Chapter 3
Giant Garter Snake

3.1 Background

The NBHCP and its Implementing Agreement require that an annual survey of giant garter snake be conducted throughout the Basin (Chapter VI, Section E [2][a][2] of the 2003 NBHCP). An annual assessment of canals and ditches that provide connectivity between giant garter snake habitats is also required (Chapter VI, Section E [2][a][5]) of the 2003 NBHCP). In compliance with the conditions described in the NBHCP, this chapter summarizes the results of monitoring efforts for giant garter snake in the Basin.

In 2001, TNBC contracted with the U.S. Geological Survey (USGS) to conduct giant garter snake surveys, emphasizing the collection of distribution and demographic information needed to guide the conservation and management of giant garter snake under the NBHCP (Wylie et al. 2000, 2001, 2002, 2003, 2004). Monitoring—with an emphasis on distribution and abundance of giant garter snakes on TNBC reserves—continued through 2003. The information collected by USGS, such as trap locations, length of deployment, and capture information, has been incorporated into this report where appropriate to allow for comparison of results across time (Wylie et al. 2000, 2001, 2004).

3.2 Goals and Objectives

Monitoring efforts were conducted in accordance with protocols developed specifically to meet the goals and objectives of the NBHCP. The main objectives of the giant garter snake monitoring effort as described in the NBHCP are listed below.

- To evaluate whether the conservation objectives of the NBHCP are being met.
- To detail the progress of NBHCP implementation with respect to giant garter snake and the wetland reserve system.
- To evaluate the habitat potential of mitigation lands proposed for acquisition.

- To aid in decision making for improving and adapting reserve design and management to better meet the needs of giant garter snake.

Ancillary objectives include determining the following.

- Presence and relative abundance in the reserve system's wetland habitats.
- Presence and relative abundance in rice field habitat compared to managed marsh habitat.
- Relative abundance in constructed marshes of different designs.
- The information needed for more focused studies on life history variables, absolute population size, or habitat use.

This monitoring effort employs a strategy for addressing giant garter snake presence and abundance in the aforementioned habitat types, while collecting the data necessary for more focused ecological studies conducted in a standardized, repeatable fashion. Monitoring is also necessary to evaluate the relative success of giant garter snake habitat restoration efforts. Restoration efforts are designed to increase a habitat's ability to support target species, providing an opportunity to measure the species' response to habitat manipulation. Because efforts to restore giant garter snake habitat throughout its range have only recently begun, little information is available to guide the restoration process. In order to develop appropriate restoration protocols for this species, all restoration efforts should incorporate careful evaluation of species response at prescribed benchmarks to facilitate adaptive management.

3.3 Life History

Giant garter snake is an aquatic species endemic to the Great Central Valley of California. Described as among California's most aquatic garter snakes (Fitch 1940), giant garter snakes are associated with low-gradient streams and valley floor wetlands and marshes, and have adapted successfully to rice agriculture. Giant garter snake is one of the largest species in the genus *Thamnophis*. A sexually dimorphic species, females can exceed lengths of 1 meter (39.37 inches) and weights of 0.9 kilogram (1.98 pounds), while proportionately smaller males are slightly shorter and seldom exceed 0.25 kilogram (0.55 pound). Originally considered a subspecies of *Thamnophis ordinoides* (Fitch 1940), giant garter snake has undergone a lengthy series of taxonomic revisions and was finally accorded full species status in the late 1980s on the basis of morphological and distribution data (Rossman and Stewart 1987). This classification was subsequently supported by genetic analyses (Paquin 2001).

3.3.1 Status and Range

Giant garter snake (Figure 3-1) was listed by DFG as threatened on June 27, 1971, under the California Endangered Species Act and by USFWS on October 20, 1993, under the federal ESA (58 FR 54053). The species is considered vulnerable by the World Conservation Union (IUCN) (Baillie 1996).

The Natomas Basin supports one of the 13 extant giant garter snake subpopulations recognized by USFWS (U.S. Fish and Wildlife Service 1999). USFWS states that protection of the giant garter snake population in Natomas Basin is a *Priority 1* recovery task, defined as "an action, which must be taken to prevent extinction or to prevent a species from declining irreversibly" (U.S. Fish and Wildlife Service 1999).

Giant garter snake once ranged throughout the wetlands of California's Central Valley from Buena Vista Lake near Bakersfield in Kern County to the vicinity of Chico in Glenn and Colusa Counties (Hansen and Brode 1980). Giant garter snake appears to have been extirpated from the San Joaquin Valley south of Mendota in Fresno County (Hansen and Brode 1980; Rossman and Stewart 1987; Stebbins 2003). The current known distribution of the species is patchy, extending from near Chico in Butte County to Mendota Wildlife Area in Fresno County. Current locality records indicate that within this range, giant garter snakes are distributed in unique population clusters coinciding with historical flood basins, marshes, wetlands, and tributary streams of the Central Valley (Hansen 1980; Brode and Hansen 1992; U.S. Fish and Wildlife Service 1997, 1999). These populations are isolated, lack protected dispersal corridors to other adjacent populations, and are threatened by land use practices and other human activities—particularly development of wetland and suitable agricultural habitats.

