent eradication, which indirectly eliminates the occurrence and abundance of underground burrows and retreats for giant garter snakes. Giant garter snakes depend upon rodent burrows to thermoregulate, to provide cover during ecdysis (the shedding of skin), and for over-wintering. The coexistence of burrowing mammals greatly benefits giant garter snakes (Wylie *et al*. 1996, Wylie *et al*. 1997). Other types of maintenance activities occurring in irrigation canals include: (1) de-silting, (2) excavation and re-sloping of ditches and channels, (3) deposition of ditch and canal spoils materials on adjacent property, (4) placement of fill material within the canal, and (5) control of vegetation in and around canals, ditches, and drains by mowing and other measures. These activities can injure and kill giant garter snakes.

The flood control practice of lining streams and canals with large and extensive quantities of concrete or rock riprap is detrimental to wetland ecosystems (USFWS 2000). Though giant garter snakes have been observed to use riprap to thermoregulate, large quantities of riprap eliminate a natural thermal mosaic, and may be composed of material that degrades and pollutes water. Also, riprap may be installed in conjunction with ground cloth that is impermeable to rodents thereby preventing rodent burrowing. The effect of riprap on giant garter snake behavior was studied at the Coulsa drainage canal by USGS Dixon Field Station (see above, previous section Wylie *et al*. 2008). Giant garter snakes did not show preferential use of riprap versus other canal treatments that included soil over rock with native plants and soil and native plants without rock substrate; however, the giant garter snakes were found most often in the untreated control area.

There have been no mortality reports of the giant garter snake since the previous status review that were believed to be directly the result of flood control or canal maintenance activities.

Agricultural Practices

The relatively abundant populations of giant garter snake in the Sacramento Valley compared to the San Joaquin Valley may reflect the availability of alternative habitat that is provided from rice cultivation. Rice agricultural has been demonstrated by many studies to serve as an alternative habitat for the giant garter snake in the absence of suitable natural wetlands (Halstead *et al.* 2010, Western Ecological Resource Center 2011). Wylie et al. (2010) demonstrated that areas of rice cultivation offer habitat that can support giant garter snakes, although this alternative habitat is of lower quality with lower densities of giant garter snakes than found in naturally occurring perennial marsh. However, dependence of the Sacramento Valley populations on agricultural croplands leaves the giant garter snake vulnerable to wide-scale habitat loss in the event of changes in agricultural management such as a change in crops or fallowing large areas of rice fields (Paquin *et al.* 2006) or encroaching urbanization, which may inhibit rice cultivation (J. Roberts pers. comm. 2006). Giant garter snakes found in rice fields or agricultural canals are threatened by conversion of rice crops to non-agricultural land uses and other crops such as grape-producing vineyards, fruit or nut producing orchards, or annual row crops (e.g., cotton). Unlike flood irrigated rice fields, other agricultural cropping systems do not hold sufficient water for long enough time periods to create artificial, temporary wetlands.

The rice industry is an important factor in assessment of the habitat for giant garter snakes. California rice producers have annually cultivated about 202,343 hectares (500,000 acres) of wetland-like habitat each year since 1996 (California Rice Commission 2010). The majority of this cultivation is located in the Sacramento Valley where rice production contributed over $1.3 billion to California's economy through the cultivation of more than 4 billion pounds of rice (California Rice Commission 2010). California also contributes to the global rice market, with U.S. rice production for export expected to account for 11 percent of the global rice trade over the next decade (U.S. Department of Agriculture [USDA] 2008). However, agricultural commodities are subject to market fluctuations. For example, Leidy (1992) cites sources that document 101,171 hectare (250,000 acre) swings in rice production in the Central Valley over a three year time span and recently the national and global rice market demand motivated an increase in California rice production, due to an ongoing drought and reduced rice production in Australia, a major exporter of rice to the Pacific-Oceana area (USDA 2010). Future turns in the market cannot always be accurately predicted by demand alone. Currently, there is a strong global demand for rice accompanied by rising prices, yet the high production costs for cultivating rice; particularly increasing costs of fuel and fertilizer, (as well as water in California) are expected to sharply limit area expansion of rice cultivation (USDA 2010). California rice plantings are not expected to vary considerably from the current level (USDA 2010, 2011). California rice producers are subject to Federal and State regulations including the Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 or California Rice Straw Burning Program, which seeks to limit pollutants from burning rice stubble, and the U.S. Environmental Protection Agency's regulation of pesticide use (California Rice Commission 2010, California Environmental Protection Agency, Air Resources Board 2011).

Fallowing of an aquatic crop, such as rice, can have significant and complex impacts on the giant garter snake. Long-term fallowing can diminish or eliminate habitat, yet short-term fallowing can ultimately improve rice agriculture and the associated habitat components and sustain them in perpetuity while reducing chemical inputs and discharges (John Roberts *in litt*. 2010). Essential to assessing the threat presented by fallowing of rice fields is determining just how the fallowing is being conducted.

Fallowing that results in barren fields and de-watered adjacent and nearby ditches. When rice fields are left out of production because of the lack of availability of water (due to water prices which are uneconomical for the farmer, drought restrictions, water transfers or selling of water rights) or because growing rice is not economically profitable, there is a substantial reduction or elimination in the use of the surrounding and nearby water conveyance structures by giant garter snakes where water supply is dependent upon surface water or ground water from non-adjacent or on-site sources. Such water conveyance structures supply the rice fields with water, and drainage ditches discharge the tailwater coming off the rice fields. Both types of conveyances, as well as the rice paddy itself, provide valuable components of giant garter snake habitat (Wylie *et al*. 1997, 2002*b*, 2008; E. Hansen 2008*b*; Halstead *et al*. 2010). When de-watered, these conveyances lose all or most of their ability to support giant garter snake populations. Radio tracked snakes are known to leave previously occupied rice land sites when fallowing is continued for more than one season (Wylie *et al.* 2008, E. Hansen 2008*b*).

Fallowing as a part of a crop rotation program to keep rice production sustainable. Rice fields that are left out of rice cultivation and production temporarily in order to sustain rice production offer a different set of challenges. If these rice fields are planted with a rotation crop, especially one that is irrigated, essential habitat components for the giant garter snake may be maintained, and the long-term values to the giant garter snake may be enhanced if the rice crop is made more sustainable where it otherwise might be eliminated. A rice crop rotation program is likely to have the additional benefit of reducing farm chemical input, since a crop rotation program, in general, is known to provide the significant benefits of reducing resistant weed damage (herbicide use reduction), soil depletion (fertilizer and other nutrient reductions), and plant disease (fungicide use reduction) (Kansas Rural Center 1998). Rotation also plays a role in water quality in and around the rice environment. In such a setting, an irrigated rotation crop will likely keep water conveyances charged with water, and are more likely to assist in prey production over a fallowed field that is left bare (Wylie *et al.* 2002*a*, 2002<u>*b*</u>, 2008; E. Hansen 2008*b*).

The permanent conversion of rice fields to alternative crops that do not require summer flooding of the fields will reduce the amount of available habitat overall; however, the irrigation needs of the alternative crops will determine the amount of remaining aquatic habitat available for the garter snake and its prey (Wylie *et al.* 2002*a*, 2002<u>*b*</u>, 2008; E. Hansen 2008*b*). Fallowing fields alternately in a “checkerboard” pattern will also minimize the impact to the giant garter snake (USFWS *in litt*. 2008)

Agricultural practices such as tilling, grading, harvesting, or mowing may kill or injure giant garter snakes (CDFG 1992). Giant garter snakes have been observed to over-winter near canals within or adjacent to rice fields making them especially vulnerable to earth moving activities required to shape flood irrigated fields, form rice checks (small berms that affect water flow), and install irrigation boxes (structures which regulate flow quantity). Giant garter snakes have been captured in ditches with apparent poor habitat and lack of vegetative cover, but that were immediately adjacent to nearby rice fields that are presumably beneficial to the snakes (Wylie *et al*. 2002*b*).

The growing of wild rice crops may result in more adverse effects than growing the more common long and short grain rice. Long and short grain rice are harvested after irrigation has ceased and fields have dried. Because radio-marked giant garter snakes have been observed moving from rice fields into the nearby canals as water recedes prior to harvest (Wylie 1998, Wylie *et al.* 2008), giant garter snakes are presumed to be absent when mechanical harvesters are driven into the fields. In contrast, wild rice is harvested while the field is inundated with water. The effects of mechanical harvesting upon giant garter snakes in fields where water and prey are present are unknown but, the harvesting is suspected to disrupt hunting, basking, or other behaviors.

