Giant Gartersnake
(*Thamnophis gigas*)

5-Year Review:
Summary and Evaluation

Photo Credit: U.S. Geological Survey, public domain

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

June 2020

5-YEAR REVIEW
Giant gartersnake (*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 gartersnake (*Thamnophis gigas*) is one of the largest gartersnakes, reaching a total length of at least 162 centimeters (63.7 inches) (Service 1993). They feed on small fishes, tadpoles, and frogs. The giant gartersnake 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. The following three habitat components have been identified as the most important to the giant gartersnake (Service 2017):

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

The range of the giant gartersnake largely remains the same as that described in the previous 5-year review, from the city of Chico in Butte County southward to the Mendota Wildlife Area in Fresno County.

Methodology Used to Complete This Review:

This review was prepared by the Sacramento Fish and Wildlife Office (SFWO), following the Legacy Region 8 guidance issued in March 2008. We used information from the 2017 Recovery Plan for the Giant Garter Snake (*Thamnophis gigas*) (Recovery Plan), the previous 2006 and 2012 5-year status reviews, peer-reviewed journal articles, survey information from experts who have been studying various localities of the species, open-file reports from the U.S. Geological Survey, documents generated as part of section 7 and section 10 consultations, monitoring reports from preserved properties and conservation banks, and the California Natural Diversity Database (CNDDB) maintained by the California Department of Fish and Wildlife (CDFW). The Recovery Plan, peer-reviewed journal articles, and survey information were our primary sources of information used to update the species' status and threats. 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:

Lead Regional Office: Angela Picco, Deputy Chief of Ecological Services and Regional Recovery Coordinator, California-Great Basin Region 10; (916) 414-6490.

Lead Field Office: Josh Hull, Recovery and Listing Division Chief, Sacramento Fish and Wildlife Office; (916) 414-6742.

Cooperating Field Office: Steven Detwiler, Recovery and Listing Division Chief, Bay Delta Fish and Wildlife Office; (916) 930-2640.

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 July 26, 2019 (84 FR 16116). No comments were received.

Listing History:

<u>Original Listing</u>
FR Notice: 58 FR 54053
Date of Final Listing Rule: October 20, 1993
Entity Listed: *Thamnophis gigas*, a wildlife species
Classification: Threatened

<u>State Listing</u>
The giant gartersnake (*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 associated rulemakings, such as 4(d) rules or proposal or designation of critical habitat, have been published.

Review History:

Previous 5-year reviews were completed in September 2006 and June 2012.

Species' Recovery Priority Number at Start of 5-Year Review:

The recovery priority number for the giant gartersnake 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:** Recovery Plan for the Giant Garter Snake (*Thamnophis gigas*)
> **Date Issued:** September 28, 2017

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 distinct population segments of the giant gartersnake.

Information on the Species and its Status

For information on the giant gartersnake (*Thamnophis gigas*) and its status described previously, see the final listing rule (Service 1993), previous 5-year reviews (Service 2006; 2012), the Halstead et al. (2015a) literature review, and the final recovery plan (Service 2017). This section focuses on new information available since the species was last reviewed (Service 2012).

<u>Species Biology and Life History</u>

The giant gartersnake is one of the largest gartersnakes, reaching a total length of at least 162 centimeters (63.7 inches) (Service 1993). They feed on small fishes, tadpoles, and frogs. Ersan (2015) observed that giant gartersnakes both prefer and select native Sierran treefrogs (*Pseudacris sierra*), although they will also readily consume non-native bullfrogs (*Lithobates catesbeianus*) and, to a lesser extent, non-native fish (sunfish and mosquitofish).

In the Sacramento Valley, individual growth rate has been found to be positively related to the abundance of frogs at individual sites, as well as the amount of precipitation in the prior water year (Rose et al. 2018a). Female giant gartersnakes grow faster than males, and growth rate varies more among years than among sites (Rose et al. 2018b), but the smaller males approach their maximum size at a faster rate (Rose et al. 2018a). Survival increases with snout-to-vent length (SVL) (Rose et al. 2018c), and the survival of adult female giant gartersnakes appears to be the most important demographic factor influencing population growth rate (Rose et al. 2019a).

Female giant gartersnakes reach sexual maturity at 3 years (Rose et al. 2018a). Both fecundity (Rose et al. 2018d) and the probability of a female giant gartersnake being gravid (Rose et al. 2018b) are positively related to SVL. Larger females are more likely to be gravid, and if gravid, produce more fetuses (Scherer et al. 2019). In one study in the Sacramento Valley, the average litter size was found to be 15.9, and the proportion of gravid females was 0.50 in 2014, 0.47 in 2015, and 0.62 in 2016 (Rose et al. 2018d). The authors believe these differences may be explained by a decrease in reproduction due to the 2012-2015 California drought. Another study throughout the Central Valley found the average litter size to be 14, with the largest females averaging 34 fetuses, and the probability of a female of average SVL (728 mm) being gravid was 0.237, increasing to 0.964 for the largest female (1,144 mm) (Scherer et al. 2019). This study did not find a difference in fecundity or the probability of being gravid between giant gartersnakes inhabiting seminatural versus agricultural wetlands.

In a study focused on giant gartersnake responses to availability of aquatic habitat in the Sacramento Valley, Reyes et al. (2017) found that adult snakes demonstrated core area and home range fidelity among years. In addition, adult female giant gartersnakes exhibited less frequent and shorter movements with decreased availability of ricelands. This indicates that giant gartersnakes may be unlikely to disperse into new habitats when availability of aquatic habitat decreases.

Spatial Distribution and Abundance

The range of the giant gartersnake largely remains the same as that described in the previous 5-year review, from the city of Chico in Butte County southward to the Mendota Wildlife Area (WA) in Fresno County. One notable exception is the Liberty Farms population in the Yolo Basin, which was previously presumed extirpated (Service 2012; Table II-1). Giant gartersnakes were trapped during surveys conducted at Liberty Farms in 2018 (B.J. Halstead, USGS, in litt. 2018; see ***Yolo Basin Recovery Unit*** below).

Known information about populations of the giant gartersnake in each Recovery Unit identified in the 2017 *Recovery Plan for the Giant Garter Snake* (*Thamnophis gigas*) (Service 2017; Figure 1; Table II-1) is discussed below. Each Recovery Unit is subdivided into Management Units that serve to organize the Recovery Unit into separate and approximately equal areas that will assist in managing the implementation of the recovery actions.

The current distribution of the giant gartersnake in the Sacramento Valley appears to be closely tied to the historic extent of tule marsh (Halstead et al. 2014, 2015b). A possible relationship with soil order has also been modeled, with estimated occupancy over five times greater on alfisols, mollisols, and vertisols, which are associated with hydric conditions due to frequent flooding, than on entisols and inceptisols, which drain rapidly and are associated with elevation and coarse deposition by floodwaters (Hansen et al. 2017).

Table II-1. Comparison of giant gartersnake populations identified in status reviews.

<table>
<tr><th>1993 Listing</th><th>2006 Review</th><th>2012 Review</th><th>2017 Recovery Plan</th></tr>
<tr><td>Butte Basin</td><td>Butte Basin</td><td>Butte Basin</td><td>Butte Basin</td></tr>
<tr><td>Colusa Basin</td><td>Colusa Basin</td><td>Colusa Basin</td><td>Colusa Basin</td></tr>
<tr><td>Sutter Basin</td><td>Sutter Basin</td><td>Sutter Basin</td><td>Sutter Basin</td></tr>
<tr><td>American Basin</td><td>American Basin</td><td>American Basin</td><td>American Basin</td></tr>
<tr><td>Yolo Basin – Willow Slough</td><td>Yolo Basin – Willow Slough</td><td>Yolo Basin</td><td rowspan="2">Yolo Basin</td></tr>
<tr><td>Yolo Basin – Liberty Farms</td><td>Yolo Basin – Liberty Farms</td><td>presumed extirpated</td></tr>
<tr><td>Badger Creek – Willow Creek</td><td rowspan="4">Delta Basin</td><td>Cosumnes-Mokelumne Watershed</td><td>Cosumnes-Mokelumne Watershed</td></tr>
<tr><td>Sacramento Basin</td><td rowspan="3">Delta Basin</td><td rowspan="3">Delta Basin</td></tr>
<tr><td>Caldoni Marsh (White Slough WA)</td></tr>
<tr><td>East Stockton – Diverting Canal</td></tr>
<tr><td>North and South Grasslands</td><td rowspan="3">San Joaquin Valley</td><td>San Joaquin Basin</td><td>San Joaquin Basin</td></tr>
<tr><td>Mendota</td><td>Tulare Basin</td><td rowspan="2">Tulare Basin (extirpated south of Mendota)</td></tr>
<tr><td>Burrell-Lanare</td><td>presumed extirpated</td></tr>
</table>

Butte Basin Recovery Unit

Llano Seco Management Unit

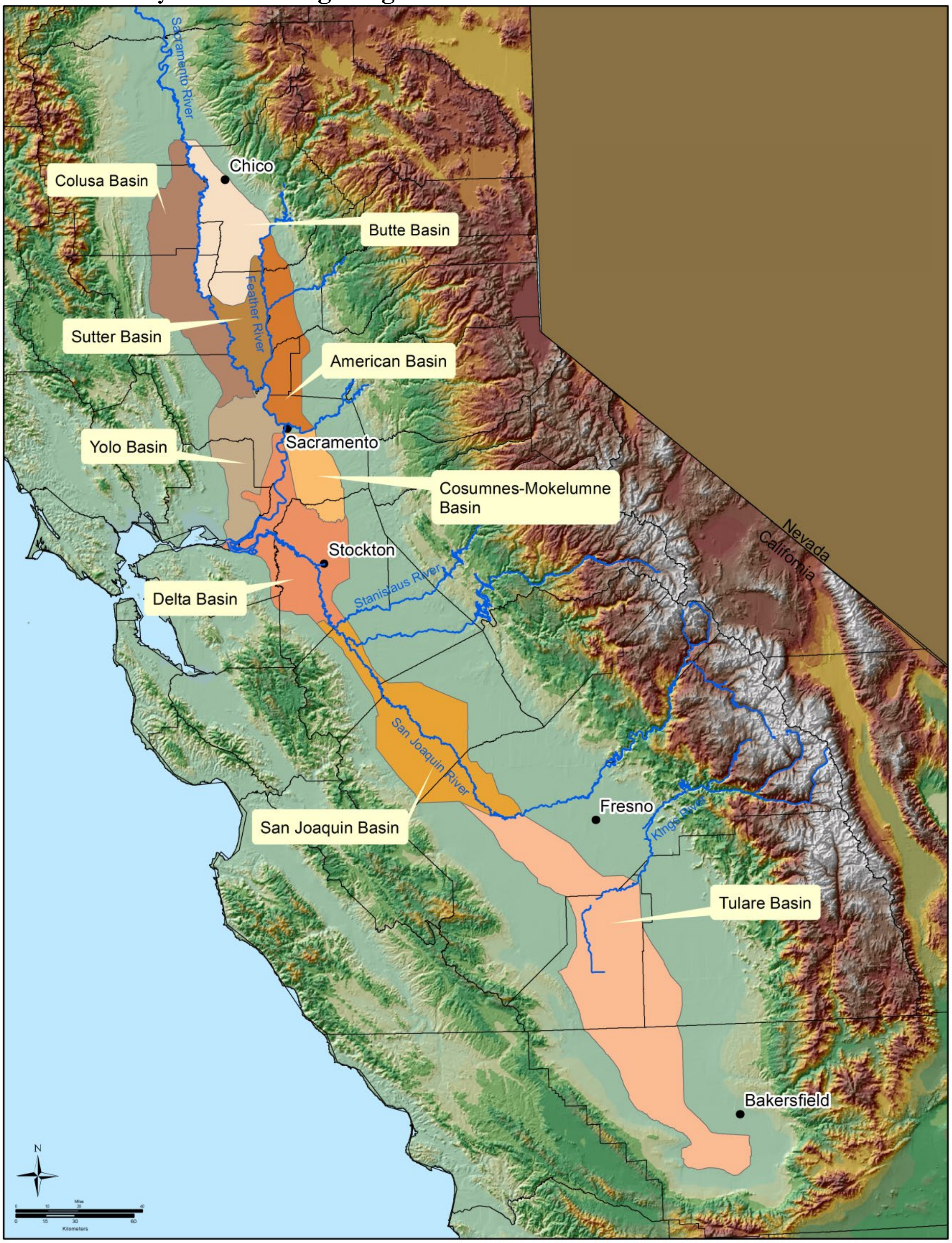
Three traplines were established in private ricelands within the Llano Seco Management Unit in 2019, resulting in the capture of 11 individual giant gartersnakes along one of the traplines (Halstead, in litt. 2019). There are an additional six occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); however four are prior to 1999, and the most recent is from 2011.

Upper Butte Basin Management Unit

Private ricelands were trapped at one site in the Upper Butte Basin Management Unit in 2013, where three female giant gartersnakes were captured (G.D. Wylie, USGS, in litt. 2013; CDFW 2019a). An additional site on private ricelands was trapped from 2015-2017, with increased effort in 2016 and 2017 (Rose et al. 2018b). Abundance was estimated to be 86 in 2016 and 66 in 2017. Although the sampling effort was lower in 2017, there was some statistical support for a decline in population growth rate at this site. Apparent survival from 2016-2017 was estimated to be 0.14. Few large female giant gartersnakes were captured, but this may be due to delayed sampling because of low water in the site's canals in 2017.

A total of 14 traplines were established in private ricelands within this management unit in 2019, resulting in the capture of 231 individual giant gartersnakes along 12 of the traplines (Halstead, in litt. 2019). There are an additional 23 occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); although 14 are prior to 1999. One of the occurrences was reported since the 2012 5-year review, where two adults were observed "hunting mosquitofish and bullfrog tadpoles from riprap at culvert outlet in agricultural ditch" on August 30, 2013.

Figure 1. Recovery units for the giant gartersnake.



Gray Lodge/Butte Sink Management Unit

Between spring 2013 and summer 2015, Phase 1 of the Gray Lodge Wildlife Area Water Supply Project was constructed along 4.2 miles of canals serving the Gray Lodge WA. During construction, 228 giant gartersnakes were encountered by biological monitors, of which 180 were relocated (including 4 recaptured later), 36 were killed, 4 were injured, and 8 were euthanized due to extensive injuries (SBI 2015a; J. Mitchell, Swaim Biological Inc., in litt. 2015). Age and sex data were taken on 186 of the snakes, which included 81 males, 66 females, and 36 of unknown sex; and 138 adults, 38 juveniles, 2 young of the year, and 9 of unknown age. Many of the snakes were discovered during removal of partially-buried concrete rip-rap and rock from canal and levee banks and vegetation removal from toe drains adjacent to the canal levees. Phase 2 of the project began on August 22, 2019. Through January 2020, 25 giant gartersnakes have been observed within the Phase 2 project area. Of these, 14 were allowed to leave the work area on their own, and 11 were captured and relocated outside the work area, including one that received treatment for injuries at the Sacramento Zoo. The captured snakes included 4 males and 7 females, and 8 adults and 3 juveniles (Mitchell, in litt. 2019).

Private ricelands were trapped at two sites in the Gray Lodge/Butte Sink Management Unit in 2013, where eight male and five female giant gartersnakes were captured (Wylie, in litt. 2013; CDFW 2019a). An additional site on private ricelands was trapped from 2015-2017, with increased effort in 2016 and 2017 (Rose et al. 2018b). Abundance was estimated to be 106 in 2016 and 90 in 2017, although there was no statistical support for an actual decline in abundance. Apparent survival from 2016-2017 was estimated to be 0.51.