Loss or degradation of aquatic habitat resulting from agricultural and urban development is the primary cause of these declines. Other factors contributing to the decline of this species include predation of juvenile giant garter snakes by introduced predators, elimination of prey species by pesticides, road mortality, and maintenance and modification of agricultural water conveyance and reclamation infrastructure.

Selenium contamination and impaired water quality have also been identified as threats to giant garter snakes, particularly in the southern portion of their range (U.S. Fish and Wildlife Service 1999). While limited data are available regarding the effects of specific contaminants, the bioaccumulative properties of selenium in the food web have been well documented in the Kesterson National Wildlife Refuge area (Ohlendorf et al. 1988; Saiki and Lowe 1987; Saiki and May 1988; Saiki et al. 1991; U.S. Fish and Wildlife Service 1999). Efforts to measure levels of selenium and mercury in giant garter snake populations in the Sacramento Valley are currently underway; these efforts include samples from the Natomas Basin (Wack pers. comm.).

3.3.2 Habitat Use

Habitats occupied by giant garter snakes contain permanent or seasonal water, mud bottoms, and vegetated dirt banks (Fitch 1940; Hansen and Brode 1980). Prior to reclamation, these wetlands probably consisted of freshwater marshes and low-gradient streams. In some rice-growing areas, giant garter snakes have adapted well to vegetated, artificial waterways and the rice fields they supply (Hansen and Brode 1993).

Giant garter snakes are associated with aquatic habitats characterized by the following features.

- Sufficient water during the snake's active season (typically early spring through mid-fall) to supply cover and food such as small fish and amphibians.
- Emergent herbaceous wetland vegetation such as cattails and bulrushes accompanied by vegetated banks, which together provide basking, foraging, and escape cover during the active season.
- Upland habitat (e.g., bankside burrows, holes, and crevices) to provide short-term refuge areas during the active season.
- High ground or upland habitat above the annual high water mark to provide cover and refuge from flood waters during the dormant winter period (Hansen and Brode 1980; Hansen 1998).

The species appears to be absent from most permanent waters that support established populations of predatory game fishes; from streams and wetlands with sand, gravel, or rock substrates; and from riparian woodlands lacking suitable basking sites, prey populations, and cover vegetation (Hansen 1980; Rossman and Stewart 1987; Brode 1988; U.S. Fish and Wildlife Service 1999). The species also appears to be absent from natural or artificial waterways that undergo aggressive mechanical or chemical weed control or compaction of bank soils (Hansen 1988; Hansen and Brode 1993).

In the Central Valley, rice fields have become important habitat for giant garter snakes. Irrigation water typically enters the ricelands during April along canals and ditches. Giant garter snakes use these canals and their banks as permanent habitat both for spring and summer active behavior and for winter hibernation. Where these canals are not regularly maintained, lush aquatic, emergent, and streamside vegetation develops prior to the snakes' spring emergence. This vegetation, in combination with cracks and holes in the soil, provides much-needed cover during spring emergence and throughout the remainder of the summer active period.

Rice is planted during the spring after the winter fallow fields have been cultivated and flooded with several inches of standing water. In some cases, giant garter snakes move from the canals and ditches into these rice fields soon after the rice plants emerge above the water's surface, and continue to use the fields until the water is drained during late summer or fall (Hansen and Brode 1993). It appears that the majority of giant garter snakes move back into the canals and ditches as the rice fields are drained, although a few may overwinter in the fallow fields where they hibernate in burrows in the small berms separating the rice checks (Hansen 1998).

While in the rice fields, the snakes forage in the shallow warm water for small fish and larvae of bullfrogs and treefrogs. For shelter and basking sites, giant garter snakes utilize the rice plants; small, vegetated berms dividing the rice checks; and vegetated field margins. Gravid (pregnant) females may be observed in the rice fields during the summer; at least some giant garter snakes are born there (Hansen and Brode 1993; Hansen 1998).

Water is drained from the fields during the late summer or fall by a network of drainage ditches. These ditches are sometimes routed alongside irrigation canals, and are often separated from the irrigation canals by narrow vegetated berms that may provide additional shelter. Remnants of old sloughs may be present in rice-growing regions, where they serve as drains or irrigation canals. Giant garter snakes may use vegetated areas along any of these waterways as permanent habitat.