Wetland Management for Waterfowl

Clusters of giant garter snakes occur on State and Federal refuges managed for wildlife purposes; however, some management actions may not benefit the giant garter snake habitat or its prey base (G. Hansen 1988, Dickert 2005, Paquin *et al*. 2006). Giant garter snakes require water during the active phase of their life cycle in the summer; however, some refuge areas are managed to provide water for waterfowl during the winter and spring months, and are drained during the summer months (G. Hanson 1988, Beam and Menges 1997). Summer aquatic habitat is essential because it supports the frogs, tadpoles, and small fish on which the giant garter snake preys. However, permanent water that provides suitable giant garter snake habitat generally supports populations of largemouth bass or other non-native fish that may prey upon giant garter snakes.

A reduction of wetland habitat during the driest part of the year may have a substantial impact on the survival of giant garter snake populations in the San Joaquin Valley (Paquin *et al*. 2006, E. Hansen 2008*a*). For example, Beam and Menges (1997) evaluated historic wetland management practices on State Wildlife Areas and private duck clubs in the Grassland Wetlands of Merced County and concluded that several historic changes in the landscape may be linked to the observed decline of giant garter snakes in this region. Changes in the landscape that did not favor giant garter snakes included: (1) wetland management techniques that did not provide summer water, (2) use of contaminated agricultural drain water on wetland areas, and (3) lack of flood control.

Since the previous five year review changes have been seen in refuge management for water fowl, where the following refuges are now providing blocks of habitat that are managed for the giant garter snake: Sacramento NWR, the San Luis NWR, and the Volta WA (Wylie *et al.* 2006; E. Hansen 2008*a*; C. Isola, USFWS, pers. comm. 2011).

Introduction and Eradication of Non-Native Plants

Introduced, non-native plants may adversely affect the giant garter snake. For example, water primrose (*Ludwigia peploides* ssp. *montevidensis*) may concentrate giant garter snake prey in select pockets. Introduced water primrose has also been observed to constrain movements of giant garter snakes (M. Carpenter, pers. comm. 2001), thereby increasing their vulnerability to predation. However, there is a lack of agreement among giant garter snake researchers regarding whether proliferation of the water primrose may adversely affect the species. Any efforts to reduce the invasion of non-native terrestrial plants may disturb or injure the giant garter snake if herbicides or mechanical removal is not compatible with giant garter snake requirements and behavior. Mechanical removal, discing, mowing, or burning, for example, may result in direct injury or death to giant garter snakes if not conducted according to best management practices. Loss of vegetative terrestrial cover and the thermal mosaic of shaded and unshaded areas which plants provide may result in a reduction in habitat used by the giant garter snakes for regulating their body temperature and for avoiding predators (G. Hansen 1988, Hansen and Brode 1993).

Efforts to eradicate invasive water plants may also disturb or injure the giant garter snake. The invasive water hyacinth (*Eichornia crassipes*) is considered one of the most productive plants on earth and its ability to invade and displace native plants quickly allows it to degrade wetland habitats. Water hyacinth forms dense mats that competitively exclude native submersed and floating plants. Low oxygen conditions develop beneath water hyacinth and the dense floating mats impede water flow and create good breeding conditions for mosquitoes (Western Aquatic Plant Management Society 2006). Mosquito abatement measures include spraying herbicides in aquatic environments to eliminate water hyacinth. The effect of herbicides upon the giant garter snake is unknown, but may include indirect effects by altering the prey base.

Herbicides are suspected to reduce the prey base for the giant garter snake (Brode 1996). For example, when herbicides are applied to aquatic plants and the plants die, the subsequent decomposition process may decrease dissolved oxygen levels in the water, which, if reduced sufficiently, could suffocate the snake's prey (Thayer *et al*. 2003). Additionally, herbicides eliminate wetland plants, whose surfaces are colonized by algae, protozoa, rotifers and other small organisms that serve as a food supply for amphibian larvae (Hurlbert 1975), thereby adversely affecting the primary production level of the food chain upon which giant garter snakes ultimately depend. Further, some research has documented the detrimental effects of the commonly used herbicide Atrazine, on the sexual development of larval amphibians (Hayes *et al*. 2002), which may affect the availability of prey for the giant garter snake.

Water Transfers

Water transfers are increasingly being used to facilitate movement of water from users with discretionary supplies to those with critical needs. For example, the Metropolitan Water District of Southern California consulted with the USFWS in 2003 on a transfer that would obtain CVP water from several Sacramento Valley water districts. The transfer would have resulted in removing up to 18,212 hectares (45,000 acres) of rice from cultivation, and, thus, eliminating potential habitat for the giant garter snake. However, this water transfer was never completed using CVP water. In subsequent years State Water Project water has been transferred to Southern California. As discussed in earlier sections recent studies have concluded that giant garter snakes have adapted to the mosaic of seasonal wetlands and upland habitats that rice cultivation mimics, and use flooded rice fields for foraging, and irrigation dikes for basking sites. Every year water transfers occur between water users within any water district and transfers between districts are becoming more common (DWR 2005). Regular long-term contractual water transfers have the potential to reduce significantly the amount of rice lands and the temporary and artificial wetlands they produce. Impacts may be especially severe in those areas adjacent to State and Federal wildlife refuges which may function as the core habitat to lead recovery efforts.

Water transfers can be conducted with an emphasis on minimizing the effect on the giant garter snake. For example, the USFWS recently consulted with Conaway Preservation Group regarding a transfer of up to 22,522 acre-feet of CVP water from the Conaway Ranch in Yolo County (an area where occurrences of the giant garter snakes are documented) to the San Luis and Delta-Mendota Water Authority (USFWS 2008). This transfer will result in a reduction of approximately 17 percent from the 10-year average acreage of rice that has been maintained in the area, the fallowing of 1,000 acres of rice, and an additional replanting of 2,500 acres in non-rice crops. The biological opinion (USFWS *in litt.* 2008) stated that the transfer will result in increased mortality of the giant garter snake from increased competition for resources, reduced reproductive rates, and increased mortality from predation when crossing dewatered areas in search of suitable forage areas. It was pointed out, however, that minimization measures, including following the best management practices for the giant garter snake, as outlined in Appendix K of the draft recovery plan (USFWS 1999) will ameliorate the adverse effects to some degree. The biological opinion further stated that the transfer program will result in the lowest acreage planted in rice in the area since 1998, but if there is a population of giant garter snakes that has persisted in the Conaway Ranch during this time, it is not anticipated that the effects of the 2008 transfer program will impair the ability of that population to continue to persist.

Groundwater pumping in southern Sacramento County has severely depleted regional groundwater, resulting in reduced surface flows in the Cosumnes River during the fall season, north of the Badger Creek giant garter snake population. Fall flows in the Cosumnes River have been so low in recent years that the entire lower river has frequently been completely dry between October and December (Fleckenstein *et al*. 2004). The lowering of the water table may affect surface flows on tributaries such as Badger Creek (E. Hansen 2001) and can also deplete nearby wetland habitats (Dunne and Leopold 1978). Historically, Badger Creek provided persistent year-round surface water in channels; however, the water level is currently dependent on seasonal precipitation and agricultural runoff, which provide no guarantee of sustainable suitable habitat for the giant garter snake (E. Hansen 2001). In 2001, Badger Creek experienced a comprehensive drying of aquatic habitat, which disrupted the connectivity between the western portion of the Badger Creek giant garter snake population and the formerly occupied snake habitat upstream (E. Hansen 2001). The drying of aquatic habitat persisted throughout the active season of the snake and may have resulted in part from water diversion for agricultural use (E. Hansen 2001). Additionally, the drying of aquatic habitat, such as that which occurred in 2001, may also eliminate populations of prey species of the snake (E. Hansen 2001).

No new information has become available since the previous five year review on the potential effects of lowering of the water table of other watersheds within the range of the giant garter snake.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

No new information is available regarding an increase in threats to the snake from collectors, although new information is available on the effects of scientific collection, as discussed below:

Scientific collection

Qualified individuals may obtain permits to conduct scientific research activities on the giant garter snake under section 10(a)(1)(A) of the Act. Specific activities that may be authorized include: capturing, confining, tagging, handling, obtaining tissue or blood samples, and measuring. These activities may be done in conjunction with radio telemetry tracking studies, genetic studies, contaminant studies, and behavioral, ecological, and life history studies. Short term impacts of these activities may include accidental injury or death of a limited number of giant garter snakes; however, these activities are not a significant source of loss of giant garter snakes. Injuries or mortalities that are a result of permitted trapping surveys, or giant garter snakes mortalities that are found incidental to conducting surveys, are reported to the Sacramento Fish and Wildlife Office (SFWO). These mortality numbers are maintained in a database in order to monitor the effect of trapping.