Three traplines were established in private ricelands within this management unit in 2019, resulting in the capture of 103 individual giant gartersnakes along two of the traplines (Halstead, in litt. 2019). There are an additional 13 occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); although six are prior to 1999. Three of these occurrences were reported since the 2012 5-year review. Two giant gartersnakes were found dead due to vehicular collisions in 2013 and 2014, and one was located at a construction site on June 26, 2014 and relocated to a canal away from the site.

Colusa Basin Recovery Unit

Willows Management Unit

Three traplines were established in private ricelands within this management unit in 2019, resulting in the capture of seven individual giant gartersnakes along one of the traplines (Halstead, in litt. 2019). There are eight additional occurrences presumed extant in the CNDDB within the Willows Management Unit (CDFW 2019a); however one is prior to 1999. Five of the occurrences are from a 2005 trapping effort on the Sacramento National Wildlife Refuge (NWR), and the most recent is from 2011.

Delevan Management Unit

Private ricelands were trapped at multiple sites in the Delevan Management Unit from 2013-2015 (Wylie, in litt. 2013, 2015; CDFW 2019a). Three males and two females were captured in 2013, 24 males and 31 females were captured in 2014, and nine snakes were captured in 2015. Five traplines were established in private ricelands within this management unit in 2019, resulting in the capture of 69 individual giant gartersnakes among all five traplines (Halstead, in litt. 2019). There are 21 additional occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); although nine are prior to 1999, and none are more recent than 2011.

Colusa Management Unit

The Colusa NWR maintains two tracts of wetlands managed for the giant gartersnake, totaling 378 acres. Trapping surveys have been conducted by the U.S. Geological Survey (USGS) on these tracts, and results are summarized in Table II-2.

Table II-2. Results of giant gartersnake trapping on the Colusa National Wildlife Refuge.

Year	Number of Snakes	Number of Recaptures	Sightings
2012	84	14	4
2013	80	96	4
2014	95	48	2
2015	126	243	12
2016	51	9	5
2017	32	11	3

Data from Wylie, in litt. 2012, 2013, 2014, 2015, 2016, 2017

The Colusa Basin Mitigation Bank (Colusa Bank) was established in 2015 on former riceland south of Colusa NWR (Westervelt 2019a). The Colusa Bank provides 121.12 acres of open water, perennial marsh, semi-permanent marsh, and upland habitat for the giant gartersnake, with an additional 33.5 acres on the same property as a permittee-responsible mitigation site established in 2013. Trapping surveys conducted on the permittee-responsible mitigation site resulted in the capture of one male and two female giant gartersnakes in both 2015 (E.C. Hansen, in litt. 2016) and 2018 (Hansen 2018a). Trapping surveys conducted on the Colusa Bank resulted in the capture of one male and two female giant gartersnakes in 2016 and five males, two gravid females, and 1 juvenile male in 2018 (Hansen 2018b).

The Ridge Cut Giant Garter Snake Conservation Bank (Ridge Cut Bank) was established in 2009 on former agricultural land growing rice and row crops, approximately 4 miles southeast of the town of Dunnigan in Yolo County. The Ridge Cut Bank provides 185.9 acres of open water, marsh, and upland habitat for the giant gartersnake. Trapping surveys conducted on the Ridge Cut Bank detected one snake in 2017 (Wildlands 2018a) and none in 2018 (Wildlands 2018b).

Private ricelands were trapped at four sites in this management unit from 2014-2017, with increased effort in 2016 and 2017 (Rose et al. 2018b). Abundance and apparent survival were estimated, and results are summarized in Table II-3. Although the sampling effort was lower in 2017 than in 2016, there was some statistical support for declines in population growth rate at sites C2 and C3. At site C3, a notable lack of small female giant gartersnakes was found, possibly indicating low recruitment at this site.

A total of 25 traplines were established in private ricelands within this management unit in 2019, resulting in the capture of 133 individual giant gartersnakes along 22 of the traplines (Halstead, in litt. 2019). There are 28 additional occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); although nine are prior to 1999, and none are more recent than 2012.

Table II-3. Results of giant gartersnake trapping at four sites on private ricelands in the Colusa Management Unit.

	Estimated Abundance		Apparent Survival
Site	2016	2017	2016-2017
C1	100	101	0.40
C2	123	99	0.32
C3	43	28	0.35
C4	171	188	0.42

Data from Rose et al. 2018b

Sutter Basin Recovery Unit

Sutter Management Unit

Private ricelands were trapped at multiple sites in the Sutter Management Unit from 2013-2015 (Wylie, in litt. 2013, 2014, 2015; CDFW 2019a). One male and one female were captured at one site in 2013, and at a second site, 29 snakes were captured in 2014 and one snake was captured in 2015. Two traplines were established in private ricelands within this management unit in 2019, but no giant gartersnakes were captured (Halstead, in litt. 2019). There are eight additional occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); although three are prior to 1999, and none are more recent than 2012.

Gilsizer Slough Management Unit

The Gilsizer Slough South Conservation Bank (Gilsizer Bank) was established in two phases, Phase I in 2006 and Phase II in 2009, along the eastern side of the Sutter Bypass (Wildlands 2018c). The Gilsizer Bank provides 379.4 acres of open water, perennial marsh, and upland habitat for the giant gartersnake. The 162-acre Gilsizer Slough Giant Garter Snake Preserve (Gilsizer Preserve) is directly north of the Gilsizer Bank, providing 145 acres of giant gartersnake habitat (Wildlands 2018d). Trapping surveys have been conducted by USGS on and around the Gilsizer Bank and Gilsizer Preserve, and results are summarized in Table II-4. East of the Gilsizer Preserve is the 79.4- acre Gilsizer Slough North Giant Gartersnake Preserve (Gilsizer North). Visual encounter surveys did not detect any giant gartersnakes on Gilsizer North in 2017 (Wildlands 2018e).

Table II-4. Results of giant gartersnake trapping on preserves along Gilsizer Slough.

Year	Number of Snakes	Number of Recaptures	Sightings
2012	85	64	10
2013	67	37	1
2014	15	4	0
2015	29	28	3
2016	30	6	3
2017	36	20	2

Data from Wylie, in litt. 2012, 2013, 2014, 2015, 2016, 2017

The Sutter Basin Conservation Bank (Sutter Bank) was established in 2008 along the eastern side of the Sutter Bypass and has been under long-term management since 2014 (Westervelt 2019b). Restored habitats at the Sutter Bank include 407.55 acres of open water, perennial marsh, seasonal marsh, and upland habitat for the giant gartersnake. Trapping surveys have been conducted since establishment, both within the Sutter Bank and in irrigation canals along the perimeter, and results are summarized in Table II-5. The 25 individual giant gartersnakes captured in 2018 included nine adult males, 11 adult females (5 gravid), one juvenile male, three juvenile females, and one unknown (Hansen 2018c). Trapping effort was decreased in the perimeter canals in 2018, contributing to the decrease in number of giant gartersnakes detected. In addition, habitat availability on the Sutter Bank was somewhat limited in 2018 due to curtailed water allocations and site management.

There are five additional occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); although none of these are more recent than 2011.

Table II-5. Number of individual giant gartersnakes and total captures at the Sutter Basin Conservation Bank.

		Number of Captures[1]	
Year	Number of Snakes	Created Habitat	Perimeter Drains
2010	19	6	14
2012	31	13	19
2014	52	34	26
2018	25	11	14

[1]Including recaptures; therefore, the total number of captures may exceed the number of individual snakes in each year.

Data from Hansen 2018c

Robbins Management Unit

Private ricelands were trapped at two sites in this management unit from 2014-2017, with increased effort in 2016 and 2017 (Rose et al. 2018b). Abundance and apparent survival were estimated, and results are summarized in Table II-6. There was some statistical support for the apparent increase in abundance at site R2; however, a notable lack of small female giant gartersnakes was found, possibly indicating low recruitment at this site.

Table II-6. Results of giant gartersnake trapping at two sites on private ricelands in the Robbins Management Unit.

	Estimated Abundance		Apparent Survival
Site	2016	2017	2016-2017
R1	109	106	0.39
R2	29	39	0.63

Data from Rose et al. 2018b

Ten traplines were established in private ricelands within this management unit in 2019, resulting in the capture of 36 individual giant gartersnakes along seven of the traplines (Halstead, in litt. 2019). There are an additional 21 occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); although three are prior to 1999. One of these occurrences was reported since the 2012 5-year review, where a dead snake was observed, but cause of death was not reported.

American Basin Recovery Unit

District 10 and Olivehurst Management Units

There are no verified observations of the giant gartersnake in these two management units. A single occurrence appears in the CNDDB (#346), but the associated information is not adequate to confirm identification. Two locations were sampled in District 10 in 2012, but no snakes were captured (Halstead et al. 2015b). This area was historically California prairie habitat, not considered habitat for the giant gartersnake, separated from historic tule marsh by riparian forest. Although much of the area is now planted in rice, these historic habitat conditions, coupled with the limited dispersal and recolonization ability exhibited by the giant gartersnake, may explain the apparent lack of snakes in this area. However, no systematic sampling has been undertaken in these two management units.

Nicolaus Management Unit

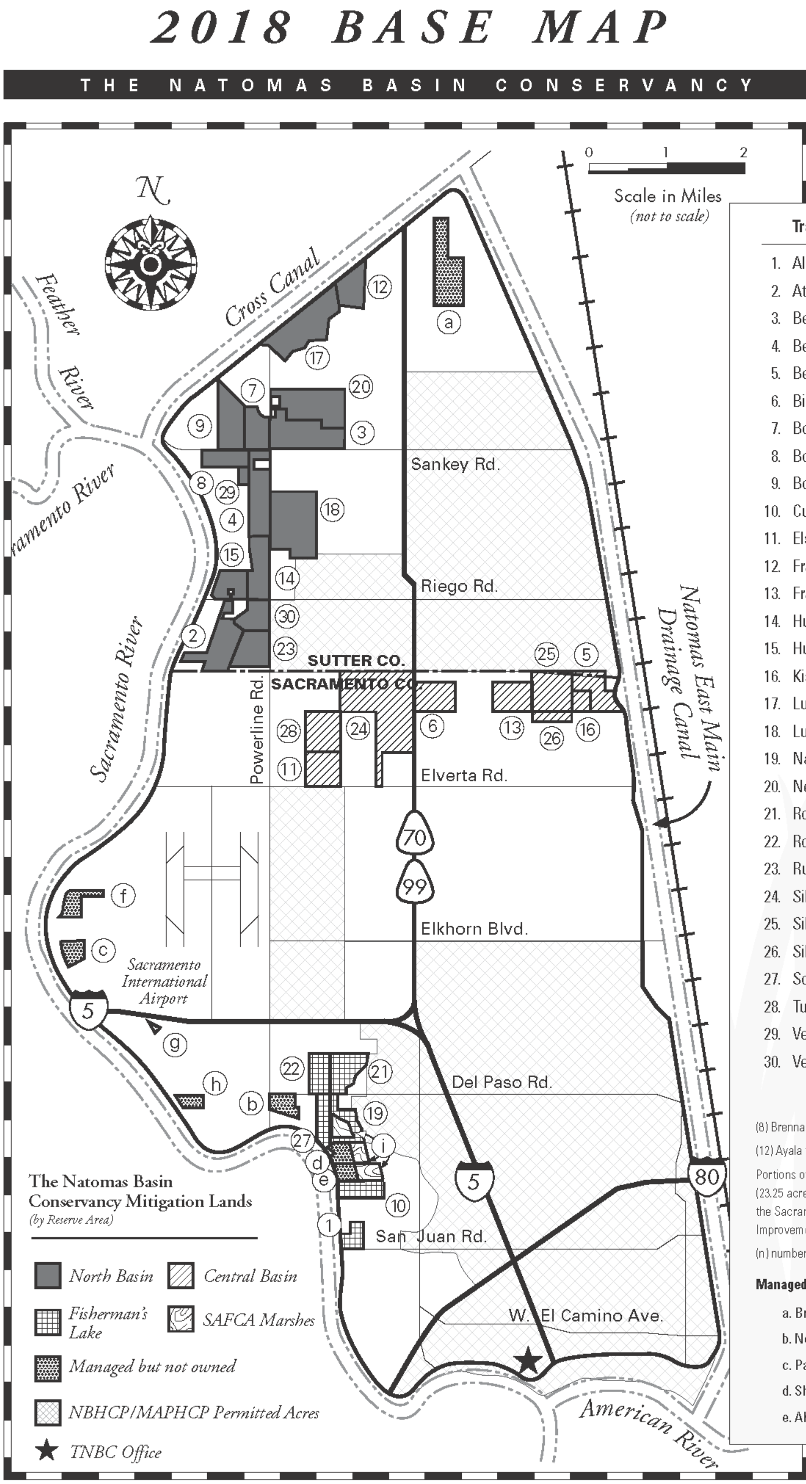
Trapping in ricelands in this management unit was undertaken from 2001 to 2012, resulting in 755 captures of 639 individuals (Hansen et al. 2015). Female giant gartersnakes were found to have a higher survival probability than males, but no correlation with SVL was indicated. There are an additional three occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); although two are prior to 1999 and the remaining occurrence is from 2008.

Natomas Basin Management Unit

The annual biological effectiveness monitoring report for the Natomas Basin Habitat Conservation Plan (NBHCP) provides an assessment of snake populations and habitat connectivity within the Natomas Basin (ICF 2019). Prior to 2011, studies focused on the distribution of snakes in the Basin. In 2011, the study was redesigned in order to increase sample sizes and account for detection probability in a more statistically rigorous manner. Beginning in 2018, the study design was further revised due to advances in analytical methods and knowledge of the ecology of the snake. However, due to this revision, estimates of abundance and demographic parameters are not directly comparable to previous years and will not be reported until after the 2020 trapping season.

In 2018, 265 individual snakes were captured 374 times, representing the highest number of unique snakes captured for any year from 2011 to 2018. Catch per unit effort was higher than any previous year of the study. Overall, snakes were expected to occur in nearly three-quarters of reserve lands, with occupancy highest in the Central Basin (Figure 2). Connectivity between the Fisherman's Lake and Central Basin Reserves remains poor, and it is unlikely that the reserves are currently demographically connected. Additional findings in the 2018 report concluded that the probability of extirpation of snakes at any particular site in the Natomas Basin has been low and stable from 2011-2018. In addition, probability of site colonization exhibited no trend during the same period. A small decrease in the number of occupied sites was observed from 2011-2018, but this may be due to the addition of transects on additional preserves owned by the Sacramento Area Flood Control Agency. In 2019, 284 individual snakes were captured 405 times at 36 of 60 sites sampled over the course of approximately 63,350 trap days (Halstead, in litt. 2019).