3.3.3 Movement

Giant garter snakes are strongly associated with aquatic habitats, typically overwintering in burrows and crevices near their active season foraging areas (Hansen 2004a, 2004b). Individuals have been noted using burrows as far as 50 meters (164 feet) from marsh edges during the active season, and retreating as far as 250 meters (820 feet) from the edge of wetland habitats while overwintering, presumably to reach hibernacula above the annual high water mark (Hansen 1986; Wylie et al. 1997; U.S. Fish and Wildlife Service 1999).

3.3.4 Ecological Relationships

Giant garter snakes are aquatic feeders that prey on small fishes, tadpoles, and small frogs (Fitch 1941; Hansen 1980; U.S. Fish and Wildlife Service 1999), specializing in ambushing prey underwater (Brode 1988). Historically, giant garter snakes probably preyed on native species such as thick-tailed chub, Pacific treefrog, Sacramento blackfish, and California red-legged frog (which has been extirpated from the species' current range) (Cunningham 1959; Rossman et al. 1996; U.S. Fish and Wildlife Service 1999). Giant garter snakes now utilize introduced species such as small bullfrogs and their larvae, carp, and mosquitofish. While juveniles probably consume insects and other small invertebrates, giant garter snakes are not known to consume larger terrestrial prey (e.g., small mammals or birds).

Predators of giant garter snakes include large vertebrates such as raccoon, striped skunk, red fox, gray fox, river otter, opossum, Northern harrier, hawks, herons, egrets, and American bittern (U.S. Fish and Wildlife Service 1999). In areas near urban development, giant garter snakes may also fall prey to domestic or feral housecats (Hansen pers. comm.).

Nonnative bullfrogs are known to prey directly on juvenile giant garter snakes throughout their range (Treanor 1983; Dickert 2003; Wylie et al. 2003). While the extent of this predation and its potential effect on populations is poorly understood, preliminary data from a study at Colusa National Wildlife Refuge suggest that 22% of neonate giant garter snakes succumb to bullfrog predation (Wylie et al. 2003). Studies of bullfrog predation on snakes have documented bullfrogs ingesting other species of garter snakes up to 0.8 meter (31.5 inches) long, resulting in a depletion of this age class within the subject population, which experienced alternating resurgence and decline coinciding with fluctuations in the local bullfrog population (Bury and Wheelan 1984). Introduced predatory game fishes such as black basses, striped bass, catfishes, and sunfish probably prey on giant garter snakes and compete with them for smaller prey (Hansen 1988; U.S. Fish and Wildlife Service 1993).

Giant garter snakes coexist with valley garter snakes (*T. sirtalis fitchi*); in limited instances, both may be found with mountain garter snake (*T. elegans elegans*) where the latter species' range extends to the Central Valley floor. The extent of competition among these species is unknown, but it is likely that differences in habitat use and foraging behavior allow their coexistence (Brode 1988; U.S. Fish and Wildlife Service 1999).

3.4 Assessment of Populations

Documented occurrences of giant garter snakes in the Natomas Basin have been collected from a variety of sources, including the California Natural Diversity Database, monitoring and project reports, and published and unpublished notes and reports. The distribution of these occurrences are shown in Figure 3-2.

3.4.1 Methods

Surveys for giant garter snake were conducted throughout the Natomas Basin from the time of warming temperatures in April until rice fields dried and temperatures decreased in late September. All canals, ditches, or drains within the Natomas Basin that were accessible by either public ownership or specific right of entry were surveyed for giant garter snake presence and habitat potential. In some instances, survey duration was limited by trap theft and tampering at areas of public access (e.g., West Drainage Canal), or by variable water and habitat conditions (e.g., Fisherman's Lake). All aquatic habitats within the Basin were investigated periodically throughout the survey; however, intensive daily efforts were confined to areas possessing at least marginal habitat value for giant garter snake. Person hours ranged from 8 to 30 per day.

Study design combined the comprehensive visual survey and aquatic trapping methodologies applied by previous investigators, with more weight given to trapping surveys conducted in accordance with USGS methodology (Hansen and Brode 1980; Hansen 1988; Brode and Hansen 1992; Wylie et al. 2004). A passive aquatic trapping approach was favored because this approach increases the proportion of time spent sampling an area and facilitates the recapture of individuals necessary to assess population numbers. Active visual surveys were conducted during all reconnaissance and trap-checking efforts, but were not the mainstay of sampling during the first year of monitoring. All sampling for giant garter snake was conducted from April 25 to September 25, 2004.

Active Surveys

Active surveys are visual encounter surveys entailing walking or boating along linear ditches, drains, ponded areas, managed marshes, and adjacent uplands to search for basking, mating, and foraging snakes. Binoculars were used to detect wary snakes at a distance. When possible, snakes discovered during these searches were captured by hand or with reptile snares to collect data for demographic analyses. When capture was not possible, information regarding location, activity, ambient conditions, and environmental characteristics was recorded. Although visual encounter surveys were conducted in 2004, permanent visual transects were not established due to personnel and access limitations. Therefore, the majority of visual surveys were conducted incidental to trap placement, trap checking, and site reconnaissance.