Specifics of activities associated with capture, use of transmitters and holding of giant garter snakes are discussed below.

Capture. Most reptiles experience stress in response to capture and short-term confinement as indicated by an increase in blood plasma corticosterone levels (Lance 1990). Additionally, trapping techniques that employ the use of floating minnow traps place giant garter snakes at risk for drowning where water quantity or flow fluctuates or being caught in the mesh as they try to escape. Trapping may also increase the risk of predation while the giant garter snake is retained in the trap or place it at risk due to the loss of the ability to thermoregulate. Transporting and storing giant garter snakes are also sources of risk to the snake. Another potential threat to the snake includes the theft of snake traps while they are deployed in the field (The Natomas Basin Conservancy 2006*b*). If a snake is in a trap when it is stolen, the snake could be injured or killed, depending on the reaction of the trap thief. Since the last status review in 2006 the following trap related mortalities were reported to the SFWO: 2007 – 1 mortality; 2008 – 3 mortalities; 2009 – 2 mortalities; 2010 – 3 mortalities, and 2011 – 3 mortalities.

Transmitters. The external attachment of radio transmitters can result in tail loss (Sloan 2003). In a study by Sloan (2003), to find an alternative method to internal implantation of radio transmitters, transmitters were attached to the tails of valley garter snakes, a similar species chosen as a surrogate for the giant garter snake. Five of 14 valley garter snakes in the study lost their tails after the attached transmitters became entangled in vegetation and the tails were torn away with the transmitters (Sloan 2003). In addition, a recent study demonstrates that most snakes with internally placed transmitters may be affected by infections where transmitters are installed, even when completed under very careful and sanitary conditions (Lentini *et al*. 2011). The following factors were shown to reduce the risk of infection: skill of surgeon implanting the transmitter, use of nonreactive transmitter material, preparation and post-operative care of the animal, and the use of antiseptic conditions (Lentini *et al*. 2011). Recently USGS deployed transmitters externally on giant garter snakes using tape in an experiment to reduce the risk of infections. However, USGS has not found any mortalities during or after their radio transmitter studies during the last two years (B. Halstead, pers. comm. 2011).

Holding. Researchers who do not retain captive giant garter snakes from separate populations in separate facilities, potentially risk the spread of disease and infection among healthy populations. Infected giant garter snakes held temporarily in the lab or in care facilities while recovering from radio implant surgery, for example, have the potential to spread disease or parasites to healthy giant garter snakes simultaneously held nearby. Upon return to the capture site newly infected individuals could infect a previously healthy population. Similarly, giant garter snakes fed prey (which can act as hosts for parasites) from areas outside their home ranges could be at risk for the spread of parasitism (G. Hansen *in litt.* 1992).

Factor B is considered to remain a potential threat, although the degree of this threat is not believed to be of great significance.

FACTOR C: Disease or Predation

Since the previous 2006 status review the identity of potential and known predators has not changed significantly. However, new information is available on some of these threats and is discussed below.

Parasites
A study of giant garter snake parasitology was conducted by Dr. Ray Wack and Eric Hansen and funded by the CVPIA (E. Hansen *et al.* 2011). Examination of both giant garter snakes and valley garter snakes was conducted at four locations: Natomas Basin, Badger Creek, Los Banos, and Mendota. Initial results demonstrate that subcutaneous nematodes (species not yet identified) were found in less than half of the snakes sampled, except for Los Banos where 10 of 17 giant garter snakes hosted nematodes, and that oral leeches (*Lechriorchis primus*) occurred only in giant garter snakes from the Natomas Basin and Badger Creek. It did not appear to the researchers that the parasitic infections had a significant effect on the health of the hosts (E. Hansen *et al.* 2011). Direct fecal sampling showed that the most common infestations were Trichomonad and Coccidia protozoa, which were found in snakes at all four sites (E. Hansen *et al.* 2011).

Predatory fish
Habitat degradation or alteration that benefits non-native species may increase the vulnerability of giant garter snakes to predation. Introduced game fish such as largemouth bass and catfish eat giant garter snakes. These introduced predatory fishes have been responsible for eliminating many species of native fishes and aquatic vertebrates in the western United States (Minkley 1973, Moyle 1976). Brood areas free of predatory fish may be important in that these areas allow juvenile giant garter snakes to grow large enough to avoid predation by game fish (G. Hansen pers. comm. 1998). Introduced predatory fish may also compete with giant garter snakes for smaller forage fish (G. Hansen 1986, CDFG 1992).

Crayfish
The signal crayfish (*Pacifastacus leniusculus*) and the Louisiana crayfish (*Procambarus clarkia*) are introduced species in California that inhabit giant garter snake habitat. When crayfish molt, they may become the prey of giant garter snakes under certain conditions. Crayfish also may be predators upon the giant garter snake. At the Badger Creek study area, the use of floating minnow traps to capture giant garter snakes resulted in the simultaneous capture of crayfish. We have no data to indicate whether and how often crayfish may prey on giant garter snake outside of traps.

Bullfrogs
Several researchers have implicated the spread of bullfrogs in the demise of numerous species of native amphibians and reptiles (Schwalbe and Rosen 1989, Holland 1992). Bury and Whelan (1984) cited 14 cases of bullfrogs eating snakes. These studies documented: (1) bullfrog ingestion of garter snakes up to 80 centimeters (31.5 inches) in length, (2) depletion of garter snake age class structure less than 80 centimeters (31.5 inches) in snout-vent length, and (3) disappearance and subsequent resurgence of garter snake populations coincident with the introduction and decline of bullfrog populations. Schwalbe and Rosen (1989) concluded that bullfrogs have a high potential of eliminating garter snake populations. Although these studies were conducted on garter snake species other than the giant garter snake, it is likely that the giant garter snake may be similarly affected.

Others have found the bullfrog to be a predator of the giant garter snake. Treanor (1983) found that unidentified garter snakes comprised 6.0 and 6.4 percent volume of bullfrog stomach contents in the months of July and August at Gray Lodge Wildlife Area, Sutter County, where giant garter snakes are known to occur. Wylie *et al*. (2003*a*) examined stomach contents of 99 bullfrogs over three field seasons at the Colusa National Wildlife Refuge, Colusa County. Neonate giant garter snakes contributed to about 4 percent of bullfrog stomach contents. The authors estimated that predation by bullfrogs accounted for the mortality of 21.5 percent of all neonate giant garter snakes in the area where the study was being conducted (Wylie *et al*. 2003*a*). Adult bullfrogs were found to eat neonate giant garter snakes (208 and 213 millimeters in length) at the Volta Wasteway in Volta Wildlife Area, Merced County (Dickert 2003).

Introduced Snake Species

The Southern water snake (*Nerodia fasciata*) has been introduced into the Folsom, California region, where it has reached high local densities (Balfour and Stitt 2002). This species, whose life history is closely related to the giant garter snake in being primarily aquatic and requiring upland habitat for basking and aestivation, is an opportunistic invasive species, having apparently expanded its range near Folsom since it was first discovered there in 1992 (Stitt *et al*. 2005). It appears to be able to inhabit both small and large bodies of water (Stitt *et al*. 2005). Stitt *et al*. (2005) identified the Southern water snake as a potential threat to the giant garter snake because there is the possibility that the introduced, invasive species may out-compete the endemic giant garter snake to the point of competitive exclusion. Recently, observations of *Nerodia* sp. have been recorded at Stone Lakes NWR and in the City of French Camp just south of Stockton (Eric Stitt, *in litt*. 2012). Although there have been incidental observations of snakes in the Natomas Basin that match the morphology of *Nerodia* sp., the non-native water snake has yet to be found within giant garter snake populations, but due to the high risk to giant garter snake populations from this invasive species, this threat should be continued to be monitored and eradication of any *Nerodia* sp found in the Central Valley should be prioritized.

Predation by Domestic Cats

Domestic cats, depending upon the environment, may travel 0.8 kilometer (0.5 mile) or more from their owner’s homes for the purpose of hunting. G. Hansen (USFWS 1993) observed numerous snake kills (of several snake species including the giant garter snake) by domestic cats. These observations were in one of his longtime study areas, approximately 3.2 kilometers (2 miles) from the closest urban development in the City of Davis, Yolo County.