Figure 2. Natomas Basin Conservancy Reserve Lands



Tract	Acq. Date	Acres
1. Alleghany (14)	11.07.02	50.26
2. Atkinson (16)	06.12.03	199.21
3. Bennett North (4)	05.17.99	226.68
4. Bennett South (5)	05.17.99	132.49
5. Betts (2)	04.05.99	138.99
6. Bianchi West (28)	11.07.06	110.16
7. Bolen North (23)	04.29.05	113.62
8. Bolen South (24)	04.29.05	102.38
9. Bolen West (26)	09.01.06	155.03
10. Cummings (15)	11.07.02	66.83
11. Elsie (29)	11.07.06	158.03
12. Frazer North (9)	07.31.00	92.60
13. Frazer South (30)	11.07.06	110.37
14. Huffman East (19)	09.30.03	135.75
15. Huffman West (18)	09.30.03	157.76
16. Kismat (3)	04.16.99	40.46
17. Lucich North (6)	05.18.99	267.99
18. Lucich South (7)	05.18.99	351.89
19. Natomas Farms (11)	07.09.01	55.28
20. Nestor (27)	09.01.06	233.16
21. Rosa East (21)	03.23.05	106.28
22. Rosa Central (22)	03.23.05	100.02
23. Ruby Ranch (17)	06.23.03	91.08
24. Sills (13)	07.15.02	436.41
25. Silva (1)	01.07.99	159.20
26. Silva South 1 (31)	09.28.12	29.12
27. Souza (10)	07.02.01	40.00
28. Tufts (20)	09.29.04	147.95
29. Verona (25)	09.20.18	16.00
30. Vestal (25)	09.12.05	94.95
		4,119.93

(8) Brennan tract, acquired 6.15.00, exchanged 9.1.06. (242.38 acres)

(12) Ayala tract, acquired 2.20.02, exchanged 11.3.06. (317.37 acres)

Portions of the Atkinson tract (6.76 acres), the Huffman West tract (23.25 acres), and the Natomas Farms tract (41.27 acres) were sold to the Sacramento Area Flood Control Agency for the Natomas Levee Improvement Program (NLIP).

(n) number in parentheses represents chronological order of acquisition

Managed but not owned (SAFCA)

a. Brookfield 180.00 acres
b. Novak 52.753 acres
c. Pappa Rosa 35.77 acres
d. Sharma 20.81 acres
e. AKT 16.01 acres
f. South Sutter 75.08 acres
g. Willey 4.69 acres
h. Hewitt 23.830 acres
i. SAFCA marshes 132.26 acres

Revision Date: 12.31.2018

Figure from NBC 2019

Trapping and visual encounter surveys conducted in the southwestern portion of the Natomas Basin in 2019 did not detect any giant gartersnakes within the West Drainage Canal or agricultural ditches in the area; however, three positive environmental DNA (eDNA) detections were made in and adjacent to the West Drainage Canal (Hansen 2019a). The efficacy of eDNA surveying for the giant gartersnake and other aquatic snakes is still under evaluation (see Halstead et al. 2017, Rose et al. 2019b, Schumer et al. 2019).

The 42.7-acre Prichard Lake Preserve was established in the Natomas Basin in 2008, but is not associated with the NBHCP. Trapping surveys and monitoring have detected giant gartersnakes on the property since 2009 (CNLM 2018), with a single snake observed during construction monitoring in 2018 (Hansen 2018d). Similarly, the 217-acre Willey Wetlands Preserve was established in 2009. Trapping surveys conducted during 2018 resulted in the capture of 15 giant gartersnakes, including five males and ten females, two of which were found to be gravid (Hansen 2018e). Snakes had not been detected during surveys since 2011.

Trapping conducted within the Natomas Basin from 2004 to 2012 resulted in 1,272 captures of 1,129 individuals, which were used to estimate survival probability (Hansen et al. 2015). Survival probability was found to be positively correlated with SVL, with weaker support for females having higher survival probability than males.

Yolo Basin Recovery Unit

Ridgecut Slough Management Unit

There are three occurrences presumed extant in the CNDDB within the Ridgecut Slough Management Unit (CDFW 2019a); however one is prior to 1999, and the most recent is from 2011.

Willow Slough Management Unit

There are 26 occurrences presumed extant in the CNDDB within the Willow Slough Management Unit (CDFW 2019a), with the eight most recent from 2012. The majority of the occurrences are on private lands, with the exception of two on the Davis Wetlands in 2007 and 2012.

Yolo Bypass Management Unit

The Pope Ranch Conservation Bank was established in 2002, providing 251 acres of perennial and seasonal marsh, 49 acres of open water, and 88 acres of upland habitat for the giant gartersnake. Individual snakes were trapped at Pope Ranch prior to 2008; however, the size of the population did not appear to be large (Service 2012).

Trapping conducted within this management unit in 2018 and 2019 resulted in the capture of giant gartersnakes at three locations (Halstead, in litt. 2018; 2019). On Yolo Flyway Farms, a habitat restoration project at the southern end of the Yolo Bypass, a young female was captured in 2018, but no snakes were captured on two traplines in 2019. South of Liberty Farms, four adult male and two adult female giant gartersnakes were captured in 2018, and one adult male and one adult female were captured in 2019. One adult female giant gartersnake was captured along Sycamore Slough in 2019.

There are an additional seven occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); although one is from 1987. Two of these occurrences was reported since the 2012 5-year review, including one sighting on the Yolo Bypass WA in 2014 and one roadkill found in the Liberty Farms area in 2017.

Cosumnes-Mokelumne Basin Recovery Unit

A population of giant gartersnakes is known to occur in the Badger Creek Unit of the Cosumnes River Preserve (CRP) in southern Sacramento County (Service 2012, 2017). The population is concentrated in an area of natural marsh at the confluence of Badger and Willow Creeks known as "Snake Marsh," managed by CDFW. Previous work conducted at Snake Marsh found a high density of giant gartersnakes (8.0 individuals/hectare), with individual snakes demonstrating better health than those at other sample locations (Wylie et al. 2010). In addition, the population possessed high genetic uniqueness (Paquin et al. 2006; Engstrom 2010; Wood et al. 2015). However, due to the 2012-2015 drought, Snake Marsh dried completely in 2014, 2015, and 2016. Trapping surveys conducted in 2017 indicate a sizable decrease in abundance of giant gartersnakes post-drought (Table II-7; Hansen and Scherer 2017a), potentially causing a loss of genetic diversity in the population. Of the 26 individual snakes captured in 2017, 16 were females and 10 were males.

Table II-7. Estimates of abundance of giant gartersnakes at Snake Marsh (Badger Creek) pre- and post-drought.

Year	Number of Snakes	Estimate of Abundance	95% Credible Interval
2009	194	651.1	409-962
2017	26	98.4	41-226

Data from Hansen and Scherer 2017a

East of State Route 99, the North Fork Badger Creek and South Fork Badger Creek converge at Horseshoe Lake on the CRP. Visual encounter and trapping surveys conducted in 2015 (SBI 2015b) and 2018 (Hansen 2018f) did not detect any giant gartersnakes within freshwater marsh habitat in the area; however, positive eDNA detections were made in 2018. The efficacy of eDNA surveying for the giant gartersnake and other aquatic snakes is still under evaluation (see Halstead et al. 2017, Rose et al. 2019b, Schumer et al. 2019). Only Horseshoe Lake maintained water throughout the snake's active season in 2018, as the upper reaches of Badger Creek dried rapidly (Hansen 2018f).

Delta Basin Recovery Unit

Little is known about the overall status of the giant gartersnake in the Sacramento-San Joaquin Delta (Delta). A large portion of the Delta has not been comprehensively surveyed, primarily due to the fact that the majority of land is privately owned (Service 2012).

Stone Lakes Management Unit

There are four giant gartersnake occurrences presumed extant in the CNDDB within this management unit (CDFW 2019a); however, two are only dated as prior to 1986, and two are most recently from 1992.

White Slough Management Unit

Trapping surveys conducted throughout the White Slough WA in 2009-2010 resulted in the capture of 27 individuals only in Coldani Marsh (Pond 9), including 14 males and 13 females (Hansen 2011). Abundance was estimated to be 22 snakes in 2010. The 144-acre Shin Kee Wetlands and Restoration Project adjacent to White Slough WA was trapped in 2019, resulting in the capture of two adult female giant gartersnakes (Zentner 2019).

In 2017, seven giant gartersnakes were observed on each of two consecutive days basking among the rip-rap along the north shore of Jersey Island (H. Burger, Stillwater Sciences, in litt. 2017). In 2018, USGS began a two-year effort to study the distribution of the giant gartersnake in the Delta. Three traplines were set on Twitchell Island in 2018, but no giant gartersnakes were captured (Halstead, in litt. 2018). In 2019, traplines were placed on Staten Island, Twitchell Island, and Sherman Island (Halstead, in litt. 2019). Only a single young male giant gartersnake was captured on Sherman Island. These, and additional sporadic, visual observations, are listed in Table II-8.

Stockton Management Unit

Sporadic, visual observations in this management unit are listed in Table II-8.

Table II-8. Recent observations of the giant gartersnake in the Sacramento-San Joaquin Delta.

Location	Year	No. of Snakes	Source
White Slough Management Unit			
Twitchell Island	2016	2	CNDDB #407 (CDFW 2019a)
Sherman Island	2016	2	CNDDB #404, 405 (CDFW 2019a)
Sherman Island	2019	1	Halstead, in litt. 2019
Jersey Island	2017	7+	Burger, in litt. 2017
Bradford Island[1]	2015	1	AECOM 2015
Webb Tract	2014	1	CNDDB #359 (CDFW 2019a)
Empire Tract	2016	1	CNDDB #403 (CDFW 2019a)
Shin Kee	2019	2	Zentner 2019
Stockton Management Unit			
Bacon Island[1]	2017	1	Hansen, in litt. 2017
Blackslough Landing	2018	2	CNDDB #425 (CDFW 2019a)

[1]Unconfirmed, but probable.

Tracy Management Unit

No occurrences of the giant gartersnake are known from the Tracy Management Unit.

San Joaquin Basin Recovery Unit

The San Joaquin Basin Recovery Unit is comprised of four management units: San Joaquin River, San Luis/Volta, Brito, and Merced. In the San Joaquin Basin, giant gartersnakes occur in the Grasslands Ecological Area (GEA), a mosaic of freshwater marsh and grassland on protected lands in Merced County (Service 2012). Visual encounter and trapping surveys were conducted in 2015 and 2016 in portions of the GEA, including Volta WA, San Luis NWR, Grasslands Mitigation Bank, and the aquatic habitat corridors of Los Banos Creek, Mud Slough, and Salt Slough (Hansen and Scherer 2017b). Snakes were only captured at Pond 10 in the Volta WA, which represents the only known breeding population in the San Joaquin Valley; however, eDNA was detected at 28 of 52 locations sampled, including the northern and southern GEA, an irrigation ditch south of San Luis NWR, and Grasslands Mitigation Bank. The efficacy of eDNA surveying for the giant gartersnake and other aquatic snakes is still under evaluation (see Halstead et al. 2017, Rose et al. 2019b, Schumer et al. 2019). During these surveys, a pilot study using scent detection dogs was also undertaken, with trained dogs detecting giant gartersnakes in four of five locations in the Volta WA and the northern and southern GEA (Powers et al. 2016), where positive detections were also made using eDNA sampling. On the Grasslands Mitigation Bank, which is adjacent to Pond 10 at Volta WA, two adult female giant gartersnakes were captured in 2018 (Hansen 2018g), and an additional adult female was captured in 2019 (Hansen 2019b).

Estimation of demographic features for the Volta WA population are imprecise due to low capture probabilities, but indicate a small population (Table II-9; Hansen and Scherer 2017b). Estimates of apparent survival probability range from 0.63 to 0.70.

Table II-9. Annual estimates of abundance of giant gartersnakes at the Volta Wildlife Area.

Year	Number of Captures	Estimate of Abundance	95% Credible Interval
2013	23	78.80	38-141
2014	19	44.04	22-113
2015	34	142.60	56-315
2016	18	104.40	34-231

Data from Hansen and Scherer 2017b

Tulare Basin Recovery Unit

Four management units have been defined for the Tulare Basin Recovery Unit: Mendota, Burrell Lanare, Kern, and Buena Vista Lake. Surveys conducted in the southern San Joaquin Valley since the 1980s have demonstrated that the giant gartersnake is probably extirpated south of the Mendota Management Unit (Service 2012).

Mendota Management Unit

Suitable habitat for the giant gartersnake was mapped in the area of Mendota Pool and Fresno Slough during surveys conducted in 2016 for the San Joaquin River Restoration Program (Hansen 2017). No demographic feature estimates are available for this population; however, due to the fact that trapping was unsuccessful during the study, the size of the population likely remains very low. Although no snakes were observed during visual encounter or trapping surveys, eDNA was detected at 10 of 23 locations sampled. The efficacy of eDNA surveying for the giant gartersnake and other aquatic snakes is still under evaluation (see Halstead et al. 2017, Rose et al. 2019b, Schumer et al. 2019). During these surveys, a pilot study using scent detection dogs was also undertaken, with trained dogs indicating a giant gartersnake detection south of Mendota (Powers et al. 2016), where positive detections were also made using eDNA sampling.

Habitat or Ecosystem

The giant gartersnake 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 (Service 1993). The following three habitat components have been identified as the most important to the giant gartersnake (Service 2017):

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

In a study in and around Gilsizer Slough, adult female gartersnakes were found to be 14.7 times more likely to be active when in aquatic habitats than when in terrestrial habitats (Halstead et al. 2016). The snakes positively selected microhabitats associated with cover, particularly emergent vegetation, terrestrial vegetation, and litter. The most strongly selected vegetation type was tules (*Schoenoplectus acutus*), perhaps due to the fact that giant gartersnakes are more able to move among the single, round stems, and downed stems provide stable, horizontal basking surfaces from which snakes can easily escape predators by dropping into the water below. Conversely, the flat leaves of cattails (*Typha* spp.) do not provide the same structure conducive to locomotion and horizontal basking. Although water-primrose can clog waterways and may exclude giant gartersnakes when forming a dense monoculture, in this study, giant gartersnakes were found to select water-primrose, likely due to active control restricting the plant to wetland and canal edges. Survival of giant gartersnakes has been found to be positively related to the cover of emergent and floating vegetation (Rose et al. 2018c).

The giant gartersnake appears to be reliant on ricelands in the Sacramento Valley (Halstead et al. 2019). Although ricelands provide suboptimal habitat for giant gartersnakes, due to incongruency of water availability with the snake's active season and the potential for mortality due to management practices, and snakes spend little time in the rice fields themselves (Reyes et al. 2017), this work found that adult survival decreases when less ricelands are available. Trapping on private ricelands from 2016-2018 found a positive relationship between site occupancy and the extent of active rice growing within a 3-kilometer buffer of the site (Rose et al. 2019c). Survival has also been found to be positively related to precipitation (Rose et al. 2018c), emphasizing the importance of water availability to the giant gartersnake.

While water is considered a steadfast requirement for the giant gartersnake, recent work has found that individual snakes spend more than half their time in terrestrial habitats during the summer (Halstead et al. 2015c). Giant gartersnakes were found underground more than half the time when in terrestrial habitats in the early afternoon, with an increased probability of being underground during extreme temperatures. The average giant gartersnake was found within 30 meters (98.4 feet) of water, with 95% of observations within 10 meters (32.8 feet). However, individual variation between snakes was high, and models predicted that some individuals could be found as far as 174 meters (570.9 feet) from water.

Changes in Taxonomic Classification or Nomenclature

The Eighth Edition of the *Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding* published by the Society for the Study of Amphibians and Reptiles identifies the standard English name of *Thamnophis gigas* as the Giant Gartersnake (Crother 2017).

Genetics

Genetic studies have been conducted on the giant gartersnake since the time of listing. Paquin et al. (2006) sampled 14 populations in six watersheds in the Central Valley and found significant genetic variation between watersheds due to low interpopulation and interregion gene flow. Engstrom (2010) found low diversity of haplotypes and restricted gene flow among seven watersheds. These studies are discussed in the previous 5-year reviews.

Wood et al. (2015) estimated contemporary giant gartersnake population structure and diversity using microsatellite loci. Five genetic clusters were identified, with three northern basins forming a single genetic cluster: Colusa Basin, Sacramento Valley (Butte, Sutter, and American Basins), Yolo Basin, Delta Basin (Badger Creek), and San Joaquin Basin (Volta WA). The results demonstrated higher connectivity between the northern drainage basins than among central and southern basins and greater differentiation between isolated populations in the central and southern basins. Evidence of population bottlenecks and low effective population size estimates were detected in about half of the populations sampled.