Passive Surveys

Passive surveys involve the use of traps and were conducted in conjunction with active surveys. A set of 400 floating aquatic traps was divided into eight lines of 50 traps each and deployed along selected linear transects. Traps were placed at approximately 10-meter (33-foot) intervals along areas of linear aquatic habitat (canals, ditches, and drains) or the vegetation/open water interface of ponded or marshy habitat. Resulting transects were approximately 500 meters (1,640 feet) long. GPS units were used to record the UTM coordinates of each unique trap location, and environmental characteristics, such as vegetation and substrate types, were noted for each point. Trap design and placement were modeled after methods refined by USGS (Casazza et al. 2000). Permanent reference and rotating trapping strategies were used. The locations of 2004 traplines are shown juxtaposed with 2000–2003 trapline locations in Figure 3-3.

The study design involved the use of three reference traplines and five rotating traplines. Reference traplines are by definition left in place throughout the snakes' active season, and are useful for several reasons. Permanent reference sites increase the probability of recapture of individuals through time, resulting in better estimates of survival and recruitment within the local population. Reference sites can also provide better information regarding species response to changing habitat conditions over time than do non-reference traplines, thereby developing information to inform adaptive management. Finally, reference sites provide information on seasonal variation in giant garter snake activity that short-term trap transects cannot.

The Natomas Basin is subdivided into three regions by major highways: Area 1 is north of Interstate (I)-5 and west of State Route (SR) 99; Area 2 is south and west of I-5 and north of I-80; and Area 3 is east of I-5, east of SR 99, and north of I-80 (Figure 3-4). One permanent reference trapline was established in each area; two remained in place until the end of the sampling season, and one was removed prematurely due to deteriorating habitat conditions. Reference sites were established in areas likely to remain viable as habitat during the term of the NBHCP permits, with emphasis placed on areas where capture and habitat history were previously documented by USGS (e.g., Snake Alley, T Drain, Fisherman's Lake) (Figure 3-4).

The remaining five traplines were rotated at set intervals across predetermined locations on both reserve lands and non-reserve lands throughout the Basin. Whenever possible, transects were sampled twice to further account for seasonal variability of giant garter snake activity. Emphasis was given to reserve lands over non-reserve lands by design and as a result of limited access to private properties throughout the Basin. Where canals or ditches were present next to managed marsh, transects were placed in parallel (both ditch and marsh) to detect movement between these features.

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

Habitat Characteristics

Dominant terrestrial and aquatic vegetation, cover type and percentage, and hydrographic profile were documented within a 1-meter (3.3-foot) radius of all trap and capture locations to examine giant garter snake habitat use. In late July 2004, protocols were modified to include a classification of slope at each trap location to examine whether giant garter snake presence varies with slope and the proximity of upland refugia. Except in instances where traps had been tampered with or where an overabundance of crayfish necessitated the daily emptying of trap contents, prey composition and density were also documented for each trapline in an effort to correlate these factors with capture success.

Marking and Measuring

Weight, total length, snout to vent length, sex, scale counts and measurements on head and midbody, and other physical features such as scars and tumors were noted for all snakes captured. Captured snakes were implanted with passive integrated transponder (PIT) tags for permanent identification. In some cases, blood was drawn to examine mercury and selenium levels. All snakes were released at their point of capture after recording data.

Population and Density Estimates

The FORTRAN software program CAPTURE (White et al. 1978; White et al. 1982) was used to estimate population size on the basis of capture histories of marked individuals within hydrologically isolated areas. Because most giant garter snake habitat exists in the form of linear water conveyance features, and because all traplines were placed along these ditches and drains, population estimates were converted to a measure of linear density as the number of snakes present per kilometer (0.62 mile) of linear habitat. A linear index of density was chosen because the rotation of rice fields through active and fallow periods makes an index based on surface area seasonally inconsistent and therefore impractical. Accordingly, methods for estimating densities are consistent with those applied by USGS in previous studies of giant garter snake within the Natomas Basin (Wylie et al. 2000, 2001, 2004).

Survey Locations

Reserve Lands

Extensive sampling was conducted throughout TNBC reserves, with greater emphasis on managed marshes. Reserves were not sampled where aquatic habitat was not available, or where visual exposure or accessibility by the general public put traps at risk of theft or tampering that could result in unauthorized "take" of giant garter snake. The Alleghany 50, Cummings, Souza, Brennan, and Ruby Ranch and Huffman Reserves were not trapped, although visual surveys were conducted where aquatic habitat was available.

Non-Reserve Lands

Fisherman's Lake

Because Fisherman's Lake is adjacent to the Souza/Natomas Farms and Cummings Reserves and has historical significance as giant garter snake habitat, the portion of the lake south of Del Paso Road was selected as the site for the Area 2 reference line (Brode and Hansen 1992; Wylie et al. 2000a) (Figure 3-4). Traps were placed in three clusters in enclosed wetland vegetation; they remained from June 29 to August 7, when they were removed due to diminished water levels and excessive encroachment by yellow water primrose.