Predation by Native Species

Predation by native species upon the giant garter snake has not been well documented. No analysis of predation or examination of the stomach contents of suspected predators has been conducted for the giant garter snake. Anecdotal information includes observations of hawks, herons, and river otters (*Lutra canadensis*) preying upon the giant garter snake. Although no quantitative data exist on predation of giant garter snakes by river otters, three to four giant garter snakes have been observed that were believed to be killed by otters (G. Wylie in litt. 2006). River otters, which are numerous in Badger Creek and some areas of the Natomas Basin, have also been known to kill giant garter snakes without consuming them (G. Wylie pers. comm. 2006). According to Rossman *et al*. (1996), some species of garter snakes may be important prey for several vertebrate predators including jays (*Cyanocitta cristata*) and crows (*Corvus brachyrhynchos*), carnivorous fish, and small mammals. Small native mammalian predators are likely to include raccoons (*Procyon lotor*), skunks (*Mephitis mephitis*) or (*Spilogale gracilis*), opossums (*Didelphis virginiana*), and foxes (*Vulpes vulpes*, *Urocyon cinereoargentius*, or *Vulpes macrotis*). Both USGS and Eric Hansen have reported that raptors appear to be common predators of snakes including the giant garter snake (B. Halstead pers. comm. 2011, E. Hansen pers. comm. 2011). Anthropogenic (human caused) changes in ecosystem dynamics may favor and subsidize these predator populations especially in areas at the urban-interface. The result may be an increase in predation pressure upon the giant garter snake, but we have no specific data to evaluate the risk at this time.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

The giant garter snake final listing rule discussed the adequacy of a number of regulatory mechanisms in providing protection for this species (USFWS 1993). Specifically, it discussed the adequacy of the National Environmental Policy Act (NEPA), Section 404 of the Clean Water Act (CWA), the California Environmental Quality Act (CEQA) and the California Endangered Species Act (CESA). As discussed in the final rule, each of these laws provides some protection to the snakes, but has provisions or exemptions that could allow activities that would adversely affect the snakes. A brief description of each of these laws follows:

NEPA: NEPA provides some protection for the giant garter snake. For activities undertaken, authorized, or funded by federal agencies, NEPA requires the project be analyzed for potential impacts to the human environment prior to implementation (42 U.S.C. 4371 et seq.). Instances where that analysis reveals significant environmental effects, the federal agency must propose mitigations that could offset those effects (40 CFR 1502.16). These mitigations are usually developed in coordination with the Service during Section 7 consultation and should provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, and so some impacts could still occur. Additionally, NEPA is only required for projects with a federal nexus, and therefore, actions taken by private landowners are not required to comply with this law.

CWA: Under section 404 of the CWA, the U.S. Army Corps of Engineers (Corps) regulates the discharge of fill material into waters of the United States, which include navigable and isolated waters, headwaters, and adjacent wetlands (33 U.S.C. 1344). In general, the term “wetland” refers to areas meeting the Corps criteria of having hydric soils, hydrology (either sufficient flooding or water on the soil surface), and hydrophytic vegetation (plants specifically adapted for growing in wetlands). Any actions within giant garter snake habitat that has the potential to impact waters of the United States would be reviewed under the CWA as well as NEPA and the Endangered Species Act. These reviews would require consideration of impacts to the giant garter snake and its habitat, and when significant impacts could occur, mitigations would be recommended.

CESA: The giant garter snake was listed as a threatened species in 1971 under the California Endangered Species Act of 1984 which means that it cannot be taken without a special permit issued for scientific collecting or research. This legislation requires State agencies to consult with the California Department of Fish and Game on activities that may affect a State-listed species.

CEQA: The California Environmental Quality Act requires review of any project that is undertaken, funded, or permitted by the State or a local governmental agency. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA Sec. 21002). In the latter case, projects may be approved that cause significant environmental damage, such as destruction of listed endangered species or their habitat. Protection of listed species through CEQA is, therefore, dependent upon the discretion of the lead agency involved.

CEQA requires disclosure of potential environmental impacts of public or private projects carried out or authorized by all nonfederal agencies in California. Under CEQA, a significant effect on the environment means "a substantial, or potentially substantial, adverse effect on the environment" (California Public Resources Code §21068). Any project that affects a protected species results in a mandatory finding of significant effect and all the mitigation requirements appurtenant. The lead agency can either require mitigation for unavoidable significant effects. In rare circumstances, and under specified conditions, the lead agency can make a determination that overriding considerations make the mitigation infeasible (California Public Resources Code §21002) and provide other mitigation. CEQA can provide protections for a species that, although not listed as threatened or endangered, meets one of several criteria for rarity (14 California Code of Regulations §15380).

Because of State environmental laws such as CEQA, planned development often provides avoidance, minimization, and mitigation measures which are specifically for, or which may incidentally benefit, giant garter snake, as a result of conformance with local land use plans for providing open space, through working with the California Department of Fish and Game under the authority of CEQA. The avoidance, minimization, and mitigation measures of individual projects nevertheless tend to result in fragmented landscapes and a trend of cumulative regional habitat loss and fragmentation. Mitigation does not create new land, it simply balances land converted with land protected for natural values, so even with mitigation, a net loss of habitat results. So while mitigation provided by developments under CEQA may be offered with the intent to benefit giant garter snake, the resulting fragmentation of regional landscapes over time creates high risk of disrupting or precluding migration patterns, isolating small local populations, and subjecting animals to higher risks from road crossing mortality and other risks associated with urban preserves.

Since the previous five year review two new regulations were recognized to have some level of protection for the giant garter snake. These include:

Porter-Cologne Act: The Porter-Cologne Act of 1969 is the primary statute protecting water quality in California, and includes both surface waters (in conjunction and in compliance with the Federal Water Pollution Control Act) and ground waters. Under the Porter-Cologne Act the state must develop water quality plans both statewide and on a regional (basin) basis that identify beneficial uses, water quality objectives (including water quality control plans), and implementation plans. As previously mentioned water quality is a vital concern to the conservation of the giant garter snake. California water bodies are now being assessed for their levels of pollutants.

The Lacey Act: The giant garter snake is protected by the Lacey Act (P.L. 97-79), as amended in 16 U.S.C. 3371**.** The Lacey Act makes unlawful the import, export, or transport of any wild animals whether alive or dead taken in violation of any U.S. or Indian tribal law, treaty, or regulation as well as the trade of any of these items acquired through violations of foreign law, and further makes unlawful the selling, receiving, acquisition or purchasing of any wild animal, alive or dead. The designation of wild animal includes parts, products, eggs, or offspring.

Numerous activities do not require compliance with any of these laws. Examples are the drying of rice fields in anticipation of future development or the modification or destruction of wetland habitat prior to application by the project proponent for appropriate permits to develop the land. It is unclear to what extent these unpermitted activities are occurring and what impact it is having on giant garter snakes and their habitat.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

Other natural or manmade factors affecting the continued existed of giant garter snakes that were identified in the 1993 listing rule (USFWS 1993) included seasonal fluctuations in rice production, canal management, changes in water management, water transfers, contaminants, flooding, and habitat fragmentation/population isolation. In addition the previous five year review included the following threats under Factor E: Drought and climate change, mosquito abatement, road mortality, the use of erosion control netting, water quality, harassment during recreational use of habitat, and exploration activities for natural gas. As noted in the section on Factor A threats, the following threats were moved from Factor E to Factor A: water management and water transfers, habitat fragmentation and population isolation, and canal management. The threats from natural gas exploration and grazing listed in Factor A in the last five year review were moved to Factor E in this five year review. New information about each of the Factor E threats identified since the last five year review is discussed below.

Floods

Though the giant garter snake is an aquatic species, it is subject to the detrimental effects of floods. Giant garter snakes may be displaced during a flood, buried by debris, exposed to predators, and subject to drowning when burrows and over-wintering sites become inundated with water. Giant garter snakes are not known to occupy the area within the Sutter Bypass which is flooded regularly (Wylie *et al*. 2005); although snakes are known to occupy the Yolo Bypass during the active season when flooding is unlikely (E. Hansen 2009*a*). Snakes appear to survive at least some inundation of their burrows. Wylie observed snakes emerging from burrows after a period of inundation (G. Wylie pers. comm. 2006).