Species-specific Research and/or Grant-supported Activities

In addition to trapping surveys conducted throughout the range of the giant gartersnake, a number of journal articles and white paper reports have been published since issuance of the previous 5-year review. While many of these publications have been cited in this review, a full list is included in Appendix A.

The Service is aware of the following on-going studies:

- Giant Gartersnake Demography and Distribution in the Natomas Basin (USGS)
- The Effects of Water Availability on the Demography, Occupancy, and Distribution of the Giant Gartersnake in the Sacramento Valley (USGS)
- Giant Gartersnake Translocation and Head-starting in the Natomas Basin (USGS)
- Giant Gartersnake Mesocosm Feeding Trials (USGS)

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.

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

New information regarding threats identified in the 1993 listing rule and previous 5-year reviews are discussed below. The previously-identified threat of wetland management for waterfowl, while not beneficial for the giant gartersnake, does not in itself represent a threat.

Urbanization

Urbanization remains a threat to the giant gartersnake, as it contributes to the loss and fragmentation of habitat throughout the Central Valley. Urbanization is predicted to increase substantially in the Central Valley through 2051 (Radeloff et al. 2012). Development and road projects that are subject to consultation under the federal and state Endangered Species Acts (see Factor D) normally include habitat compensation, which offsets the habitat loss associated with these projects. However, although some mitigation and restoration projects involve creation of marsh habitat, there is still overall loss and fragmentation of habitat available to the giant gartersnake.

<u>Habitat Conservation Plans</u>

A number of Habitat Conservation Plans (HCPs) developed in support of federal Incidental Take Permits include the giant gartersnake as a covered species. These plans cover large, regional areas and describe measures to minimize and mitigate the effects of covered activities, such as urban development, transportation projects, and utilities. Pacific Gas and Electric implements two HCPs for their operations and maintenance activities in the San Francisco Bay Area and San Joaquin Valley. Regional plans with larger impacts and potential for conservation are described below.

Natomas Basin and Metro Air Park Habitat Conservation Plans

The Natomas Basin Habitat Conservation Plan (NBHCP) was adopted in December 1997 and revised in 2003. It incorporates the Metro Air Park Habitat Conservation Plan, which was adopted in 2001. Habitat estimates identified 24,567 acres of snake habitat within the Natomas Basin (City of Sacramento et al. 2003), which is in the Natomas Basin Management Unit of the American Basin Recovery Unit. A total of 8,512 acres of snake habitat may be permanently removed by covered activities throughout the 50-year life of the NBHCP permit. During construction, covered activities are required to implement avoidance and minimization measures for the snake.

The NBHCP will preserve a total of 8,750 acres of habitat for the NBHCP covered species. Of this 2,187.5 acres (25%) will be created marsh, managed specifically for the snake, and 4,375 acres (50%) will be riceland, managed to be compatible with the snake. By the end of the 50-year permit, one habitat block of the reserve system will be a minimum of 2,500 acres in size, and the balance of reserve lands will be in blocks a minimum of 400 acres in size. In addition, a primary goal of the

NBHCP is to ensure connectivity for the snake between individual reserves and between reserves and surrounding agricultural lands.

As of reporting through 2018, development fees have been paid on 7,180.56 acres within the permit areas of the plans, plus 318.84 acres of non-NBHCP development (NBC 2019). Although fees have been paid, not all of the acres within the City of Sacramento permit area have yet been graded. The Natomas Basin Conservancy has acquired 4,103.93 acres of reserve lands on 29 individual tracts (Figure 2), which included 2,262.2 acres of riceland and 630.1 acres of managed marsh in 2018 (ICF 2019).

Yolo Habitat Conservation Plan and Natural Community Conservation Plan

The Yolo Habitat Conservation Plan and Natural Community Conservation Plan (Yolo HCP/NCCP) began implementation on January 11, 2019. Habitat modeling identified 77,056 acres of habitat for the snake within the Plan Area (ICF 2018), which includes portions of the Colusa Basin and Yolo Basin Recovery Units. Of this, a total of 1,966 acres may be permanently removed by covered activities throughout the 50-year life of the Yolo HCP/NCCP permit, and up to 815 individual snakes associated with this habitat may be injured or killed. During construction, covered activities are required to implement avoidance and minimization measures for the snake.

The Yolo HCP/NCCP will protect 7,195 acres of previously unprotected snake habitat, including 2,800 acres of rice habitat, 420 acres of aquatic habitat, 500 acres of freshwater emergent wetland habitat, 1,160 acres of active season upland movement habitat, and 2,315 acres of overwintering habitat. Additionally, the Yolo HCP/NCCP will restore freshwater emergent wetland and aquatic habitat for the snake to result in no net loss. In addition to the newly protected and restored snake habitat, the Yolo HCP/NCCP will enroll 2,910 acres of pre-permit reserve lands supporting snakes into the reserve system, and will monitor, and adaptively manage these lands consistent with the plan's conservation strategy. The 10,290 acres of newly protected and pre-permit reserve lands supporting snake habitat will be sited in association with other public and easement lands to establish a large, interconnected network of protected habitat for the snake.

To date, no projects or reserve lands containing giant gartersnake modeled habitat have been approved under the Yolo HCP/NCCP. Annual reports are expected by the end of March of each year.

South Sacramento Habitat Conservation Plan

The South Sacramento Habitat Conservation Plan (SSHCP) began implementation on July 26, 2019. Habitat modeling identified 35,159 acres of habitat for the snake within the Plan Area (County of Sacramento et al. 2018), which includes portions of the Cosumnes-Mokelumne Basin and Delta Basin Recovery Units. Of this, a total of 2,358 acres of modeled habitat may be permanently removed by covered activities throughout the 50-year life of the SSHCP permit, including 169 acres of aquatic habitat and 2,189 acres of upland habitat. During construction, covered activities are required to implement avoidance and minimization measures for the snake.

The SSHCP will preserve a total of 5,524 acres of modeled snake habitat, including 406 acres of aquatic habitat and 5,118 acres of upland habitat. Of this, 996 acres will be what is considered highvalue habitat by the SSHCP, which is limited to the vicinity of Badger Creek and Stone Lakes NWR. In addition, 303 acres of snake habitat will be re-established or established, including 169 acres of aquatic habitat and 134 acres of upland habitat. The SSHCP includes additional objectives developed in support of the plan's biological goal to maintain or expand the distribution of the giant gartersnake in the Plan Area.

To date, no projects or preserves containing giant gartersnake modeled habitat have been approved under the SSHCP. Annual reports are expected by the end of March of each year.

East Contra Costa County Habitat Conservation Plan and Natural Community Conservation Plan

The East Contra Costa County Habitat Conservation Plan and Natural Community Conservation Plan (ECCHCP/NCCP) was adopted on December 19, 2006. Habitat modeling identified 151 miles of sloughs and 14,016 acres of upland habitat suitable for the giant gartersnake within the Plan Area (Jones & Stokes 2006), including a portion of the Delta Basin Recovery Unit. Of this, a total of 0.4 mile of aquatic habitat and 2,674 acres of upland habitat may be permanently removed by covered activities throughout the 30-year life of the ECCHCP/NCCP permit. During construction, covered activities are required to implement avoidance and minimization measures for the snake.

Under the ECCHCP/HCCP Conservation Strategy, for every 1 acre of aquatic habitat lost, 1 acre of aquatic habitat and at least 2 acres of upland habitat will be preserved. For every 1 acre of upland habitat lost, 1 acre will be preserved. Since the start of implementation, minimal impacts to giant gartersnake habitat have occurred. The Knightsen Wetland Restoration Project is currently being planned, adjacent to existing Delta sloughs, which will provide aquatic and upland habitat appropriate for the giant gartersnake (E.P. Kieli and M. Lindley, Environmental Science Associates, in litt. 2017).

San Joaquin Multi-Species Habitat Conservation and Open Space Plan

The San Joaquin Multi-Species Habitat Conservation and Open Space Plan (SJMSCP) began implementation in 2001, covering the majority of San Joaquin County. A total of 6,420 acres of aquatic, natural upland, and agricultural upland habitats for the snake may be converted in the Plan Area over the 50-year life of the Plan, to be offset through the preservation of 8,580 acres, all within the Delta Basin Recovery Unit. No occupied habitat may be removed. During construction in potential habitat, covered activities are required to implement avoidance and minimization measures for the snake.

The SJMSCP has established the Lodi White Slough Preserve adjacent to the White Slough WA, including 104.55 acres of row and field crop intended to provide upland habitat for the giant gartersnake (SJCOG 2018).

<u>Habitat Preservation</u>

In addition to preserves established under HCPs, habitat for the giant gartersnake is also permanently preserved on mitigation and conservation banks and other private preserves as a result of urban development projects subject to federal and state Endangered Species Act consultations.

These properties provide larger blocks of habitat managed specifically for the giant gartersnake. Properties permanently preserved and managed for the giant gartersnake are listed in Table II-10.

Table II-10. Locations and acreage of preserved habitat for the giant gartersnake.

Recovery Unit	Preserve Name	Preserve Type[1]	Acres
Butte Basin	*Gray Lodge/Butte Sink Management Unit*		
	Gray Lodge Wildlife Area	Refuge	77[2]
Colusa Basin	*Willows Management Unit*		
	Sacramento National Wildlife Refuge	Refuge	1,289[3]
	Delevan Management Unit		
	Delevan Wildlife Refuge	Refuge	1,060[3]
	Colusa Management Unit		
	Dolan Ranch Conservation Bank/Dolan Preserve	Bank/PRS	190.31
	Colusa National Wildlife Refuge	Refuge	824[3]
	Colusa Basin Mitigation Bank/Maxwell Mitigation Site	Bank/PRS	87.62
	Ridge Cut Conservation Bank	Bank	185.9
Sutter Basin	*Sutter Management Unit*		
	Sutter National Wildlife Refuge	Refuge	249[3]
	Tule Basin Conservation Bank	PRS	150
	Gilsizer Slough Management Unit		
	Gilsizer Slough South Conservation Bank/Gilsizer Preserve	Bank/PRS	524.4
	Gilsizer Slough North Preserve	PRS	79.4
	Sutter Basin Conservation Bank	Bank	407.55
American Basin	*Natomas Basin Management Unit*		
	Natomas HCP North Basin Reserve/Willey Wetlands	HCP/PRS	631
	Prichard Lake Preserve	PRS	42.7
	Natomas HCP Central Basin Reserve	HCP	140
	Natomas HCP Fisherman's Lake Reserve	HCP	72.3
Yolo Basin	*Yolo Bypass Management Unit*		
	Pope Ranch Mitigation Bank	Bank	387
Delta Basin	*Stone Lakes Management Unit*		
	South Stone Lake Mitigation Preserve	PRS	129
	White Slough Management Unit		
	White Slough Wildlife Area[4]/Shin Kee Preserve/ SJMSCP Lodi White Slough Preserve	Refuge/ PRS/HCP	760.55
San Joaquin Basin	*San Luis/Volta Management Unit*		
	Grasslands Mitigation Bank	Bank	186

[1]Preserve Type category key: Refuge = National Wildlife Refuge or State Wildlife Area; Bank = Mitigation or Conservation Bank; PRS = Permittee-responsible Mitigation Site; HCP = Habitat Conservation Plan preserve
[2]Acreage identified as compensation for the Gray Lodge Wildlife Area Water Supply Project.
[3]Actual acres of Summer Water, Permanent Pond, and Ditch habitat types reported by the Sacramento NWR Complex for 2018-2019. These values are dependent on water availability and timing.
[4]This property is owned by the California Department of Water Resources (DWR), but has been designated as a Wildlife Area due to past recreation management by CDFW. This management no longer occurs, and the designation is proposed for removal (C. Bonham, CDFW, in litt. 2019). DWR does not currently undertake any management of the property.

Agricultural Conversion

Agricultural conversion from ricelands in the Sacramento Valley represents a significant threat to the giant gartersnake. While conversion due to urbanization normally requires environmental analysis, long-term fallowing or permanent conversion to another crop type may occur without regulatory oversight. If giant gartersnakes are forced to abandon ricelands due to fallowing, they may be subjected to a greater risk of predation while seeking new habitat or vehicular strike when crossing roads. In addition, they may not return even if the area is later returned to rice, due to limited dispersal and home range fidelity (Reyes et al. 2017). Annual acreages planted in rice in the Sacramento Valley are shown in Table II-11.

With the exception of Sacramento County, large decreases in acreage of ricelands occurred due to the 2012-2015 California drought. Since then, acres have increased, although not to 2012 levels, resulting in an overall decrease as shown in Table II-11.

Two Safe Harbor Agreements covering the giant gartersnake have been approved by the SFWO. One, executed in 2007 and covering Yolo County, has two enrolled properties, each with natural waterways adjacent to active agricultural fields. The other, executed in 2013 and covering the Sacramento River and its tributaries, has two enrolled properties in Colusa County, both including ricelands. Under these agreements, conversion of suitable habitat for the snake, including ricelands, beyond baseline conditions are not covered. Therefore, it is expected that a minimum of the baseline of habitat on these covered properties will remain throughout the 30-year duration of the agreements.

Table II-11. Acres of ricelands in the Sacramento Valley by county 2012-2018.

County/ Year	Butte	Colusa	Glenn	Sacramento	Sutter	Yolo	Total
2012	94,451	157,000	86,000	5,899	120,000	40,461	543,211
2013	98,445	164,000	80,000	8,363	117,000	38,432	543,740
2014	77,800	115,000	63,500	8,589	98,000	39,325	439,214
2015	87,700	111,000	60,900	8,260	93,000	23,000	417,860
2016	95,045	150,000	75,000	8,840	120,000	35,800	520,785
2017	93,444	135,000	73,700	7,300	80,000	28,600	449,044
2018	92,250	140,000	80,500	8,812	108,000	33,300	462,862
% change from 2012	**-2%**	**-11%**	**-6%**	**49%**	**-10%**	**-18%**	**-8%**

Data from Butte County 2014, 2016, 2018, 2019; County of Sacramento 2013, 2015, 2017, 2018; U.S. Department of Agriculture 2019; County of Yolo 2014, 2015, 2016, 2018

Water Transfers

On June 4, 2015, the SFWO issued a revised programmatic biological opinion on the Bureau of Reclamation's Central Valley Project Long Term Water Transfers for 2015-2024 (Service File Number 08ESMF00-2015-F-0116). On June 7, 2018, the biological opinion was vacated by the U.S. District Court, Eastern California District, and a new opinion for the remainder of the period was issued on May 17, 2019 (Service File Number 08ESMF00-2019-F-0619-1). These transfers may occur from upstream of the Delta to buyers in the Sacramento River basin, the San Francisco Bay area, or south of the Delta. Water may be made available through groundwater substitution, reservoir release, cropland idling, crop shifting, or conservation. The maximum amount of ricelands that can be idled or shifted under the opinion is 60,693 acres in each of 2 years in Glenn, Colusa, Butte, Yolo, Solano, and Sutter Counties. Areas identified as priority giant gartersnake populations are not permitted to participate in cropland idling or shifting, and major irrigation and drainage canals on sellers' properties must still maintain adequate water.

If giant gartersnakes are forced to abandon ricelands due to crop idling or shifting, they may be subjected to a greater risk of predation while seeking new habitat or vehicular strike when crossing roads. In addition, they may not return even if the area is later returned to rice, due to limited dispersal and home range fidelity (Reyes et al. 2017). A total of 40,490 acres of ricelands were idled in 2015 under the original opinion (Reclamation 2016). No water transfers occurred in 2016, 2017, or 2018.