Metro Air Park

Although the Metro Air Park (MAP) HCP area was sampled routinely by USGS from 2000 through 2003, construction activities precluded trapping within the MAP HCP area during 2004. Current plans call for drainages within MAP to be abandoned or converted to underground pipe, rendering them unsuitable as permanent sampling sites. Lone Tree Canal (Figure 3-4) will remain outside the western edge of the MAP HCP area, providing regional drainage and serving as a conduit for giant garter snakes dispersing from north to south. Due to its importance as a migratory corridor, one transect was established in the Lone Tree Canal; theft and tampering resulted in this trapline's early and permanent removal during 2004 (Figure 3-4).

Snake Alley

The ditch referred to as *Snake Alley* is situated in northern Sacramento County east of SR 99. This site has been sampled by USGS since 1998 (Wylie et al. 2000, 2001, 2004). Because it has been monitored intensively over the years and is located in near the BKS Reserve, this site was selected as one of the permanent reference sites (Figure 3-4).

Sacramento County Airport System

Access was granted by the Sacramento County Airport System (SCAS) to trap for giant garter snakes on all SCAS properties within the Basin, including the fenced Airport Operational Area (AOA). Outside the AOA, traps were divided into two 50-trap transects, consistent with methods employed elsewhere in the Basin. Within the AOA, escorts were required at all times. In order to maximize geographic coverage under this constraint, traps were divided into four 25-trap transects (Figure 3-4). With one exception, all transects remained in place for 14 days. Unfortunately, all traps in the West Drainage Canal were stolen, decreasing this undertaking to 9 days of sampling effort on SCAS property south of I-5. Due to the risk of continued theft, these traps were not replaced.

3.4.2 Results

A total of 152 observations of giant garter snakes were recorded during 2004. Of these, 137 were captures of live snakes: 68 females and 69 males. The live snakes comprised 86 verified individuals; 18 of these individuals were captured multiple times. Of the 86 individuals captured, six—five females and one male—were marked in previous years by USGS. Giant garter snakes were observed for the first time in constructed wetlands on TNBC reserve lands, comprising 16 observations of 13 individuals. The balance of recorded observations consisted of mortalities and sightings during active surveys. Of the mortalities, four individuals were found dead on roads and two were found dead along ditches, the apparent victims of predation. The locations of captures for the 2004 surveys are shown in Figure 3-5.

Reserve Lands

Souza/Natomas Farms, Cummings, and Alleghany 50

No giant garter snakes were observed on reserve lands south of I-5. This may be due to the fact that construction of the managed marshes on the Souza/Natomas Farms and the Cummings properties was only completed in 2003 and 2004, respectively. However, giant garter snakes have been captured in managed marshes on other reserve lands shortly after construction (e.g., Lucich North/Frazer). Survey results suggest that the population of snakes in the southwest portion of the Basin is very small; if this is true, then recolonization of newly constructed habitats should not be expected to occur rapidly. One 50-trap transect, comprising 4,500 trap days, was dedicated to the Souza/Natomas Farms property for the duration of the season, and a 500-trap-day effort was expended in the Kimura Ditch along the southern edge of Natomas Farms (Figure 3-3). Fluctuating water levels caused by efforts to find a leak in the newly constructed wetland made trapping problematic because these fluctuations moved the water's edge significantly from day to day. Trapping took place for 100 days between May 15 and September 18 in six distinct transects.

One valley garter snake was captured in the northwest wetland in May, and several were observed dead along Del Paso Road south of the reserve.

Atkinson and Ruby Ranch

No giant garter snakes were observed within the Atkinson Reserve. Trapping was carried out for a single rotation comprising 750 trap days in the Highline Canal adjacent to the North Drainage Canal (Figure 3-3). During 2003, two giant garter snakes were caught in the Highline Canal in 725 trap days, but none were caught in the adjacent North Drainage Canal after 406 trap days (Hansen 2003c). In both 2003 and 2004, surveyors observed a number of trespassers on the Ruby Ranch parcel, and did not place traps on the parcel for fear of tampering or theft that could result in unauthorized "take" of giant garter snake. Visual encounter surveys were conducted within and along the edges of the Highline Canal and along the edge of the North Drainage Canal, but no giant garter snakes were observed.

Ayala

No giant garter snakes were observed within the Ayala reserve. Trapping was conducted for two rotations, comprising 1,500 trap days (Figure 3-3). In consultation with TNBC, it was decided to discontinue transects on this parcel after the first rotations in favor of sampling in constructed wetlands elsewhere in the Basin. Visual encounter surveys were conducted within and along the edges of the wetland and along the edges of ditches and rice fields, but no giant garter snakes were observed.