Drought and Climate Change

Because of the giant garter snake's dependence upon permanent wetlands, water availability will play a significant role in its survival and recovery. In a state where much of the wetland habitat is maintained by managed water regimes, the lack of sufficient water supply may preclude consistent and timely delivery of water to sustain suitable habitat for the giant garter snake. Drought conditions place additional strains on the water allocation system. Where populations currently persist on only marginal habitat, emergent drought or higher temperature conditions are likely to result in high rates of mortality in the short term with the effects of low fecundity and survivorship persisting after the drought has ceased (McMenamin *et al*. 2008, Mitchell *et al*. 2008). It is unknown how quickly giant garter snake populations may rebound after severe climatic conditions, particularly since these conditions might further exacerbate the impact from existing threats to the giant garter snake, such as habitat loss and fragmentation, and small, isolated populations. The giant garter snake as a species has survived recorded historic droughts, but presumably under conditions where fewer cumulative threats existed.

The history of California=s climate has been incompletely reconstructed through the study of tree rings, sediment, and pollen. Evidence suggests that California experienced two sustained drought periods, extending over more than three centuries. The first drought lasted more than two centuries before the year 1112; the second drought lasted more than 140 years before 1350 (DWR 2002). More recently, records depict a pattern of lesser droughts lasting three years or less. Such environmental conditions and random events may cause small sub-populations to be extirpated from isolated and fragmented habitats or to suffer reduced genetic variability from inbreeding (Schonewald-Cox *et al*. 1983).

The global average temperature has risen by approximately 0.6 degrees centigrade (1.08 degrees Fahrenheit) during the 20th Century (International Panel on Climate Change 2001, 2007; Adger *et al* 2007). There is an international scientific consensus that most of the warming observed has been caused by human activities (International Panel on Climate Change 2007, Adger *et al.* 2007), and that it is “very likely” that it is largely due to increasing concentrations of greenhouse gases (carbon dioxide, methane, nitrous oxide, and others) in the global atmosphere from burning fossil fuels and other human activities (Cayan *et al.* 2005, Adger *et al*. 2007, U.S. Environmental Protection Agency [EPA] 2011). Eleven of the twelve years between 1995 and 2006 rank among the twelve warmest years since global temperatures began to be recorded in 1850 (Adger *et al*. 2007). The warming trend over the last fifty years is nearly twice that for the last 100 years (Adger *et al*. 2007). Looking forward, under a high emissions scenario, the International Panel on Climate Change estimates that global temperatures will rise another four degrees centigrade by the end of this century; even under a low emissions growth scenario, the International Panel on Climate Change estimates that the global temperature will go up another 1.8 degrees centigrade (3.24 degrees Fahrenheit) (International Panel on Climate Change 2007).

The increase in global average temperatures affects certain areas more than others. The western United States, in general, is experiencing more warming than the rest of the Nation, with the 11 western states averaging 1 degree Centigrade (1.7 degrees Fahrenheit) warmer temperatures than this region’s average over the 20th Century (Saunders *et al*. 2008). California, in particular, will suffer significant consequences as a result of global warming (California Climate Action Team 2006). In California, reduced snowpack will cause more winter flooding and summer drought, as well as higher temperatures in lakes and coastal areas. The incidence of wildfires in the state also will increase and the amount of increase is highly dependent upon the extent of global warming. No less certain than the fact of global warming itself is the fact that global warming, unchecked, will harm biodiversity generally and cause the extinction of large numbers of species. If global mean temperatures exceed a warming of two to three degrees centigrade (3.6 to 5.4 degrees Fahrenheit) above pre-industrial levels, twenty to thirty percent of plant and animal species will face an increasingly high risk of extinction (International Panel on Climate Change 2001, 2007).

The mechanisms by which global warming may accelerate species extinction are complex and inter-related. Global warming increases the frequency of extreme weather events, such as heat waves, droughts, and storms (Lenihan *et al.* 2003, California Climate Action Team 2006, International Panel on Climate Change 2007). Extreme events, in turn may cause mass mortality of individuals (by affecting habitat or ecosystem characteristics, for example) and significantly contribute to determining which species will remain or occur in natural habitats (Whitfield *et a*l. 2007). As California's average temperature and precipitation change, species ranges tied to climate dependant habitats are moving northward and upward, but in the future, range contractions are more likely than simple northward or upslope shifts (Loarie *et al.* 2008, 2009).

Research has already revealed correlations between climate warming and declines in amphibians and reptiles in different parts of the world (Wake 2007, Whitfield *et al*. 2007, McMenamin *et al*. 2008, Mitchell *et al*. 2008, Huey *et al*. 2010). In 2010 the first validation of an extinction directly linked to climatic changes caused by global warming was published (Huey *et al*. 2010). This was a study of four species of lizards of the genus *Sceloporus* which demonstrated that climate warming in recent years was responsible for the extinction of two of the four species under observation (Huey *et al*. 2010).

Table I-3: Predicted changes in California climate and possible effect on giant garter snakes (www.climatechange.ca.gov)

Climate change condition (predicted)	**Impact to giant garter snake**
Reduction in snow accumulation and snow melt	Reduction in summer water availability
Increase in frequency and severity of extreme weather events: heat waves	Increase of air temperature for longer duration will stress thermoregulation capabilities, change behavioral patterns including feeding regime, and affect body condition.
Increase in frequency and severity of extreme weather events: drought	Reduction in summer water availability, further loss of aquatic habitat, stress thermoregulation capabilities, and reduction in native cover vegetation.
Sea level rise and wave intensity	Increase in water salinity in Delta recovery area. Reduction and elimination of available habitat
Increase in invasive species: plants	Habitat alteration
Increase in invasive species: parasites and disease bearing organisms	Direct injury or mortality
Changes in forage prey base, reduction due to reduced water availability	Direct health and fitness problems as a result of improper nutrition. Direct mortalities from starvation.
Further loss of wetlands, lower ground water level.	Habitat loss: loss of wetted marsh area.
Disruption of seasonal timing (phenology)	Disruption of life history events
Water pollution increase from storm runoff	Habitat alteration, direct mortality due to sickness, indirect effect by reducing prey base

The hypothesis that Huey *et al*. tested was that increased temperatures caused lizards, being cold blooded, to spend increased time within refuges to maintain their preferred body temperature, which meant that they decreased their foraging opportunities to the extent of negatively affecting their reproductive output. This decline in reproduction was shown to lead to the extinctions. Huey *et al.* (2010) predict that by the year 2080 about 40 percent of all present day lizard species will be extinct. It is currently unknown to what extent climate change has impacted snake populations. Ongoing global climate change likely imperils the giant garter snake and the resources necessary for its survival (Inkley *et al*. 2004, Adger *et al*. 2007, Kanter 2007). Since climate change threatens to disrupt annual weather patterns and will affect summer water availability, it may result in a loss of giant garter snake habitats and/or prey, and/or lead to increased numbers of predators, parasites, and diseases (Mawdsley *et al.* 2009). Where giant garter snake populations are isolated, a changing climate may result in local extinction, with range shifts precluded by lack of habitat (California Climate Action Team 2006, Mawdsley *et al.* 2009). Predicted changes in California's climate and the effect of the changes on the biodiversity of California are addressed in a California Climate Adaption Strategy which is being developed by the California Climate Change Center (California Natural Resources Agency 2009). The predicted changes that may affect the giant garter through habitat degradation that were discussed in the California Climate Adaptation Strategy are included in table I-3.

Mosquito Abatement

Currently, there are 12 mosquito-borne viruses recognized in California, however only West Nile virus, western equine encephalomyelitis, and Saint Louis encephalitis are significant threats to public health (California Department of Public Health 2011). There are now more than 50 species of mosquitoes found in California that can be found throughout the state in a variety of habitats ranging from lowland deserts to meadows at elevations of 10,000 feet or higher (U.C. Davis Integrated Pest Management 2011). The mosquito species of major concern are in the genera *Culex*, *Aedes*, and *Anopheles* (U.C. Davis Integrated Pest Management 2011). Water managers and mosquito abatement districts throughout the Central Valley work to reduce populations of mosquitoes by not allowing water to stagnate, thereby making it less suitable for mosquito larval development, or by spraying insecticides into inundated areas including flooded rice fields and the surrounding irrigation and drainage canals inhabited by giant garter snakes (Kwasney *et al*. 2004, California Department of Public Health and Mosquito Vector Control Association of California. 2010).

The mosquito abatement districts' goals, which call for no open shallow water in summer or vegetation in water, conflicts with the design of preserves for the giant garter snake (G. Sutter pers. comm. 2006, California Department of Public Health and Mosquito Vector Control Association of California. 2010). Preserves designed to meet the habitat requirements of the giant garter snake contain shallow open water and wide benches of emergent vegetation, such as tules (*Scirpus* species) that benefit the giant garter snake by providing summer habitat for the snake and its prey. Early coordination with mosquito abatement districts, however, can resolve many of the issues (G. Sutter pers. comm. 2006).