Flood Control and Canal Maintenance

As identified in the previous 5-year reviews, ongoing maintenance of levees and canals may result in direct mortality to giant gartersnakes. Levees provide sheltering and brumation habitat for the giant gartersnake in rodent burrows or areas of appropriately-sized rip-rap. However, the snakes are difficult to detect when underground and may be crushed or smothered during levee work. Large-scale levee setback and repair projects are ongoing along the Sacramento and Feather Rivers, the Yolo Bypass, and Delta islands. The extent of effects on the giant gartersnake from these projects are unknown, as no mortalities have been reported.

Canal maintenance activities include vegetation clearing, rodent control, and excavation. These activities can injure and kill giant gartersnakes, as well as removing sheltering habitat. Due to the fact that giant gartersnakes spend more time in the terrestrial environment than previously thought (Halstead et al. 2015c), more snakes may be directly impacted by these activities, despite best management practices (BMPs) that have been developed. Any mortalities due to canal maintenance activities are unlikely to be detected; therefore, the magnitude of this threat on the giant gartersnake is unknown.

Introduction and Eradication of Non-Native Plants

As discussed in previous 5-year reviews, the introduction of non-native plants, such as water hyacinth (*Eichornia* sp.) and water-primrose (*Ludwigia* sp.), has conflicting effects on the giant gartersnake. These plants can choke up waterbodies, decreasing the open water edges that giant gartersnakes prefer to hunt along, and snakes may be injured or killed during activities to control the plants. However, the plants may also provide shelter for thermoregulation and avoiding predators. A study in Gilsizer Slough found that giant gartersnakes positively selected water-primrose, but the plant was actively controlled at this site through herbicide use and mechanical removal and not allowed to form a dense monoculture (Halstead et al. 2016).

Summary of Factor A

In summary, loss of habitat continues to be a threat to the giant gartersnake. While some habitat loss is offset through regulatory permitting processes, urbanization continues to contribute to fragmentation and an overall loss of remaining habitat. Due to the giant gartersnake's dependence on ricelands (Halstead et al. 2019), the continued loss of this habitat due to agricultural conversion represents a significant threat in the Sacramento Valley. Water transfers have the potential to place additional pressure on the giant gartersnake through the temporary loss of additional riceland habitat. While the degree of threat from flood control, canal maintenance, and uncontrolled non-native plants is lower than that of urbanization and agricultural conversion, these activities add to the overall threat of habitat loss to the giant gartersnake.

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

Overutilization was not identified as a threat to the giant gartersnake in the 1993 listing rule. As discussed in the 2012 5-year review, qualified individuals may obtain permits to conduct scientific research activities on the giant gartersnake under section 10(a)(1)(A) of the Act. Injury or death of giant gartersnakes may occur during these activities; however, these consequences are reported to the SFWO and are low in number. Therefore, overutilization for any purpose does not appear to be a threat at this time.

FACTOR C: Disease or Predation

New information regarding threats identified in the 1993 listing rule and previous 5-year reviews are discussed below.

Disease

At the time of listing, little information on diseases affecting the giant gartersnake was available (Service 1993). A recent study explored the bacterial flora of giant gartersnakes captured at four separate locations and found a wide variety of potentially pathogenic bacteria that may impact the health of snakes (Wack et al. 2017). Eight giant gartersnakes sampled had cutaneous abscesses, and one of these was severely emaciated.

In late 2019, the emerging Snake Fungal Disease (SFD) was confirmed in a California kingsnake (*Lampropeltis californiae*) in Plymouth, Amador County (CDFW 2019b). The fungus that causes SFD was also detected on a southern watersnake (*Nerodia fasciata*) found deceased in Folsom, Sacramento County. Cases of the disease range from mild to life-threatening, and affected snakes are often emaciated. It is unknown how SFD may affect the giant gartersnake, but CDFW plans increased surveillance and implementation of precautions to minimize risk of human-caused spread.

Parasites

The potential threat of parasites to the giant gartersnake was discussed in the 1993 listing rule and previous 5-year reviews. The presence of parasites was not found to affect survivability of giant gartersnakes during a study conducted in the American Basin from 2001-2012 (Hansen et al. 2015). However, the overall degree of threat from parasites remains unknown.

Predation

In the 1993 listing rule, predation by both native and non-native predators was considered a threat to the giant gartersnake (Service 1993). These predators both prey upon giant gartersnakes and compete for prey. This predation continues today, but is not believed to pose a significant threat (Service 2017). In some cases, this relationship may be more complicated. For example, adult bullfrogs prey upon juvenile giant gartersnakes, but giant gartersnakes also consume bullfrog tadpoles, metamorphs, and adults (Ersan 2015). They may also consume small black bullhead catfish (*Ameiurus melas*), which are armed with spines in their fins that have been observed to protrude through the skin of giant gartersnakes and may cause injury, blockages, or potentially death (USGS, unpublished observation, as cited in Ersan 2015).

Introduced Snake Species

The introduction of non-native watersnakes was identified as a potential threat to the giant gartersnake in the 2006 5-year review. The southern watersnake (*Nerodia fasciata*) has been established in Folsom, California (Stitt et al. 2005), and the common watersnake (*Nerodia sipedon*) was found to be well established in Roseville, California, approximately 13 kilometers from known populations of the giant gartersnake (Rose et al. 2013). A common watersnake was photographed along Steelhead Creek on the eastern border of the Natomas Basin in 2016 (P. Balfour, ECORP Consulting, in litt. 2016). These species of watersnakes are highly aquatic and feed on fish and amphibians, which could lead to competitive exclusion of giant gartersnakes if the watersnakes become established in their range. In addition, the watersnakes may serve as vectors for disease, such as SFD. As mentioned above, the fungus that causes SFD was detected on a southern watersnake found deceased in Folsom in late 2019.

Rose and Todd (2014) used several approaches to species distribution modeling to project the invasion risk of these non-native watersnakes and predicted that both *N. fasciata* and *N. sipedon* have the potential to overlap the range of the giant gartersnake, based on climatic models and connectivity, if allowed to expand. Eradication efforts are currently underway by the CDFW Invasive Species Program, with funding secured through 2021 (M. Volkoff and T. Jensen, CDFW, pers. comm. 2019). Therefore, this potential threat should continue to be monitored, but does not appear to be impacting giant gartersnake populations at this time.

Summary of Factor C

Much is still unknown regarding the effects of disease and predation on the giant gartersnake. While parasites and predation do not appear to be significant on their own, they contribute additional pressures on the species. Although it is currently unknown how SFD may affect the giant gartersnake, the emerging threat of this disease is of great concern.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

At the time of listing, regulatory mechanisms thought to have some potential to protect the giant gartersnake included: (1) listing under the California Endangered Species Act (CESA); (2) the California Environmental Quality Act (CEQA) and the National Environmental Quality Act (NEPA); and (3) permitting under section 404 of the Clean Water Act (CWA). As discussed in the final rule, each of these laws provides some protection to the snake, but has provisions or exemptions that could allow activities that would adversely affect the snake. In addition, the 2012 5-year review recognized (4) the Porter-Cologne Act of 1969; and (5) the Lacey Act. These analyses appear to remain currently valid.

California Endangered Species Act: The CESA (California Fish and Game Code, section 2080 *et seq*.) prohibits the unauthorized take of state-listed threatened or endangered species. The CESA requires state agencies to consult with CDFW on activities that may affect a state-listed species and mitigate for any adverse impacts to the species or its habitat. Pursuant to CESA, it is unlawful to import or export, take, possess, purchase, or sell any species or part or product of any species listed as endangered or threatened. The state may authorize permits for scientific, educational, or management purposes, and to allow take that is incidental to otherwise lawful activities. The giant gartersnake has been listed as threatened under CESA since 1980.

California Environmental Quality Act: The CEQA 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 section 21002). Protection of listed species through CEQA is, therefore, dependent upon the discretion of the lead agency involved.

National Environmental Policy Act: NEPA (42 USC 4371 *et seq*.) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by federal agencies. Prior to implementation of such projects with a federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40 CFR 1502.16). These mitigations usually provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

Clean Water Act: Under section 404, 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 USC 1344). In general, the term "wetland" refers to areas meeting the Corps' criteria of hydric soils, hydrology (either sufficient annual flooding or water on the soil surface), and hydrophytic vegetation (plants specifically adapted for growing in wetlands). Any action with the potential to impact waters of the United States must be reviewed under the CWA, NEPA, and Endangered Species Act. These reviews require consideration of impacts to listed species and their habitats, and recommendations for mitigation of significant impacts.

The Porter-Cologne Act of 1969: The Porter-Cologne Act 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. California water bodies are now being assessed for their levels of pollutants.

The Lacey Act**:** The Lacey Act (PL 97-79), as amended in 16 USC 3371, makes unlawful the import, export, or transport of any wild animals whether alive or dead taken in violation of any United States or Indian tribal law, treaty, or regulation, as well as the trade of any of these items acquired through violations of foreign law. The Lacey Act 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.

Summary of Factor D

In summary, the Endangered Species Act is the primary Federal law that provides protection for the giant gartersnake since its listing as threatened in 1993. Other federal and state regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act. Therefore, we continue to believe other laws and regulations have limited ability to protect the species in absence of the Endangered Species Act. A discussion of how the Endangered Species Act limits the amount of habitat loss can be found above, under Factor A.

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

No new information has become available since the previous 5-year review on the following threats: mosquito abatement, water quality, recreation associated impacts and human encounters, grazing, and natural gas exploration.

Floods

Although the giant gartersnake is an aquatic species, it relies on upland refugia for shelter during the active season and brumation during the inactive season. Giant gartersnakes may be displaced during flood events, buried by debris, exposed to predators, or drowned in their burrows. Flooding during the winter of 2016-2017 inundated portions of Colusa County and some Delta islands and required opening of the Sacramento Weir for the first time since 2006. In addition, floodwaters can destroy suitable habitat for the giant gartersnake or damage water delivery systems. Late rains in the 2018-2019 winter led to damage of a permittee-responsible mitigation site for the giant gartersnake in the Colusa Management Unit. Restoration of the site is ongoing, with temporal loss of habitat on a portion of the site in the meantime.

Drought

Drought affects the availability of water delivery to permanent wetlands, managed marsh, and ricelands that the giant gartersnake relies on. During the 2012-2015 California drought, effects on the giant gartersnake were observed, including a sizable decrease in abundance of the population at Badger Creek (Hansen and Scherer 2017a) and a decrease in the proportion of gravid females trapped throughout the Sacramento Valley (Rose et al. 2018d). Also in the Sacramento Valley, fewer acres were planted in rice during the drought (see Table 11 above). Due to the fact that the giant gartersnake relies on the availability and delivery of water to its habitats, drought is a great threat to the continued persistence of the species.

Climate Change

Current climate predictions for California indicate that temperatures will increase and sea levels will rise (very high confidence), and that frequency of drought and intensity of heavy precipitation events will increase (medium-high confidence) (Bedsworth et al. 2018). These effects may exacerbate known threats to the giant gartersnake, including habitat loss, floods, drought, and the spread of invasive species and diseases.

Roads

As discussed in the previous 5-year reviews, roads present a threat to giant gartersnakes both from direct mortality due to vehicle collision and fragmentation of habitat. Five of the 58 occurrences in the CNDDB reported since the 2012 5-year review are mortalities due to vehicular collision (CDFW 2019a). An assessment of road risk to reptiles and amphibians in California determined that the giant gartersnake was at very high risk of negative road impacts, primarily due to concerns with aquatic habitat connectivity (Brehme et al. 2018).

Netting/Erosion Control Products

As discussed in the previous 5-year reviews, netting and erosion control products can entangle and injure giant gartersnakes. However, the majority of construction projects that take place in the range of the giant gartersnake include BMPs which prevent the use of these materials. For example, the California Department of Transportation Construction Site BMP Manual states that plastic netting should not be used if there is a potential for endangering wildlife (Caltrans 2017). No reports of mortality due to netting or erosion control products has been reported to the SFWO since the 2012 5-year review.

Summary of Factor E

In summary, both the lack and abundance of water pose threats to the water-reliant giant gartersnake, with effects on the snake and its habitat documented during the recent 2012-2015 drought and 2016-2019 flood cycle. Exacerbated by predicted changes in climate, this altered water cycle will continue to affect the giant gartersnake throughout its range. As giant gartersnakes move about the landscape seeking or fleeing water, they will be more exposed to road mortality. The additional threats identified under Factor E exert additional pressures on a species already coping with an altered water regime.

III. RECOVERY CRITERIA

The Recovery Plan for the Giant Garter Snake (*Thamnophis gigas*) was issued on September 28, 2017. Recovery plans provide guidance to the Service, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough, to downlist or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the most recent 5-year review by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

Progress toward the recovery criteria identified in the Recovery Plan is presented in Table III-1.

IV. SYNTHESIS

The range of the giant gartersnake largely remains the same as that described in the 1993 listing rule and previous 5-year reviews. In the San Joaquin Valley, the remaining known populations (Volta WA and Mendota) still appear to be in danger of extirpation due to low numbers and limited availability of habitat. The sizable decrease in the Badger Creek population due to effects of the drought represents an unanticipated loss to a population previously recognized for its genetic uniqueness and individual health. However, additional survey effort has located giant gartersnakes in areas with little known information (the Delta) or where presumed extirpated (Liberty Farms in Yolo Basin).

Habitat loss continues throughout the range of the snake, primarily due to urbanization and agricultural conversion. While some habitat preservation normally occurs to offset losses due to urbanization, agricultural conversion is unmitigated permanent loss of habitat occurring throughout the Central Valley. Water availability and delivery is a complex issue in the Central Valley, exacerbated by the recent cycle of drought and flood, which was observed to have negative effects on the giant gartersnake. These events are expected to increase in frequency and intensity due to climate change. The additional threats identified (such as disease, predation, and roads), while not necessarily significant at a population level on their own, place increased pressure on individuals. Therefore, due to the persistence of threats on populations of the giant gartersnake throughout its range and the potential loss of additional populations, the species continues to meet the definition of a threatened species, and no change in its status is recommended at this time.

Table III-1. Progress toward recovery criteria for the giant gartersnake, prepared for 2019 5-year review.

Recovery Criterion	Criterion Met?
Factor A	
A1 <u>Butte Basin Recovery Unit</u>:	
• Minimum of six habitat block pairs with no less than two block pairs per management unit in the Butte Basin Recovery Unit.	No
• Additional protection along the following watercourses in the Butte Basin will provide for connectivity between existing populations of giant garter snakes and will protect habitat immediately on either side of the main watercourse at a minimum of 0.25 miles from each bank:	
a. Little Chico Creek – 1,036 hectares (2,560 acres) abutting the Llano Seco Unit of the Sacramento NWR and continuing northeastward.	No
b. Butte Creek – 1,295 hectares (6,400 acres) abutting the Upper Butte Basin management unit and continuing northeastward.	No
c. Cherokee Canal – 3,108 hectares (7,680 acres) abutting Gray Lodge/Butte Sink management unit and continuing northeastward.	No
A2 <u>Colusa Basin Recovery Unit</u>:	
• Minimum of six habitat block pairs with no less than two block pairs per management unit in the Colusa Basin Recovery Unit.	Partial (see Table II-10)
• Additional protection along the watercourses in the Colusa Basin will provide for connectivity between existing populations of giant gartersnakes and will protect habitat immediately on either side of the main watercourse at a minimum of 0.25 miles from each bank – 8,417 hectares (20,800 acres). Final protected watercourse length should extend at a minimum from the Glenn Colusa Canal in the north to the proximity of Ridge Cut Slough in the south.	No
A3 <u>Sutter Basin Recovery Unit</u>:	
• Minimum of four habitat block pairs with no less than one block pair per management unit in the Sutter Basin Recovery Unit	Partial (see Table II-10)
• Additional protection should focus on the Sutter Bypass: 3,885 hectares (9,600 acres) comprising a continuous corridor along and outside of the western bank (levee) of the Sutter Bypass out to a width of 0.8 kilometers (0.5 miles) from the bank, and including the Tisdale Bypass 389 hectares (960 acres).	No
A4 <u>American Basin Recovery Unit</u>:	
• Minimum of eight habitat block pairs with no less than one block pair per management unit in the American Basin Recovery Unit.	No

Table III-1, continued. Progress toward recovery criteria for the giant gartersnake, prepared for 2019 5-year review.