Bennett North, Bennett South, and Lucich South

In Bennett North, the trapping effort consisted of 2,950 trap days, comprising 1,450 trap days in constructed wetland and 1,500 trap days in linear ditches (Figure 3-3). Four individual giant garter snakes were captured along the western edge of the newly constructed wetland; these were the first such captures in this location (Figure 3-5). No giant garter snakes were captured in ditches. Visual encounter surveys were conducted along wetland, ditch, and rice field edges. One shed skin, identified as that of a giant garter snake by measuring intact labial scales, was found protruding from the riprap surrounding the inlet pipe along the western edge of the wetland near Sankey Road.

In Bennett South, the trapping effort consisted of 3,000 trap days, comprising 1,350 trap days in constructed wetland and 1,650 trap days in linear ditches (Figure 3-3). Two individual giant garter snakes were captured along the eastern edge of the newly constructed wetland; these were the first such captures in this location. Five giant garter snakes were captured in the ditch at the western edge of the property, fewer than were captured in 2003 (Wylie et al. 2004) (Table 3-1, Figure 3-5). Visual encounter surveys were conducted within and along the edges of the wetland and along the edges of ditches and rice fields; one large, gravid female was found dead along the ditch. Wounds around the neck and head suggested predation, possibly by a river otter, a number of which were observed in the area during this time.

In Lucich South, the trapping effort consisted of 4,500 trap days, comprising 1,850 trap days in constructed wetland, 750 trap days along the edge of rice fields, and 1,900 trap days in the North Drainage Canal (Figure 3-3). Two individual giant garter snakes were captured along the eastern edge of the newly constructed wetland; these were the first such captures in this location. Twelve giant garter snakes were captured in the North Drainage Canal on the eastern edge of the property; one of these snakes had been marked by USGS in 2003 (Figure 3-5). Capture success in the North Drainage Canal was similar to that of previous years (Wylie et al. 2003, 2004) (Table 3-1). No giant garter snakes were captured in traps along the edge of the rice field. Visual encounter surveys were conducted in and along the edges of the wetland and along the edges of ditches and rice fields; one female giant garter snake was captured underwater along a steep, well-planted bank along the west edge of the wetland.

Betts-Kismat-Silva

Two transects were deployed in the ditch along the west edge of the Silva parcel, and two were deployed in the ditch extending north from water control structure K (Figure 3-3). This trapping effort consisted of 2,350 total trap days. Four individual giant garter snakes were trapped at the west edge of the Silva parcel and two north of water control structure K (Figure 3-5). As in previous years, giant garter snakes were observed only in these preexisting linear water conveyance features (Wylie et al. 2001, 2002, 2004).

One rotating transect was dedicated to this reserve for the duration of the season, consisting of 3,500 trap days in constructed wetlands (seasonal marsh, perennial marsh, and potholes, Figure 3-3). Visual encounter surveys were conducted in and along the edges of the wetlands, but no additional giant garter snakes were trapped or observed.

Brennan

No trapping was conducted on the Brennan parcel due to a lack of suitable aquatic habitat. Both the North Ditch and Curry Creek dried entirely during the giant garter snake active season. Visual encounter surveys were conducted along the edges of rice fields, but no giant garter snakes were observed.

Frazer and Lucich North

In Frazer, the trapping effort consisted of 2,200 trap days, comprising 1,450 trap days in constructed wetland and 750 trap days in the ditch along the toe of the Natomas Cross Canal (Figure 3-3). Three individual giant garter snakes were captured in traps: two near the northwestern corner and one near the southwestern corner of the newly constructed wetlands (Figure 3-5). One giant garter snake was captured during visual encounter surveys along the northern edge of the newly constructed wetland. These were the first such captures in these locations. No giant garter snakes were captured in the ditch along the toe of the Natomas Cross Canal; capture success was similar to that of previous years (Wylie et al. 2004) (Table 3-1).

In Lucich North, the trapping effort consisted of 10,100 trap days, comprising 2,900 trap days in constructed wetland and 7,200 trap days in the T Drain (Figure 3-3). Thirty-nine individual giant garter snakes were captured in the T Drain (Figure 3-5); two of these snakes had been marked by USGS in 2002, and one had been marked and recaptured by USGS in 2002 and 2003. Capture success was similar to that of previous years (Wylie et al. 2003, 2004) (Table 3-1). One individual giant garter snake was captured along the northwestern edge of the newly constructed wetland during visual encounter surveys; this was the first such capture in this location.

Sills Ranch

In Sills Ranch, the trapping effort consisted of 2,300 trap days in the Lateral 3C at the western edge of the property and the drain running from east to west in the center of the property (Figure 3-3). Two giant garter snakes were trapped in the Lateral 3C, and one was observed during visual encounter surveys in the east/west drain in the center of the property (Figure 3-5). Capture success was similar to that of previous years (Wylie et al. 2004) (Table 3-1).