The reduction or alteration of flood irrigation practices to control mosquitoes or other water related pathogens has the potential to adversely impact the giant garter snake and its aquatic prey, and could restrict the abundance of wetland habitat, thereby reducing the giant garter snake's distribution. Furthermore, while the toxicology of pesticides in the giant garter snake is unexplored, pesticides, such as those used to control larval and adult mosquitoes, may reduce the populations of aquatic prey upon which the giant garter snake depends (Davis *et al*. 2000, Slotton *et al*. 2000, Rowe *et al*. 2001). Mosquito adulticides approved for use in California include natural pyrethrins and synthetic pyrethroids which are known to kill non-target wildlife species, including bees, fish, and amphibians (Sparling *et al*. 2001, California Department of Public Health and Mosquito Vector Control Association of California. 2010). Bacteria that selectively kill mosquito larvae (*Bacillus thuringiensis* ssp *israelensis* and *Bacillus sphaeicus*) are also currently being used and it has been demonstrated that these agents have little, if any, harmful effect on other insects, amphibians, reptiles and birds (California Department of Public Health and Mosquito Vector Control Association of California. 2010).

Roads

The state Department of Transportation (Caltrans) is responsible for planning, designing, building, operating and maintaining California's $300 billion, 50,000-lane-mile state road system (California Department of Transportation 2011). A complex system of roads surrounds or crisscrosses nearly all natural habitats remaining in California. Direct mortality of snakes resulting from vehicle strikes on roads has been well documented (Rosen and Lowe 1994, Ashley and Robinson 1996, Rudolph *et al.* 1999, Enge and Wood 2002, Row *et al.* 2007) and has been demonstrated to be a threat to giant garter snakes throughout the Central Valley. Snakes are particularly vulnerable to vehicle strikes because of their long bodies that provide a large target area, their relatively slow speed, and their habit of lying on warm roadways during the evening to raise their body temperatures (Rosen and Lowe 1994). Rudolph *et al.* (1999) found that snake abundance in eastern Texas was reduced up to 50 percent adjacent to roads as compared with an abundance determined at 850 meters from the roads. They also found that trap success for snakes remained low to a distance of 450 meters from the road corridors and then increased substantially. Wetland as well as terrestrial herpetofauna species have been found to be impacted by road mortalities (Row *et al.* 2007).

Several local researchers have reported and collected dead giant garter snakes from roadways. Within the Natomas basin, Hansen and Brode (1993) documented 31 road killed snakes during their four-year study. In surveys conducted for giant garter snakes in the Grasslands Ecological Area, one road-killed giant garter snake was documented 1995 (G. Hansen 1996), and two road-killed giant garter snakes were documented in 1999 (Beam *et al*. 1999). Biologists working at the USGS Dixon Field Station have found and collected numerous road killed giant garter snakes during the several years of study of the giant garter snake in the Sacramento Valley. During the ten years between 1996 and 2006 USGS biologists recorded 34 giant garter snake mortalities due to automobile strikes (Wylie, USGS, unpublished data). In the Sacramento-San Joaquin Delta area 3 giant garter snakes near Little Venice Island were reported as road killed on Empire Tract Road, which all occurred within a very short time period (ESA *in litt.* 2010).

In addition to direct mortality from vehicle strikes, Fahig (1997) and Enge and Wood (2002) note that roads function as barriers that reduce ecosystem connectivity and restrict gene flow among metapopulations. Roads can serve as conduits for contaminants and the spread of non-native species. Where roads disrupt aquatic systems, altered connectivity can result in changes in water quality, and interactions with terrestrial ecosystems (Forman *et al.* 2003). Upstream and downstream flow may be disrupted where culverts result in excessive current velocity. Excessive current velocity can lead to the scouring and removal of silty-bottomed pools preferred by the giant garter snake. When constructed through wetlands, roads alter or degrade functional attributes including hydrology, nutrient supply, sediment and contaminant retention, and wildlife productivity (Forman *et al.* 2003). As road systems increase in density, surface area, and traffic volume, impacts to the giant garter snake also increase.

Maintenance of roads can also impact the giant garter snake. Mowers and other maintenance machinery may inadvertently injure or kill roadside wildlife. In addition, road maintenance in California accounted for the use of 3,088,795 pounds of pesticide (California Department of Pesticide Regulation 2011).

Netting/Erosion Control Products
Rolled erosion control products are frequently used as temporary berms to control and collect soil eroding from construction sites and other areas of disturbed soil during stormwater runoff. Bird netting, a lightweight plastic netting used to exclude wildlife from crops, and rolled erosion control products containing net-like mesh made of fibers such as nylon, plastic or jute twine, which hold materials such as straw and jute, have been found to be hazardous to several species of snakes (Stuart *et al*. 2001, Barton and Kinkead 2005). The snakes' scales catch on the netting, preventing the snakes from escaping by backing out of the mesh; the snakes then move forward into the small mesh opening which can trap the animals. The resulting lacerations from trying to escape and subsequent overheating or exposure to predators can result in death of the snakes (Stuart *et al*. 2001, Barton and Kinkead 2005). The effects of erosion control products and bird netting have not been studied specifically on the giant garter snake; however, the effects to giant garter snakes are likely similar to the effects on the species found in these studies. For example, a dead pregnant female San Francisco garter snake (*Thamnophis sirtalis tetrataenia*) was discovered caught in a small piece of jute netting in the San Francisco Bay area (S. Larsen *in litt*. 2003). The giant garter snake is expected to be particularly vulnerable to the effects of erosion control products that are encased in filament or netting because these products are often used along water ways and other aquatic habitats, which are the giant garter snake's primary habitat (E. Hansen pers. comm. 2006).

Water Quality
Selenium: Selenium contamination and impaired water quality have been identified as threats to the giant garter snake and are contributing factors in their decline, particularly for those giant garter snakes occurring in the Grassland Ecological Area of Merced County (USFWS 1993, 2006). Selenium contamination in soils and water of the Sacramento Valley are not at the high levels found in the northern San Joaquin Valley and are not considered a threat in this part of the giant garter snake's range (Seiler *et al*. 2003). However, high levels of selenium contamination have been documented in biota from at least six major canals and water courses in the Grassland Ecological Area that have historic giant garter snake records (Saiki *et al.* 1991, 1992*a*). The remaining extant giant garter snake sightings have typically been found in water bodies not impaired by selenium and agricultural drainage (e.g., Volta WA and Los Banos Creek west of the Kesterson Unit of the San Luis NWR). The bioaccumulation of selenium contamination in fish, frogs, and fish-eating birds in this region has been well documented (Ohlendorf *et al*. 1986,

1988; Saiki and Lowe 1987; Saiki and May 1988; Hothem and Ohlendorf 1989; Saiki *et al*. 1991, 1992b, 1993; Beckon et al. 2007). Contaminant studies on aquatic organisms and their habitats in the Grassland Ecological Area and neighboring areas have documented elevated levels of waterborne selenium in many representative water bodies in this region (San Joaquin Valley Drainage Program 1990, California Regional Water Quality Control Board 1992, Nakamoto and Hassler 1992). The levels of waterborne selenium were at concentrations in excess of known toxicity thresholds of giant garter snake prey species (Hermanutz 1992, Hermanutz *et al*. 1992, Nakamoto and Hassler 1992).

Implementation of the Grassland Bypass Project (GBP), a project that manages agricultural drainage south and west of the Grassland Ecological Area, has significantly improved water quality in the Grasslands wetland channels (with the exception of a portion of Mud Slough north which is used to route drainage water to the San Joaquin River), and has reduced salt and selenium loading to the San Joaquin River. With implementation of the GBP from 1996 through the present time, most of the drainage from farmlands in and adjacent to the Grassland Drainage Area has no longer been conveyed in about 93 miles of Grasslands wetland channels. However, exceedences of the 2 µg/L monthly mean selenium objective in water still occur in the Grassland wetland supply channels. For example, from September 2001 through June 2006 GBP Monthly Monitoring Reports compiled by BOR weekly water samples documented selenium levels above 2 µg/ in the Grassland wetland supply channels 23 times in Camp 13 Ditch, 14 times in Agatha Canal, 4 times in the San Luis Canal, and 14 times in the Santa Fe Canal (U.S. Bureau of Reclamation *et al.* 2006). Typically, these exceedences of 2 µg/L are associated with heavy rainfall events, occur in the spring of each year (usually in March and/or April), or occur during low flow periods in the wetland channels during the summer months. Sources of ongoing selenium contamination in Grassland wetland channels include (1) continued contamination of the water supply in the Delta Mendota Canal; (2) unregulated and unmonitored discharges of agricultural subsurface drainwater from nearby farmland into local ditches and canals that feed into the Grassland wetland supply channels; (3) and large storm events that can overwhelm the GBP channel, requiring that uncontrollable storm runoff be diverted into wetland supply channels (Beckon *et al*. 2007, Paveglio and Kilbride 2007, Crader *et al.* 2002).