Recovery Criterion	Criterion Met?
Factor A	
A5 Yolo Basin Recovery Unit: • Minimum of five habitat block pairs with no less than one block pair per management unit in the Yolo Basin Recovery Unit	No
A6 Cosumnes-Mokelumne Basin Recovery Unit: • Minimum of two pairs of habitat blocks in the Cosumnes-Mokelumne Basin Recovery Unit.	No
A7 Delta Basin Recovery Unit: • Minimum of ten habitat block pairs with no less than two block pairs per management unit in the Delta Basin Recovery Unit.	Partial (see Table II-10)
A8 San Joaquin Basin Recovery Unit: • Minimum of ten habitat block pairs with no less than two block pairs per management unit in the San Joaquin Basin Recovery Unit.	No
A9 Tulare Basin Recovery Unit: • Minimum of two habitat block pairs in the Mendota management unit in the Tulare Basin Recovery Unit.	No
All Recovery Units	
A10 Corridors of aquatic habitat with a 0.8-kilometer (0.5-mile) width hydrologically connect adjacent habitat block pairs within Recovery Units.	No
A11 Corridors hydrologically connect adjacent Recovery Units.	Partial
A12 Management plans are developed, implemented, and updated as needed for 20 years for all habitat blocks and corridors preserved for the giant garter snake listed in Criteria A1 through A9. Management plans will address as a minimum the following: water management to provide summer aquatic habitat, use of pesticides, best grazing regimes, fallowing of rice fields, eradication of invasive plants, operations and maintenance of canals and flood control structures, control of non-native predators, monitoring of native predators, location and use of roads within the conservation areas.	No
A13 Water supplied for use on all giant garter snake preserves will have annual water delivery requirements identified. Garter snake preserves are supplied with water of sufficient quantity to support the aquatic habitat component of the giant garter snake on that property in perpetuity and will be free of contaminants or will contain contaminants at levels that have been demonstrated to be harmless to giant garter snakes. Monitoring of annual water supplies and water quality standards reveals that water used to provide aquatic habitat is provided each year, and meets or exceeds quality standards over a 20-year monitoring program.	Partial

Table III-1, continued. Progress toward recovery criteria for the giant gartersnake, prepared for 2019 5-year review.

Recovery Criterion	Criterion Met?
Factor B	
Overutilization for any purpose is not known to threaten the giant gartersnake at this time. Therefore, no recovery criteria have been developed for this factor.	
Factor C	
C1 Introduced snakes (Nerodia sp.) are either eradicated or reduced in numbers throughout the historical range of the giant garter snake to the point where the transmission of disease by these non-native snakes is no longer a threat (and competitive interactions are eliminated between introduced snakes and the giant garter snake).	In progress
C2 A management plan is developed and implemented to monitor for the effects of parasites, viruses, and fungi on the giant garter snake and any discovered threats to the giant garter snake from parasites, viruses, or fungi are controlled or ameliorated to an extent they are not a threat to the populations.	No
C3 Introduced game fish (e.g., largemouth bass and catfish), crayfish (e.g., signal and Louisiana crayfish), and bullfrogs that eat giant garter snakes and compete with giant garter snakes for smaller forage fish and amphibians are either eradicated or reduced in numbers throughout the historical range of the giant garter snake to the point where garter snakes are no longer threatened by predation or competition by introduced fish, crayfish and bullfrogs.	No
Factor D	
If the threats under factors A, B, C and E are ameliorated or eliminated then additional regulatory mechanisms (beyond the existing ones) are not necessary.	
Factor E	
E1 Preserved populations are protected from predicted alterations of habitat components due to climate change through the development of contingency plans that will provide resources to ensure habitat components are maintained at all preserves during adverse climatic conditions, such as extended periods of drought, or extended periods of above average temperatures.	No
E2 The density found during trapping is at least an average 8 snakes per hectare for buffered perennial wetlands and 3 snakes per hectare for active ricelands.	No
E3 The population estimate and density are used for a trend analysis over a 20-year period that demonstrates a 90 percent probability that the population is stable or increasing.	No
E4 The habitat requirements described in delisting criteria A/1 – A/9 are available during all surveys.	Partial
E5 The sex ratio is not significantly different than 1:1.	Partial
E6 Age structure analysis reveals that recruitment is occurring at a level that will prevent a senescent population.	Partial
E7 Road mortalities of giant garter snakes are reduced to a level that does not cause declines to populations.	Partial

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

1. Establish a Recovery Implementation Team to coordinate recovery efforts as identified in the Recovery Plan.

2. Secure additional habitat and water availability in the San Joaquin Valley in order to halt the continued decline of these populations.

3. Continue to study the abundance and distribution of the giant gartersnake in the Sacramento-San Joaquin Delta, including genetic analysis to be added to the existing genetic work.

4. Continue surveillance for the emerging Snake Fungal Disease and work to prevent this disease from affecting populations of the giant gartersnake, if required.

5. Evaluate the efficacy of eDNA sampling as a survey method for the giant gartersnake.

VII. REFERENCES CITED

AECOM. 2015. Biological Assessment for Terrestrial Species Managed by the U.S. Fish and Wildlife Service – West False River Emergency Drought Barrier Project. Prepared for the California Department of Water Resources. July 2015.

Bedsworth, L., D. Cayan, G. Franco, L. Fisher, and S. Ziaja. 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission. Publication number: SUM-CCCA4-2018-013.

Brehme C.S., S.A. Hathaway, and R.N. Fisher. 2018. An objective road risk assessment method for multiple species: ranking 166 reptiles and amphibians in California. Landscape Ecology 33:911-935.

Butte County. 2014. Butte County Agricultural Crop Report 2013. Butte County Department of Agriculture / Weights & Measures. August 8, 2014.

Butte County. 2016. Butte County Crop Report 2015. Butte County Department of Agriculture / Weights & Measures. August 22, 2016.

Butte County. 2018. Butte County 2017 Crop Report. Butte County Department of Agriculture / Weights & Measures. September 11, 2018.

Butte County. 2019. Butte County 2018 Crop & Livestock Report. Butte County Department of Agriculture / Weights & Measures. September 24, 2019.

[Caltrans] California Department of Transportation. 2017. Construction Site Best Management Practices (BMP) Manual. Report No. CTSW-RT-17-314.18.1. Sacramento, California. May 2017.

[CDFW] California Department of Fish and Wildlife. 2019a. California Natural Diversity Database (CNDDB) – Government version dated September 1, 2019.

CDFW. 2019b. Snake Fungal Disease Detected in California. CDFW News. November 5, 2019. Available at: https://cdfgnews.wordpress.com/2019/11/05/snake-fungal-disease-detected-in-california/

[CNLM] Center for Natural Lands Management. 2018. Prichard Lake Preserve (CNLM #N029) – 2018 annual report (2017-10-01 to 2018-09-30). December 7, 2018.

City of Sacramento, Sutter County, Natomas Basin Conservancy, in association with Reclamation District No. 1000, and Natomas Central Mutual Water Company. 2003. Final Natomas Basin Habitat Conservation Plan. Prepared for U.S. Fish and Wildlife Service and California Department of Fish and Game. Volume 1. April 2003.

County of Sacramento. 2013. Sacramento County 2013 Crop & Livestock Report. Sacramento County Department of Agriculture, Weights & Measures.

County of Sacramento. 2015. Sacramento County 2015 Crop & Livestock Report. Sacramento County Department of Agriculture, Weights & Measures.

County of Sacramento. 2017. The 2017 Crop & Livestock Report – Sacramento County. Sacramento County Department of Agriculture, Weights & Measures.

County of Sacramento. 2018. 2018 Sacramento County Crop and Livestock Report. Sacramento County Department of Agriculture, Weights & Measures.

County of Sacramento, City of Rancho Cordova, City of Galt, Sacramento County Water Agency, and Southeast Connector Joint Powers Authority. 2018. Final South Sacramento Habitat Conservation Plan. Volume 1. January 2018.

County of Yolo. 2014. Yolo County 2013 Agricultural Crop Report. Yolo County Department of Agriculture and Weights & Measures. July 2014.

County of Yolo. 2015. Yolo County 2014 Agricultural Crop Report. Yolo County Department of Agriculture and Weights & Measures. June 2015.

County of Yolo. 2016. Yolo County 2016 Agricultural Crop Report. Yolo County Department of Agriculture and Weights & Measures. June 2016.

County of Yolo. 2018. Yolo County Agricultural Crop Report 2018. Yolo County Department of Agriculture and Weights & Measures.

Crother, B.I. (ed.). 2017. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. SSAR Herpetological Circular 43.

Engstrom, T.N. 2010. Genetic analysis of giant garter snake (*Thamnophis gigas*) populations in the San Joaquin and Sacramento Valleys. Revised final report for contracts 802706G121 and 802707G111 between the U.S. Fish and Wildlife Service and the CSU, Chico Research Foundation. Chico, California.

Ersan, J.S.M. 2015. Diet and prey preference of giant gartersnakes (*Thamnophis gigas*) in the Sacramento Valley of California. M.S. thesis, California State University, East Bay. December 2015.

Halstead, B.J., G.D. Wylie, and M.L. Casazza. 2014. Ghost of habitat past: historic habitat affects the contemporary distribution of giant garter snakes in a modified landscape. Animal Conservation 17: 144-153.

Halstead, B.J., G.D. Wylie, and M.L. Casazza. 2015a. Literature review of giant gartersnake (*Thamnophis gigas*) biology and conservation. U.S. Geological Survey Open-File Report 2015-1150. http://dx.doi.org/10.3133/ofr20151150.

Halstead, B.J., S.M. Skalos, M.L. Casazza, and G.D. Wylie. 2015b. A preliminary investigation of the variables affecting the distribution of giant gartersnakes (*Thamnophis gigas*) in the Sacramento Valley, California. U.S. Geological Survey Open-File Report 2015-1178. http://dx.doi.org/10.3133/ofr20151178.

Halstead, B.J., S.M. Skalos, G.D. Wylie, and M.L. Casazza. 2015c. Terrestrial ecology of semi-aquatic giant gartersnakes (*Thamnophis gigas*). Herpetological Conservation and Biology 10: 633-644.

Halstead, B.J., P. Valcarcel, G.D. Wylie, P.S. Coates, M.L. Casazza, and D.K. Rosenberg. 2016. Active season microhabitat and vegetation selection by giant gartersnakes associated with a restored marsh in California. Journal of Fish and Wildlife Management 7: 397-407.

Halstead, B.J., D.A. Wood, L. Bowen, S.C. Waters, A.G. Vandergast, J.S.M. Ersan, S. M. Skalos, and M.L. Casazza. 2017. An evaluation of the efficacy of using environmental DNA (eDNA) to detect giant gartersnakes (*Thamnophis gigas*). U.S. Geological Survey Open-File Report 2017-1123. https://doi.org/10.3133/ofr20171123.

Halstead, B.J., J.P. Rose, G.A Reyes, G.D. Wylie, and M.L. Casazza. 2019. Conservation reliance of a threatened snake on rice agriculture. Global Ecology and Conservation 19: e00681.

Hansen, E.C. 2011. Implementation of priority 1, priority 2, and priority 3 recovery tasks for the giant garter snake (*Thamnophis gigas*) – Status and distribution of giant garter snakes at the eastern Delta's White Slough Wildlife Area, San Joaquin County, CA. Prepared for the U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office. Sacramento, California. March 10, 2011.

Hansen, E.C. 2017. Year 2016 giant gartersnake (*Thamnophis gigas*) surveys for the San Joaquin River Restoration Program's Mendota Pool Bypass and Reach 2B Improvements Project: Fresno and Madera Counties, California. Prepared for AECOM. Sacramento, California. March 24, 2017.

Hansen, E.C. 2018a. Year 2018 giant garter snake (*Thamnophis gigas*) monitoring at Maxwell Public Utility District Treated Wastewater Re-use Project Mitigation Site: Colusa County, California. Prepared for Westervelt Ecological Services. Sacramento, California. December 13, 2018.

Hansen, E.C. 2018b. Giant garter snake (*Thamnophis gigas*) monitoring at the Colusa Basin Mitigation Bank: Colusa County, California – 2018 Monitoring Report. Prepared for Westervelt Ecological Services. Sacramento, California. December 12, 2018.

Hansen, E.C. 2018c. Giant garter snake (*Thamnophis gigas*) monitoring at the Sutter Basin Conservation Bank: Sutter County, California – 2018 Monitoring Report. Prepared for Westervelt Ecological Services. Sacramento, California. December 14, 2018.

Hansen, E.C. 2018d. Giant garter snake (*Thamnophis gigas*) biological compliance monitoring at the Willey Wetlands and Prichard Lake Preserves: Sutter and Sacramento Counties, California. Prepared for Center for Natural Lands Management (re: N031, N029). Sacramento, California. October 30, 2018.

Hansen, E.C. 2018e. Giant garter snake (*Thamnophis gigas*) monitoring at the Willey Wetlands Preserve: Sutter County, California – 2018 Monitoring Report. Prepared for Center for Natural Lands Management. Sacramento, California. November 1, 2018.

Hansen, E.C. 2018f. 2018 giant garter snake (*Thamnophis gigas*) surveys – Horseshoe Lake restoration. Prepared for Department of the Interior, Bureau of Land Management, California Region. Sacramento, California. December 20, 2018.

Hansen, E.C. 2018g. Giant garter snake (*Thamnophis gigas*) monitoring at the Grasslands Mitigation Bank: Merced County, California – 2018 Monitoring Report. Prepared for Westervelt Ecological Services. Sacramento, California. December 12, 2018.

Hansen, E.C. 2019a. Giant gartersnake (*Thamnophis gigas*) surveys at the Upper West Side Project, Sacramento, California – 2019 Monitoring Report. Prepared for: Upper Westside, LLC. Sacramento, California. October 18, 2019.

Hansen, E.C. 2019b. Giant garter snake (*Thamnophis gigas*) monitoring at the Grasslands Mitigation Bank: Merced County, California – 2019 Monitoring Report. Prepared for Westervelt Ecological Services. Sacramento, California. November 15, 2019.

Hansen, E.C. and R. Scherer. 2017a. Giant gartersnake (*Thamnophis gigas*) surveys on the Cosumnes River Ecological Reserve: Sacramento County, California – 2017 Monitoring Report. Prepared for the California Department of Fish and Wildlife. Sacramento, California. October 30, 2017.

Hansen, E.C. and R. Scherer. 2017b. Distribution of the giant gartersnake (*Thamnophis gigas*) in the Volta Area of the San Joaquin Valley. Prepared for the U.S. Fish and Wildlife Service, Pacific Southwest Regional Office. Sacramento, California. December 30, 2017.

Hansen, E.C., R.D. Scherer, G.C. White, B.G. Dickson, and E. Fleishman. 2015. Estimates of survival probability from two populations of giant gartersnakes in California's Great Central Valley. Copeia 103: 1026-1036.