Non-Reserve Lands

Fisherman's Lake

In Fisherman's Lake, the trapping effort consisted of 2,000 trap days in emergent vegetation south of Del Paso Road (Figure 3-3). One giant garter snake, a gravid female, was captured (Figure 3-5). Although this transect was intended as a reference site, rapidly advancing yellow water primrose and diminishing water levels forced removal of these traps after only 40 days. Two valley garter snakes were also trapped here. Visual encounter surveys were conducted in and along the edges of the channel proper; no giant garter snakes were observed by this method.

MAP

The trapping effort consisted of 602 trap days at Lone Tree Canal south of the Central Main Canal (Figure 3-3). Due to persistent problems with tampering and theft, traps were removed prematurely and were not returned for a second rotation. No giant garter snakes were trapped.

Two giant garter snakes—one male and one female—were detected during visual encounter surveys. They were observed in the Central Main Canal immediately west of its intersection with Lone Tree Canal in late April prior to setting traps.

Snake Alley

The trapping effort consisted of 5,650 trap days in Snake Alley (Figure 3-3). Nine individual giant garter snakes were captured, a capture rate similar to that of 2003 (Wylie et al. 2004) (Figure 3-5). Although USGS has captured and marked giant garter snakes in this location since 1998, only one that carried a PIT tag was captured. However, the surveyors could find no record of this individual, indicating that it had likely been captured and marked prior to 2000.

Sacramento County Airport System

The trapping effort consisted of 2,875 trap days inside the fenced portion of the AOA and 2,335 trap days at locations on SCAS properties outside the AOA (Figure 3-3). No giant garter snakes were trapped in any of these areas during these surveys.

A large female giant garter snake with unborn young was found dead on Powerline Road at the Flume crossing immediately east of SCAS property and north of the AOA. Sacramento International Airport (SMF) Wildlife Coordinator Chris Martin found a dead giant garter snake on May 10; Mr. Martin contacted the survey team to report the find. The snake was an adult female marked in 2003 by USGS in Meister Ditch east of Powerline Road. She was found submerged in the Airport East Ditch along the Airport East Runway north of Meister Road. Wounds around the neck and head suggested predation, tentatively attributed to river otters frequently observed at the site.

Habitat Characteristics

Information on slope was collected at 25 locations in created wetlands where giant garter snakes were captured. Sixteen of the 25 captures (64%) occurred in traps placed adjacent to banks with slopes exceeding 3:1; 11 of these 16 occurred adjacent to slopes exceeding 1:1. All nine capture locations characterized by slopes shallower than 3:1 occurred at the open water interface along the densely vegetated margins of deep channel edges within 10 meters (33 feet) of banksides characterized by dense vegetative cover, belowground retreats, or riprap.

An abundance of giant garter snake prey species was observed during trapping and survey efforts and in giant garter snake traps. Amphibian prey species included both larval and postmetamorphic bullfrogs and Pacific treefrogs. Prey fish species included a variety of bass, sunfish, common carp and other minnows, and mosquitofish. Prey species observed and their numbers and density at each trapline for which data were collected are summarized in Table 3-2.

Population and Density Estimates

Hansen and Brode (1993) estimated a local population size of 1,000 snakes per 2.6 square kilometers (1 square mile) of ricelands based on year-to-year mark-recapture rates (U.S. Fish and Wildlife Service 1999). USGS (Wylie et al. 2000a, 2000b, 2001, 2002, 2004) reported linear densities ranging from 8 (95% C.I. = 6–12) to 55 (95% C.I. not reported) giant garter snakes per linear kilometer from 1999 to 2003. Results from 2004 range from 11 (95% C.I. = 5–25) to 66 giant garter snakes per linear kilometer (95% C.I. = 15–188). Linear densities reported for 1999 through 2004 are summarized in Table 3-1.

Trapping results from 2004 provided enough information to estimate density for four locations: the Silva West Ditch on the BKS Reserve, the T drain on the Lucich North Reserve, the North Drainage Canal on the Lucich South Reserve, and Snake Alley.

The density estimate for the Silva West Ditch on the BKS reserve was 11 ± 3.78 (95% C.I. = 5–25) for 2004, down from 48 (95% C.I. = 30–98) in 2003. Likewise, density estimates from Snake Alley were lower in 2004 than in previous years. Conversely, density estimates from Lucich North indicate a continuing increase over the last 4 years, and estimates from Lucich South indicate a similar increase.

General Observations

Numerous valley garter snakes were captured throughout the season both in floating aquatic traps and by hand. Other snakes observed included California kingsnake, western yellow-bellied racer, and Pacific gopher snake. Captures of snakes other than garter snakes were entirely incidental and are not discussed further in this document.