Very little information is available on the effects of selenium on snakes, and no studies to date have looked specifically at the effects of selenium in giant garter snakes. The relative sensitivity of giant garter snakes to selenium is not certain. However, studies conducted after the listing of the giant garter snake on the effects of selenium on two other species of snakes, the brown house snake (*Lamprophis fulginosus*, a terrestrial species) and the banded water snake (*Nerodia fasciata*, an aquatic species) have found that they accumulate selenium from ingesting seleniferous prey, ultimately resulting in maternal transfer of potentially toxic quantities of selenium to their offspring (Hopkins *et al.* 2004) and in higher rates of metabolic activity than snakes from uncontaminated sites (Hopkins *et al.* 1999). Additional research has found that squamate reptiles (such as giant garter snakes) generally do not secrete an albumin layer, as do birds, crocodilians, and turtles (Unrine *et al*. 2006). These findings suggest that in fish, amphibians, and squamate reptiles, selenium may be transported through serum to the egg from the liver as vitellogenin, whereas in birds, crocodilians, and turtles, additional oviductal contributions of selenium occur postovulation (Unrine *et al.* 2006, Janz *et al.* 2010). Therefore, a dietary selenium toxicity threshold, rather than an egg concentration threshold, is believed to be the most applicable for assessing selenium effects to giant garter snakes. Hamilton (2003) and Lemly (1996a) in extensive reviews of the scientific literature on selenium toxicity thresholds for freshwater fish recommended a toxicity threshold of 3 µg/g (dwt) in diet to be protective of growth and reproduction.

Mercury: Wylie *et al.* (2009*a*) were able to conduct toxicological analysis of 23 giant garter snakes from various sites in the Sacramento Valley. Analysis included measurements of total mercury and trace elements in the livers of the snakes, and mercury levels only in the brain and tail clips. This study revealed that the mercury levels in the livers of the giant garter snakes used in the study were lower than in livers of various species of snakes used in comparable studies in other geographic areas. It was also discovered that mean mercury levels in all analyzed tissues did not differ by sex; however, mercury levels did increase with increasing body size regardless of sex. Mercury contamination found in the giant garter snakes in this study is still considered to be at a harmful level and is considered a threat (Wylie *et al.* 2009*a*). The effects of mercury exposure to the giant garter snake include decreased predator avoidance capability, reduced foraging success, difficulty in shedding skin, and a reduced capability to thermoregulate (Wylie *et al.* 2009*a*). The same study found that the levels of arsenic and chromium were at higher levels in the liver of the giant garter snakes used in the study than for other snakes used in other studies. The effects of trace elements, like arsenic and chromium, on snakes and other reptiles is not well studied.

Mercury levels in fish from the lower San Joaquin River and Mud Slough have been found to be elevated (Davis *et al.* 2000, Slotton *et al.* 2000). It is unknown the extent or severity of mercury contamination in the Grasslands Ecological Area. The Central Valley Regional Water Quality Control Board reported the highest concentrations of methyly mercury in the San Joaquin Basin occur in Mud Slough. Methyl mercury loads in Mud Slough (North) are sufficiently high that they may account for 40-60 percent of the San Joaquin River at Vernalis load during irrigation season (Foe 2003) but only 10 percent of the water volume during the non-irrigation season (September to March) (Stephenson *et. al.,* 2005).

Toxic levels of environmental contaminants such as sodium sulfate, mercury, pesticides and herbicides, may also reduce the populations of aquatic prey upon which the giant garter snake depends. In a study on southern toads (*Bufo terrestris*), aquatic systems contaminated by selenium and other components of coal ash were found to act as sinks for some amphibian populations, attracting breeding adults whose offspring failed to survive beyond the larval stage (Rowe *et al*., 2001).

Selenium and Mercury Interactions: Various selenium and mercury interactions (additive, synergistic, and antagonistic) are known to occur in many organisms including humans. (Heinz and Hoffman 1998, Jensen *et al*. 2006, Raymond and Ralston 2004). Heinz and Hoffman (1998) found that selenium counteracted the lethal toxicity of mercury in adult female mallards; however, the same study found that mercury added to selenium–enriched diets increased the amount of selenium stored in the mallard’s eggs. In Swedish lakes, as summarized by Skorupa (1998), selenium added to the water reduced mercury levels in fish: however, the selenium levels in fish increased to levels that were toxic to some species of fish like perch. Southworth et al. (2000) observed mercury levels in fish increase after a selenium source to a waterbody was removed. The potential for such complex interactions to occur in giant garter snakes and its habitat in the Grassland Ecological Area is of concern and warrants study.

Other Contaminants: In 2000, the USFWS and the National Marine Fisheries Service (NMFS) issued a final biological opinion to the Environmental Protection Agency on the California Toxics Rule (CTR) (USFWS and NMFS *in litt.* 2000). The USFWS and the NMFS conducted their effects analysis based on the potential for the numeric criteria proposed in the CTR to result in effects to the aquatic ecosystem and the species that are dependent on its function for their survival and recovery. While 126 priority pollutants were addressed within the CTR, the USFWS and the NMFS focused upon the numeric criteria for selenium, mercury, pentachlorophenol, and formula based metals criteria as the most problematic for listed species and critical habitat in California. The USFWS and the NMFS prepared this analysis of criteria for priority pollutants based on: (1) the adequacy of the proposed aquatic life and human health numeric criteria, including the necessity of wildlife criteria where aquatic life or human health criteria are not sufficiently protective; (2) the toxic effects to listed species or surrogates which may occur at proposed criteria concentrations; (3) the bioaccumulative nature of the priority pollutants at issue; and (4) the potential for interactive effects of pollutants at the proposed criteria concentrations.

Salinity: The Final Rule to list the giant garter snake (USFWS 1993) noted that elevated salinities of waters in the Grasslands due to a sodium sulfate based salt also have been documented at deleterious levels in resident fishes and amphibians (Ohlendorf *et al*. 1986, 1988; Saiki *et al*. 1992*a*, 1992*b*), the major food source of giant garter snakes. Many species of fish and amphibians cannot survive in saline waters (Ruibal 1959, 1962; Pough et al. 2001; Dodds 2002).   Cumulatively, threats to this formerly large regional population operate in combination with the other factors described herein, in contributing to the imperilment of the species.

Computer modeling of the excess groundwater pumping from data taken in 2006 suggest that groundwater levels in basins in San Joaquin County have already started to decline and that salinity is increasing from west to eastward in the Delta, filling the discharged aquifers (Mintierharnish Planning Consultants 2009). If no action is taken, such as increasing surface water flows to recharge groundwater, it is predicted that water levels will fall to as much as 160 feet below sea level and the saline water front will move eastward as much as 2 miles by the year 2020 (Mintierharnish Planning Consultants 2009). It has also been estimated that an additional 220,000 acre-feet of supplemental surface water would be needed to restore groundwater levels in this area to levels recorded before excessive pumping began (Mintierharnish Planning Consultants 2009). The effects of increased salinity of the aquatic habitat on the giant garter snake are currently unknown and warrant further study.

Recreation Associated Impacts and Human Encounters

Giant garter snakes are likely to avoid areas that are routinely disturbed and will actively move out of areas that are subject to repeated disturbance (Hansen and Brode 1993). As snakes move out of areas that are subject to repeated disturbance, they are subject to increased risks of injury and mortality from predation and vehicles (Wylie *et al*. 1997, E. Hansen pers. comm. 2006). Recreationists, such as anglers, can disturb basking snakes, thereby interfering with thermoregulation (E. Hansen pers. comm. 2006). Anglers may also interfere with predation and hunting behaviors of the giant garter snake as they intrude on areas where the snake's prey is located. Collection of crayfish for human consumption from roadside canals and rice fields disturbs giant garter snakes and may also alter their behaviors, making them more vulnerable to associated threats, for example, injurious or lethal strikes from automobiles. As urban development increasingly encroaches on remaining giant garter snake habitats, increasing disturbance to the snake and its behavior patterns is expected to occur.