Hansen, E.C., R.D. Scherer, E. Fleishman, B.G. Dickson, and D. Krolick. 2017. Relations between environmental attributes and contemporary occupancy of threatened giant gartersnakes (*Thamnophis gigas*). Journal of Herpetology 51: 274-283.

ICF. 2018. Yolo Habitat Conservation Plan/ Natural Community Conservation Plan. Final. Prepared for Yolo Habitat Conservancy. Sacramento, California. Volume 1. April 2018.

ICF. 2019. Biological effectiveness monitoring for the Natomas Basin Habitat Conservation Plan Area 2018 annual survey results (agency version). Prepared for The Natomas Basin Conservancy. Sacramento, California. April 2019.

Jones & Stokes. 2006. East Contra Costa County Habitat Conservation Plan and Natural Community Conservation Plan. Prepared for East Contra Costa County Habitat Conservation Plan Association. San Jose, California. October 2006.

[NBC] The Natomas Basin Conservancy. 2019. Implementation annual report, Calendar Year 2018. April 30, 2019.

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

Powers, R.M., K. Ayres, E. Hansen, A. Thiel, M. Hemenez, and L. Oliver. 2016. Scent-detection dog surveys for the giant garter snake (*Thamnophis gigas*). Presentation at the Giant Garter Snake Symposium, Sacramento-Shasta Chapter of The Wildlife Society. Elk Grove, California. September 21, 2016.

Radeloff, V.C., E. Nelson, A.J. Plantinga, D.J. Lewis, D. Helmers, J.J. Lawler, J.C. Withey, F. Beaudry, S. Martinuzzi, V. Butsic, E. Lonsdorf, D. White, and S. Polasky. 2012. Economic-based projections of future land use in the conterminous United States under alternative policy scenarios. Ecological Applications 22: 1036-1049.

[Reclamation] Bureau of Reclamation. 2016. 2015 annual compliance report for the Bureau of Reclamation's Central Valley Project long-term water transfers (2015-2024). Sacramento, California. January 2016.

Reyes, G.A., B.J. Halstead, J.P. Rose, J.S.M. Ersan, A.C. Jordan, A.M. Essert, K.J. Fouts, A.M. Fulton, K.B. Gustafson, R.F. Wack, G.D. Wylie, and M.L. Casazza. 2017. Behavioral response of giant gartersnakes (*Thamnophis gigas*) to the relative availability of aquatic habitat on the landscape. U.S. Geological Survey Open-File Report 2017-1114. https://doi.org/10.3133/ofr20171141.

Rose, J.P. and B.D. Todd. 2014. Projecting invasion risk of non-native watersnakes (*Nerodia fasciata* and *Nerodia sipedon*) in the western United States. PLoS ONE 9: e100277. https://doi.org/10.1371/journal.pone.0100277.

Rose, J.P., O.J. Miano, and B.D. Todd. 2013. Trapping efficiency, demography, and density of an introduced population of northern watersnakes, *Nerodia sipedon*, in California. Journal of Herpetology 47: 421-427.

Rose, J.P., B.J. Halstead, G.D. Wylie, and M.L. Casazza. 2018a. Spatial and temporal variability in growth of giant gartersnakes: plasticity, precipitation, and prey. Journal of Herpetology 52: 40-49.

Rose, J.P., J.S.M. Ersan, G.A. Reyes, B. Gustafson, A.M. Fulton, K.J. Fouts, R.F. Wack, G.D. Wylie, M.L. Casazza, and B.J. Halstead. 2018b. Findings from a preliminary investigation of the effects of aquatic habitat (water) availability on giant gartersnake (Thamnophis gigas) demography and reproduction in the Sacramento Valley, California, 2014-2017. U.S. Geological Survey Open File Report 2018-1114. https://doi.org/10.3133/ofr20181114.

Rose, J.P., G.D. Wylie, M.L. Casazza, and B.J. Halstead. 2018c. Integrating growth and capture-mark-recapture models reveals size-dependent survival in an elusive species. Ecosphere 9: e02384. doi: 10.1002/ecs2.2384.

Rose, J.P., J.S.M. Ersan, G.D. Wylie, M.L. Casazza, and B.J. Halstead. 2018d. Reproductive frequency and size-dependence of fecundity in the giant gartersnake (*Thamnophis gigas*). Herpetological Conservation and Biology 13: 80-90.

Rose, J.P., C. Wademan, S. Weir, J.S. Wood, and B.D. Todd. 2019a. Traditional trapping methods outperform eDNA sampling for introduced semi-aquatic snakes. PLoS ONE 14: e0219244. https://doi.org/10.1371/journal.pone.0219244.

Rose, J.P., J.S.M. Ersan, G.D. Wylie, M.L. Casazza, and B.J. Halstead. 2019b. Demographic factors affecting population growth in giant gartersnakes. The Journal of Wildlife Management 1-12. doi: 10.1002/jwmg.21728.

Rose, J.P., A.C. Jordan, A.M. Fulton, B.J. Halstead, J.S.M. Ersan, G.A. Reyes, K.B. Gustafson, M.L. Casazza, and G.D. Wylie. 2019c. Effects of rice idling on occupancy dynamics of giant gartersnakes (*Thamnophis gigas*) in the Sacramento Valley of California – Data summary of field observations April-October 2018. Dixon, California. Unpublished.

[SBI] Swaim Biological Inc. 2015a. Gray Lodge Wildlife Area Water Supply Project 2014 annual status report. Prepared for California Department of Fish and Wildlife. January 31, 2015.

SBI. 2015b. Results of a baseline trapping survey for the giant garter snake at the Badger Creek Restoration Site – Cosumnes River Preserve. Prepared for Cosumnes River Preserve, U.S. Bureau of Land Management. Livermore, California. June 23, 2015.

Scherer, R.D., E.C. Hansen, M. Joseph, and R.F. Wack. 2019. Estimating relationships between size and fecundity in the threatened giant garter snake in seminatural and agricultural wetlands. Population Ecology 61: 141-149.

Schumer, G., E.C. Hansen, P.J. Anders, and S.M. Blankenship. 2019. Development of a quantitative polymerase chain reaction assay and environmental DNA sampling methods for giant gartersnake (*Thamnophis gigas*). PLoS ONE 14: e0222493. https://doi.org/10.1371/journal.pone.0222493.

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

Service. 2012. Giant garter snake (*Thamnophis gigas*) 5-Year review: summary and evaluation. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office. Sacramento, California. June 2012.

Service. 2017. Recovery plan for the giant garter snake (*Thamnophis gigas*). U.S. Fish and Wildlife Service, Region 8. Sacramento, California. September 28, 2017.

[SJCOG] San Joaquin Council of Governments. 2018. San Joaquin County Multi-Species Habitat Conservation and Open Space Plan 2018 Annual Report. December 31, 2018.

Stitt, E.W., P.S. Balfour, T. Luckau, and T.E. Edwards. 2005. The southern watersnake (*Nerodia fasciata*) in Folsom, California: history, population attributes, and relation to other introduced watersnakes in North America. Prepared for U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office. Roseville, California. April 11, 2005.

U.S. Department of Agriculture. 2019. National Agricultural Statistics Service Quick Stats. Accessed 24 October 2019.

Wack, R.F., E.C. Hansen, C.K. Johnson, and R. Poppenga. 2017. Bacterial flora of the giant garter snake (*Thamnophis gigas*) and valley garter snake (*Thamnophis sirtalis fitchi*) in the Central Valley of California. Western Wildlife 4: 61-71.

[Westervelt] Westervelt Ecological Services. 2019a. Colusa Basin Mitigation Bank 2018 monitoring report. Sacramento, California. March 2019.

Westervelt. 2019b. Sutter Basin Conservation Bank 2018 annual monitoring report. Sacramento, California. May 8, 2019.

Wildlands. 2018a. Ridge Cut Giant Garter Snake Conservation Bank – 2017 monitoring report. Rocklin, California. February 2018.

Wildlands. 2018b. Giant Garter Snake Survey 2018 Annual Report. Rocklin, California. November 2018.

Wildlands. 2018c. Gilsizer Slough South Giant Garter Snake Conservation Bank Phases I & II – 2017 monitoring report. Rocklin, California. February 2018.

Wildlands. 2018d. Gilsizer Slough Giant Garter Snake Preserve – 2018 annual report. Rocklin, California. December 2018.

Wildlands. 2018e. Gilsizer Slough North Giant Garter Snake Preserve – 2017 monitoring report. Rocklin, California. February 2018.

Wood, D.A., B.J. Halstead, M.L. Casazza, E.C. Hansen, G.D. Wylie, and A.G. Vandergast. 2015. Defining population structure and genetic signatures of decline in the giant gartersnake (*Thamnophis gigas*): implications for conserving threatened species within highly altered landscapes. Conservation Genetics 16:1025-1039.

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

[Zentner] Zentner Planning & Ecology. 2019. Westlake Villages Eleventh Year (2019) Mitigation Monitoring Report. Prepared for Shin Kee Wetland and Habitat Restoration Project, LLC. Oakland, California. November 2019.

Personal Communications

Volkoff, M. and T. Jensen. 2019. California Department of Fish and Wildlife, Invasive Species Program. Meeting with Lily Douglas, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service on 25 October 2019. Subject: *Nerodia* eradication effort.

In Litteris

Balfour, P. 2016. ECORP Consulting, Inc. Email to Ken Sanchez, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service, dated March 9, 2016. Subject: northern watersnake.

Bonham, C. 2019. California Department of Fish and Wildlife. Memorandum to Melissa Miller-Henson, Executive Director, Fish and Game Commission, dated November 14, 2019. Subject: Agenda item for December 11, 2019, Fish and Game Commission meeting re: request for notice authorization amending sections 550, 550.5, 551, 552, 630, and 702, Title 14, CCR, regulations for public use of Department of Fish and Wildlife lands; designation of Ecological Reserves and a Wildlife Area.

Burger, H. 2017. Stillwater Sciences. Technical Memorandum to Brian Janowiak, Nate Hershey, and Tina Anderson, MBK Engineers, dated June 2, 2017. Subject: Jersey Island Levee Bank Protection Project: pre-construction survey methods and results for stations 390+00 to 475+00.

Halstead, B.J. 2018. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station. Report submitted to Field Office Recovery Permit Coordinator, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service. Title: 2018 Comprehensive Project Report to USFWS.

Halstead, B.J. 2019. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station. Report submitted to Field Office Recovery Permit Coordinator, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service. Title: 2019 Comprehensive Project Report to USFWS for Permit TE-157216-4.

Hansen, E.C. 2016. Consulting Environmental Biologist. Letter addressed to Daniel Marquez, U.S. Fish and Wildlife Service, and Laura Patterson, California Department of Fish and Wildlife, dated March 1, 2016. Subject: Summary of activities conducted pursuant to U.S. Fish and Wildlife Service Recovery Permit 10(a)(1)(A) TE-018177-7 and Department of Fish and Wildlife Scientific Collecting Permit 003881.

Hansen, E.C. 2017. Consulting Environmental Biologist. Email to Laura Patterson, California Department of Fish and Wildlife, dated June 5, 2017. Subject: Bacon garter snakes.

Kieli, E.P. and M. Lindley. 2017. Environmental Science Associates. Memorandum to Abigail Fateman, East Contra Costa County Habitat Conservancy dated August 18, 2017. Subject: Knightsen Wetland Restoration and Flood Protection Project – Assessment and Studies Plan.

Mitchell, J. 2015. Swaim Biological Inc. Report submitted to Jenny Marr, California Department of Fish and Wildlife dated April 27, 2015. Title: Gray Lodge Water Supply Project – quarterly compliance report.

Mitchell, J. 2019. Swaim Biological Inc. Report submitted to Juan Torres, California Department of Fish and Wildlife and Kellie Berry, U.S. Fish and Wildlife Service dated November 22, 2019. Title: Quarterly Compliance Report – Gray Lodge Wildlife Area Water Supply Project.

Wylie, G.D. 2012. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station. Report submitted to Field Office Recovery Permit Coordinator, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service. Title: 2012 annual summary report to USFWS.

Wylie, G.D. 2013. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station. Report submitted to Field Office Recovery Permit Coordinator, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service. Title: Annual recovery permit report 2013.

Wylie, G.D. 2014. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station. Report submitted to Field Office Recovery Permit Coordinator, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service. Title: 2014 annual summary report to USFWS.

Wylie, G.D. 2015. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station. Report submitted to Field Office Recovery Permit Coordinator, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service. Title: 2015 annual summary report to USFWS.

Wylie, G.D. 2016. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station. Report submitted to Field Office Recovery Permit Coordinator, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service. Title: 2016 annual summary report to USFWS.

Wylie, G.D. 2017. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station. Report submitted to Field Office Recovery Permit Coordinator, Sacramento Fish and Wildlife Office, U.S. Fish and Wildlife Service. Title: 2017 annual summary report to USFWS.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW

Giant gartersnake (*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: Sacramento Fish and Wildlife Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Sacramento Fish and Wildlife Office

Approve____ Date 06/10/2020

Appendix A – Recent publications on the giant gartersnake, prepared for 2019 5-year review.

Brehme C.S., S.A. Hathaway, and R.N. Fisher. 2018. An objective road risk assessment method for multiple species: ranking 166 reptiles and amphibians in California. Landscape Ecology 33:911-935.

This assessment utilized risk scoring based on a suite of life history and space-use characteristics associated with negative road effects. Species were ranked into five relative categories of road-related risk. The giant gartersnake was determined to be at very high risk of negative road impacts, primarily due to concerns with aquatic habitat connectivity.

Ersan, J.S.M. 2015. Diet and prey preference of giant gartersnakes (*Thamnophis gigas*) in the Sacramento Valley of California. M.S. thesis, California State University, East Bay. December 2015.

Using laboratory and field studies, this work examined dietary choices of the giant gartersnake. The responses of naïve neonates of wild-caught adult females to olfactory cues and simultaneous prey availability were observed. In the olfactory trial, neonates demonstrated a preference for native Sierran treefrogs (*Pseudacris sierra*) over non-native bullfrogs (*Lithobates catesbeianus*) and fish. They also exhibited a negative response towards the California kingsnake (*Lampropeltis californiae*), a native predator, but substantially less towards adult bullfrog. In the consumption trial, neonates selected tadpoles over fish, but did not exhibit a preference for treefrog tadpoles over bullfrog tadpoles. In the field, adult giant gartersnakes were palpated to regurgitate their stomach contents. They were found to select frogs over fish. When fish were consumed, cyprinids were more likely to be selected, and centrarchids and mosquitofish were least likely to be selected.

Halstead, B.J., G.D. Wylie, and M.L. Casazza. 2013. Efficacy of trap modifications for increasing capture rates of aquatic snakes in floating aquatic funnel traps. Herpetological Conservation and Biology 8:65–74.

This paper evaluated modifications in existing trap techniques to increase the detection and capture probabilities of giant gartersnakes. Adding a one-way valve constructed of cable ties to the small funnel opening of traps and adding hardware cloth extensions to the wide end of funnels was found to increase capture rates by 5.55 times relative to unmodified traps.

Halstead, B.J., G.D. Wylie, and M.L. Casazza. 2014. Ghost of habitat past: historic habitat affects the contemporary distribution of giant garter snakes in a modified landscape. Animal Conservation 17: 144-153.

Occupancy modeling, with an emphasis on historic and contemporary landscape variables, found that proximity to historic tule marsh best explained the probability of occurrence of giant gartersnakes in the Sacramento Valley. The authors suspect that this relationship may be caused by dispersal limitations of the giant gartersnake. They recommend that this relationship be taken into account when considering preservation or restoration of habitat for the snake.