Another threat that has been observed in the Sacramento Valley is the direct mortality of snakes as a result of encounters between humans and snakes during work performed in giant garter snake habitat. Farm workers, in particular, have increased chances of encounters with wildlife species because they share their agricultural work sites with a variety of wildlife which are seeking habitat. Farm workers not trained in the identification of the giant garter snake may intentionally kill giant garter snakes in the field with hand tools while working on irrigation canals or other alternative snake habitats (J. Roberts *in litt*. 2007).

Grazing

Although no studies have been conducted that specifically examine the potential effects of grazing on the giant garter snake, grazing is a concern for the giant garter snake, particularly in preserves that are managed for this species (E. Hansen pers. comm. 2006). Inappropriate and heavy grazing can result in the removal of upland refugia and the trampling of aquatic and terrestrial vegetative cover that provide cover and thermal mosaic environment for the snake (E. Hansen pers. comm. 2006), and giant garter snakes have been observed to avoid areas that are grazed (E. Hansen 2003*a*). Additional research is needed to better understand the effects of grazing on giant garter snakes. It was recently reported that controlled grazing by sheep or goats has less impact on the habitat of the giant garter snake than does grazing by cattle, and if managed correctly, small animal grazing can serve as a valuable tool in restoring and maintaining habitat (ICF International 2011).

Natural gas exploration

Natural gas exploration on National Wildlife Refuges in both the Sacramento and San Joaquin Valleys in 2002 and on privately-owned lands in the Butte Basin in Glenn, Colusa, and Butte counties in 2003 (USFWS *in litt*. 2002) has likely impacted giant garter snakes. Seismic exploration for natural gas may include the following activities: (1) surveying; (2) drilling; (3) lying of detectors and lines; (4) recording; and (5) equipment removal. Survey work during which the extensive array of detectors and lines are laid out is accomplished primarily on foot. However, four-wheel drive trucks, all-terrain vehicles (ATVs) and a helicopter may be used for accessing the project area. Explosive charges buried in holes are often used as the energy source for recording seismic data at predetermined source points. The giant garter snake can be disturbed by workers walking through their habitat as they conduct surveys, deploy and retrieve source and receiver lines, and remove equipment. Snakes could also be disturbed or killed by helicopters deploying drilling equipment in potential snake habitat. Snakes could also be crushed in their burrows by drilling equipment or caused to flee by the wind disturbance from the helicopters (USFWS *in litt*. 2002).

III. RECOVERY CRITERIA

No final recovery plan has been issued for the giant garter snake. The Draft Recovery Plan for the Giant Garter Snake was published in 1999 (USFWS 1999). This Draft Recovery Plan was then revised based on solicited public comments, updates in research and surveys, and further review by species experts. The revised Draft Recovery Plan was submitted to Region 8 for review as a Final Recovery Plan in September 2011.

IV. SYNTHESIS

The abundance and distribution of giant garter snakes has not changed significantly since the previous status review. Although some snakes continue to be located by trapping in several San Joaquin Valley locations (Volta WA, San Luis NWRC), these populations remain in danger of extirpation because their numbers remain very low and the habitat in this portion of the giant garter snake's range is generally of low quality.

By far the most serious threats to giant garter snake continue to be the loss and fragmentation of habitat from both urban and agricultural development as well as the potential loss of habitat associated with changes in rice production. Activities such as water management and water transfers that are associated with habitat loss are also of particular concern because they exacerbate the losses from development and from loss of rice production. The remaining threats (such as from introduced predators, roads, erosion control) are secondary to such habitat loss although habitat fragmentation could become a critical issue in the snake's survival should large scale habitat changes occur. Populations range-wide are largely isolated from one another and from remaining suitable habitat. Without preserved habitat managed for the giant garter snake with corridors linking suitable habitat blocks, prolonged periods of drought, flooding, or diminished habitat quality will result in declines in populations.

Because the giant garter snake continues to be threatened by the loss and fragmentation of habitat, by water management activities, agricultural practices, flood control and maintenance actions, and road mortality; and potentially threatened by climate change and water quality, we believe that it continues to meet the definition of a threatened species and recommend that its status be unchanged.

V. RESULTS

Recommended Listing Action:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (indicate reason for delisting according to 50 CFR 424.11):
  ____ *Extinction*
  ____ *Recovery*
  ____ *Original data for classification in error*
__X_ No Change

New Recovery Priority Number and Brief Rationale: No change.

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

The following recommendations for future actions were presented in the previous 5-year review and were the result of discussions on the status of the species and the species' needs with several recognized giant garter snake experts. All the actions listed below address the threats described in the Five-Factor Analysis and will provide important benefits for the recovery of the giant garter snake. These actions are updated based on information gained since the previous five year review.

1. In order to help address the most significant threats to the giant garter snake, habitat loss and fragmentation, described in the section on Factor A threats, identify and prioritize for protection those areas known to have occurrences of giant garter snakes. Habitat suitability modeling can be used to locate appropriate habitat for survey and potential preservation. Habitat to be protected should include corridors between existing populations, and between population centers and suitable habitat preserved for the giant garter snake. These protected areas and corridors of suitable giant garter snake habitat should be managed for the ecological needs of the giant garter snake. Since the previous 5-year review several conservation banks were opened for the giant garter snake; however, significant blocks of habitat connected by corridors throughout the historic range of the giant garter snake are not yet preserved and managed for the giant garter snake. This action remains appropriate.

2. Conduct a focused approach to recovery actions in the San Joaquin Valley, with an integrated effort that includes land use, water management, and water quality issues on private and public lands. Conduct extensive surveys to determine presence/absence, habitat use, and activity of snakes at the southern end of the known range. Conduct additional genetic analysis on southern populations to determine their relatedness to populations in northern and central portions of the species range. These areas likely have very little habitat and may need more active management to maintain any populations there. Increase Partners for Fish and Wildlife efforts on private lands in the southern portion of the species range. Restore and protect suitable habitat for giant garter snakes in San Joaquin Valley (South Valley Recovery Unit in the Draft Recovery Plan). Secure

water and suitable water management for San Joaquin Valley giant garter snakes. These actions help address the threats of habitat loss, fragmentation, and degradation that result in the San Joaquin Valley populations continuing to be in danger of extirpation as noted in the original rule to list the species and in the section on Factor A threats in this review. Several surveys were completed which have verified the tenuous hold of giant garter snake occurrences in the San Joaquin Valley. Tissue samples from San Joaquin Valley giant garter snakes were used in a recent genetic study that described the San Joaquin Valley populations as having several unique haplotypes which indicate that snakes in this area are genetically distinct to some extent than those to the north. Investigate captive propagation and reintroduction of giant garter snakes from these southern recovery units. These actions remain appropriate.

3. Examine the water quality and toxicology of the giant garter snake's habitat. Conduct a study on whether agricultural pesticides and herbicides and trace elements associated with agricultural runoff (surface and subsurface) pose problems for the giant garter snake. Several studies have been completed since the 2006 status review, which are discussed in the threats section on water quality. This action remains appropriate as the threat of water quality either as a direct threat or as an indirect threat to the prey base of the giant garter snake, remains a potential threat based on the findings of recent studies.

4. Investigate the long-term response of the giant garter snake to large scale loss of habitat, in particular from fallowing of rice fields. This action remains appropriate.

5. As roads and bridges are constructed or repaired within the range of the giant garter snake, larger and more frequent box culverts should be installed to facilitate giant garter snake movement. For example, when possible, efforts should be made to improve connectivity across Interstate Highway 5 and State Highway 99 in the Natomas Basin. Potential connectivity issues in the Natomas Basin were discussed in the Biological Opinion for the Natomas Basin Habitat Conservation Plan (Service File No. 1-1-03-F-0225). The use of larger culverts or free-standing bridges (best) that contain some of the minimum habitat characteristics of the snake (i.e., emergent vegetation up to the culvert entrances, burrows, prey) should provide improved passage opportunities for the snake. This action remains appropriate.

6. Publish the final recovery plan for the giant garter snake.

7. Develop regional conservation strategies to benefit the giant garter snake.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Giant Garter Snake (*Thamnophis gigas*)

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

____ **Downlist to Threatened**

____ **Uplist to Endangered**

____ **Delist**

_X_ **No change needed**

Review Conducted By: David Kelly, Sacramento Fish and Wildlife Office

FIELD OFFICE APPROVAL:
fs Lead Field Supervisor, Sacramento Fish and Wildlife Office

Approve ________________ Date 20 June 2012

Cooperating Field Supervisor, Bay Delta Fish and Wildlife Office

Approve Mike Chotkowski Date 20 June 2012

REGIONAL OFFICE APPROVAL:

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

Approve ________________ Date ________