Halstead, B.J., S.M. Skalos, M.L. Casazza, and G.D. Wylie. 2015. A preliminary investigation of the variables affecting the distribution of giant gartersnakes (*Thamnophis gigas*) in the Sacramento Valley, California. U.S. Geological Survey Open-File Report 2015-1178. http://dx.doi.org/10.3133/ofr20151178

This report reiterated the negative effect of distance to historic tule marsh on the probability of occurrence of giant gartersnakes. The authors suggest that this relationship may be caused by dispersal limitations of the giant gartersnake or due to extirpation of giant gartersnakes from areas farther from historic tule marsh. It is also possible that historical riparian forest represented a barrier to dispersal into otherwise suitable habitat. Further, a negative effect of submerged vegetation was observed in or near historic tule marsh, but reversed with increased distance away. The probability of occurrence of giant gartersnakes was also found to be negatively affected by relative fish count, but the cause of this relationship is unclear.

Halstead, B.J., S.M. Skalos, M.L. Casazza, and G.D. Wylie. 2015. Realized detection and capture probabilities for giant gartersnakes (*Thamnophis gigas*) using modified floating aquatic funnel traps. U.S. Geological Survey Open-File Report 2017-1200. http://dx.doi.org/10.3133/ofr20151200

This study validated the adequacy of detection and capture probabilities achieved with the modified floating aquatic funnel trap design in order to statistically evaluate occupancy, abundance, and survival of giant gartersnakes.

Halstead, B.J., S.M. Skalos, G.D. Wylie, and M.L. Casazza. 2015. Terrestrial ecology of semi-aquatic giant gartersnakes (*Thamnophis gigas*). Herpetological Conservation and Biology 10: 633-644.

This study found that individual giant gartersnakes spend more than half their time in terrestrial habitats during the summer. Giant gartersnakes were found underground more than half the time when in terrestrial habitats in the early afternoon, with an increased probability of being underground during extreme temperatures. The average giant gartersnake was found within 30 meters of water, with 95% of observations within 10 meters. The average individual underground during the summer, or a female snake during the winter, has a 10% probability of being more than 20 meters from water. However, individual variation between snakes was high, and models predicted that some individuals could be found as far as 174 meters from water.

Halstead, B.J., G.D. Wylie, and M.L. Casazza. 2015. Literature review of giant gartersnake (*Thamnophis gigas*) biology and conservation. U.S. Geological Survey Open-File Report 2015–1150. http://dx.doi.org/10.3133/ofr20151150

Prepared in cooperation with the California Department of Water Resources, this comprehensive literature review includes a collection of the known biology and conservation of the giant gartersnake through 2015.

Halstead, B.J., G.D. Wylie, M.L. Casazza, E.C. Hansen, R.D. Scherer, and L.C. Patterson. 2015. A conceptual model for site-level ecology of the giant gartersnake (*Thamnophis gigas*) in the Sacramento Valley, California. U.S. Geological Survey Open File Report 2015-1152. http://dx.doi.org/10.3133/ofr20151152

A Bayesian network model was developed in order to quantify giant gartersnake responses to site-level management decisions. High survival, high prey availability, and high habitat quality were found to be important for the best possible outcome for the snake. The demographic parameters of adult survival, first-year survival, and fecundity were found to most influence population growth, with both types of survival strongly influenced by water availability and the proportion of emergent vegetation. The authors suggest topics for additional research to further inform subsequent versions of the model.

Halstead, B.J., P. Valcarcel, G.D. Wylie, P.S. Coates, M.L. Casazza, and D.K. Rosenberg. 2016. Active season microhabitat and vegetation selection by giant gartersnakes associated with a restored marsh in California. Journal of Fish and Wildlife Management 7: 397-407.

This study examined activity patterns and microhabitat selection of adult female giant gartersnakes using radiotelemetry in and around Gilzier Slough, in Sutter County. The snakes were found to be 14.7 times more likely to be active when in aquatic habitats than when in terrestrial habitats. The snakes positively selected microhabitats associated with cover, particularly emergent vegetation, terrestrial vegetation, and litter. The most strongly selected vegetation type was tules (*Schoenoplectus acutus*), perhaps due to the fact that giant gartersnakes are more able to move among the single, round stems, and downed stems provide stable, horizontal basking surfaces from which snakes can easily escape predators by dropping into the water below. Conversely, the flat leaves of cattails (*Typha* spp.) do not provide the same structure conducive to locomotion and horizontal basking. Although water-primrose can clog waterways and may exclude giant gartersnakes when forming a dense monoculture, in this study, giant gartersnakes were found to select water-primrose, likely due to active control restricting the plant to wetland and canal edges. Both rock and rice were avoided.

Halstead, B.J., D.A. Wood, L. Bowen, S.C. Waters, A.G. Vandergast, J.S.M. Ersan, S. M. Skalos, and M.L. Casazza, 2017. An evaluation of the efficacy of using environmental DNA (eDNA) to detect giant gartersnakes (*Thamnophis gigas*). U.S. Geological Survey Open-File Report 2017-1123. https://doi.org/10.3133/ofr20171123

Evaluating both laboratory and field samples, this study concluded that further development is needed before eDNA sampling is a viable option for detecting giant gartersnakes. The authors failed to detect giant gartersnake DNA in most laboratory and all field samples. Possible reasons considered are the snake's keratinized skin and extensive time spend in the terrestrial environment, as well as hot, sunny, and turbid water conditions.

Halstead, B.J., J.P. Rose, G.A Reyes, G.D. Wylie, and M.L. Casazza. 2019. Conservation reliance of a threatened snake on rice agriculture. Global Ecology and Conservation 19: e00681.

This study identified the giant gartersnake as a conservation-reliant species. Adult giant gartersnake survival was found to have a positive relationship with the amount of ricelands available. Although snakes were found to use rice fields themselves minimally and only between mid-June and early

September, they may benefit from the fields providing nutritional subsidies to prey species in adjacent canals and/or dispersing predators. However, ricelands provide suboptimal habitat for giant gartersnakes, due to incongruency of water availability with the snake's active season and the potential for mortality due to management practices. Survival was found to be lowest in spring, as snakes emerge from brumation in March and April, but ricelands aren't flooded until mid-May.

Hansen, E.C., R.D. Scherer, G.C. White, B.G. Dickson, and E. Fleishman. 2015. Estimates of survival probability from two populations of giant gartersnakes in California's Great Central Valley. Copeia 103: 1026-1036.

This study used capture-recapture data from populations north and south of the Natomas Cross Canal to estimate survival probability and evaluate hypothesized causes of variation between individuals and years. Female giant gartersnakes in ricelands north of the canal were found to have a higher survival probability than males, but no correlation with snout-to-vent length (SVL) was indicated. A negative correlation between survival and the amount of precipitation between April 15 and May 15 in a year was observed. Within the Natomas Basin, survival probability was found to be positively correlated with SVL, with weaker support for females having higher survival probability than males.

Hansen, E.C., R.D. Scherer, E. Fleishman, B.G. Dickson, and D. Krolick. 2017. Relations between environmental attributes and contemporary occupancy of threatened giant gartersnakes (*Thamnophis gigas*). Journal of Herpetology 51: 274-283.

In this study, occupancy of giant gartersnakes was found to be strongly and positively associated with canal density and the proportion of rice and perennial wetland. A possible relationship with soil order was modeled, with estimated occupancy over five times greater on alfisols, molisols, and vertisols, which are associated with hydric conditions due to frequent flooding, than on entisols and inceptisols, which drain rapidly and are associated with elevation and coarse deposition by floodwaters. The authors suggest that giant gartersnakes may avoid areas based on chemotactic selection of the geochemical attributes of different soil orders.

Reyes, G.A., B.J. Halstead, J.P. Rose, J.S.M. Ersan, A.C. Jordan, A.M. Essert, K.J. Fouts, A.M. Fulton, K.B. Gustafson, R.F. Wack, G.D. Wylie, and M.L. Casazza. 2017. Behavioral response of giant gartersnakes (*Thamnophis gigas*) to the relative availability of aquatic habitat on the landscape. U.S. Geological Survey Open-File Report 2017-1114. https://doi.org/10.3133/ofr20171141.

See Halstead et al. 2019. In addition, this study found that giant gartersnakes spent little time in rice fields themselves and avoided ricelands relative to their availability on the landscape, but were strongly associated with the canals surrounding riceland. Distance from water had a positive effect on survival, likely due to the protection from predators afforded by being underground when away from water. Adult female giant gartersnakes exhibited less frequent and shorter movements with decreased area of ricelands. It was estimated that on average, giant gartersnakes spend half of their active season within a 325 meter-long stretch of canal. The mean home range observed was less than 4 hectares. Adult giant gartersnakes also demonstrated site fidelity among years. Core areas and home ranges were not influenced by the proportion of ricelands, suggesting that giant gartersnakes don't disperse into new habitat when the availability of aquatic habitat decreases. The amount of ricelands available was found to have no influence on the health of giant gartersnakes.

Rose, J.P., J.S.M. Ersan, G.A. Reyes, B. Gustafson, A.M. Fulton, K.J. Fouts, R.F. Wack, G.D. Wylie, M.L. Casazza, and B.J. Halstead. 2018. Findings from a preliminary investigation of the effects of aquatic habitat (water) availability on giant gartersnake (*Thamnophis gigas*) demography and reproduction in the Sacramento Valley, California, 2014-2017. U.S. Geological Survey Open File Report 2018-1114. https://doi.org/10.3133/ofr20181114.

Agricultural canals near rice fields were sampled at eight sites in the Sacramento Valley over 4 years in order to investigate the effect of the availability of ricelands on the demography of the giant gartersnake. Abundance and apparent survival varied among sites, with mean annual apparent survival estimated to be 0.40. The probability that a female was gravid and litter size were positively related to SVL. Female giant gartersnakes grew faster than males, and growth rates varied more among years than among sites.

Rose, J.P., J.S.M. Ersan, G.D. Wylie, M.L. Casazza, and B.J. Halstead. 2018. Construction and analysis of a giant gartersnake (*Thamnophis gigas*) population projection model. U.S. Geological Survey Open File Report 2017-1164. https://doi.org/10.3133/ofr20171164.

The results of this work have been published separately as the following four papers.

Rose, J.P., B.J. Halstead, G.D. Wylie, and M.L. Casazza. 2018. Spatial and temporal variability in growth of giant gartersnakes: plasticity, precipitation, and prey. Journal of Herpetology 52: 40-49.

This study observed variation in growth rate between individual giant gartersnakes collected from eight sites in the Sacramento Valley from 1995-2016. Male giant gartersnakes are smaller than females, but approach their maximum size at a faster rate. In this study, females were also estimated to reach sexual maturity at 3 years. Growth rate was found to be positively related to the abundance of anurans at individual sites, as well as the amount of precipitation in the prior water year. The authors suggest increased precipitation could increase the abundance of prey or insects supporting the prey, or make more water available for planting rice, increasing habitat availability. Slower giant gartersnake growth was found with greater abundance of fish, except when frog abundance was low.

Rose, J.P., J.S.M. Ersan, G.D. Wylie, M.L. Casazza, and B.J. Halstead. 2018. Reproductive frequency and size-dependence of fecundity in the giant gartersnake (*Thamnophis gigas*). Herpetological Conservation and Biology 13: 80-90.

Using X-radiography, the reproductive status and estimated fecundity of 73 female giant gartersnakes from the Sacramento Valley were compared to those of captive snakes. Average total litter size was 15.9 for wild-caught snakes and 15.5 for captive, but captive-born litters had high rates of stillbirth. Fecundity was positively related to SVL. The proportion of gravid females was 0.50 in 2014, 0.47 in 2015, and 0.64 in 2016, perhaps affected by the 2012-2015 drought.

Rose, J.P., G.D. Wylie, M.L. Casazza, and B.J. Halstead. 2018c. Integrating growth and capture-mark-recapture models reveals size-dependent survival in an elusive species. Ecosphere 9: e02384. doi: 10.1002/ecs2.2384.

The study utilized Bayesian hierarchical models to estimate giant gartersnake survival. A positive relationship between giant gartersnake SVL and annual survival was strongly supported. Survival was also positively related to the cover of emergent and floating wetland vegetation and precipitation. The authors recommend focusing management actions to increase the survival of large adult female giant gartersnakes.

Rose, J.P., J.S.M. Ersan, G.D. Wylie, M.L. Casazza, and B.J. Halstead. 2019. Demographic factors affecting population growth in giant gartersnakes. The Journal of Wildlife Management 1-12. doi: 10.1002/jwmg.21728.

Using data collected from 13 populations over 22 years, integral projection models were developed for the giant gartersnake. The survival, growth, and fecundity of large adult females were found to most influence population growth, with survival having the greatest influence in most scenarios. The relative importance of juvenile versus adult somatic growth was dependent on recruitment, but in developing the models, the authors found that little is known about recruitment.

Scherer, R.D., E.C. Hansen, M. Joseph, and R.F. Wack. 2019. Estimating relationships between size and fecundity in the threatened giant garter snake in seminatural and agricultural wetlands. Population Ecology 61: 141-149.

Fecundity data collected on 258 female giant gartersnakes throughout the Central Valley over nine years was analyzed to evaluate differences between seminatural and agricultural (rice) wetlands. No differences in the probability of being pregnant or the number of fetuses were observed between the two environments. Larger females were found to be more likely to be gravid, and if gravid, produce more fetuses. The probability of a female of average SVL (728 mm) being gravid was 0.237, increasing to 0.964 for the largest female (1,144 mm SVL). The probability of females shorter than 631 mm SVL was <0.10. The average litter size was found to be 14, with the largest females averaging 34 fetuses. Preliminary analyses of additional data suggest that female snakes may grow more quickly in areas dominated by ricelands than in seminatural wetlands.

Schumer, G., E.C. Hansen, P.J. Anders, and S.M. Blankenship. 2019. Development of a quantitative polymerase chain reaction assay and environmental DNA sampling methods for giant gartersnake (*Thamnophis gigas*). PLoS ONE 14: e0222493.

This study reports on the development of an assay successfully used in field eDNA sampling to detect the giant gartersnake. At the location of a known population, samples positively detected the giant gartersnake 300 meters downstream of the source. Surveys in the San Joaquin Valley detected giant gartersnakes at 28 of 52 sampled locations. The authors suggest that this method may be used to assess occupancy at greater efficiency and less cost than known trapping methods, particularly areas with low detection probability.

Wack, R.F., E.C. Hansen, C.K. Johnson, and R. Poppenga. 2017. Bacterial flora of the giant garter snake (*Thamnophis gigas*) and valley garter snake (*Thamnophis sirtalis fitchi*) in the Central Valley of California. Western Wildlife 4: 61-71.

The bacterial flora of giant gartersnakes and valley gartersnakes captured at four separate locations in the Central Valley was investigated. No significant differences in the number of isolates was observed between species or location, but significantly more isolates were recovered from the skin than the mouth or cloaca, including many potential human and reptile pathogens. The authors recommend that people working in areas with these snakes should take precautions to reduce their exposure to these potential pathogens.

Wood, D.A., B.J. Halstead, M.L. Casazza, E.C. Hansen, G.D. Wylie, and A.G. Vandergast. 2015. Defining population structure and genetic signatures of decline in the giant gartersnake (*Thamnophis gigas*): implications for conserving threatened species within highly altered landscapes. Conservation Genetics 16:1025-1039.

This study estimated contemporary giant gartersnake population structure and diversity using microsatellite loci. Five genetic clusters were identified, with three northern basins forming a single genetic cluster. The results demonstrated higher connectivity between the northern drainage basins than among central and southern basins and greater differentiation between isolated populations in the central and southern basins. Evidence of population bottlenecks and low effective population size estimates were detected in about half of the populations sampled.