As in previous seasons, river otters were noted in most regions of the study area. River otters are known to kill giant garter snakes without consuming them (Wylie pers. comm.) and are suspected in several giant garter snake mortalities throughout the species' range, including two incidents in the Natomas Basin during 2004 (Hansen unpublished notes).

3.4.3 Discussion

Capture Success

Despite a significant increase in trapping effort, fewer individual snakes were captured in 2004 than in 2003 (Wylie et al. 2004), (Table 3-3). Eighty-six individual giant garter snakes were captured in 2004, while USGS captured 101 individuals in 2003. The total capture success in the 2004 effort, expressed as individuals per trap day, was 0.0016, while that of USGS was 0.0025. Capture success, therefore, has decreased 36% from 2003. This does not, however, necessarily indicate a Basin-wide decline in giant garter snakes. Capture numbers in some areas increased in 2004; for instance, 13 individual giant garter snakes were captured in newly created wetlands on reserve lands where they had not been documented previously.

The reduction in capture success may be explained by differences in the sampling approach. While the sampling effort increased by 10,533 trap days (21.4%) over the 2003 season, the proportional effort expended in newly created managed marshes increased from 10.3% to 31.3%; in other words, more time was spent in areas where snakes were less likely to be trapped, and perhaps less likely to have become established. Furthermore, the 2004 effort was constrained by reduced access to areas that yielded a significant number of captures in previous years. For example, neither the interior of MAP nor the canal referred to as *Airstrip* west of Snake Alley were trapped due to access constraints; together, these areas yielded 30 individual giant garter snakes, or 27.9% of the snakes captured by USGS during 2003 (Wylie et al. 2004). Moreover, more traps were placed in areas not previously sampled to gain baseline information on areas that have not been recently sampled (e.g., Fisherman's Lake, SMF; see Table 3-1); the likely result of these methodological differences is a reduction in catch per unit effort.

Accordingly, comparisons of results should be made on a reach-by-reach basis in areas where 2004 sampling overlaps that of previous investigators. Both the T Drain and Snake Alley were selected as reference sites to facilitate such comparison, as were the majority of transects established in drainages next to reserve lands.

Demographics

The average size of giant garter snakes captured during 2004 was smaller (indicating younger animals) than that of individuals captured from 2000 to 2003 (Table 3-4). With the exception of female giant garter snakes captured in 2000 and 2001, the size—and, by inference, the age—of giant garter snakes indicate a general decrease in each successive monitoring year. Hansen and Brode (1993) found that of 191 giant garter snakes captured in the Basin during the late 1980s and early 1990s, males averaged 665 millimeters (26.2 inches) (n = 75) snout-vent length (SVL) with an average mass of 139 grams (4.9 ounces) (n = 74), while females averaged 886 millimeters (34.9 inches) (n = 116) SVL with an average mass of 434 grams (15.3 ounces) (n = 115) (U.S. Fish and Wildlife Service 1999). Of the 73 giant garter snakes measured in 2004, males averaged 505 millimeters (19.9 inches) (n = 34) SVL with an average mass of 77 grams (2.7 ounces) (n = 34), while females averaged 592 millimeters (23.3 inches) (n = 39) with an average mass of 145 grams (5.1 ounces) (n = 39). These data may suggest a significant decrease in the size and age distribution of giant garter snakes in the Basin.

This apparent trend could also be due to differences in sampling methodology. The hand-capture technique employed by Hansen and Brode (1993) likely selected for larger and more readily observable snakes, while the aquatic trapping utilized between 2000 and 2003 probably selects for smaller individuals (U.S. Fish and Wildlife Service 1999). Despite the disparity that may be attributed to different methodologies, results of trapping surveys during the past five seasons suggest a potential decrease in the median age of giant garter snakes (Table 3-4). Such a trend warrants consideration. Fecundity (the number of offspring produced) in this species is positively correlated with size; larger snakes produce more offspring (Hansen and Hansen 1990). Any decrease in the average size and age of female giant garter snakes would result in diminished recruitment, affecting the viability of the giant garter snake population in the Basin over time.

Habitat Characteristics

Giant garter snakes require upland habitat with grassy banks for basking adjacent to aquatic habitat (U.S. Fish and Wildlife Service 1999). Studies have shown that giant garter snakes prefer aquatic habitat with banks riddled with cracks, rodent burrows, and crayfish burrows, and that they typically do not occupy areas devoid of these characteristics (Brode and Hansen 1992; Hansen and Brode 1993). In created marshes on some reserve lands, a seasonal wetland zone created by a gradual (e.g., 5:1) slope tends to separate these bankside features from the edge of the open water channels during dry summer conditions. This separation increases the distance between aquatic and suitable upland habitats and may raise the risk of predation, potentially reducing the site's suitability. Moreover, because these seasonal wetlands are subject to periodic flooding, they may not develop the characteristics of suitable bankside habitat. Generally, bankside areas where slopes approach 2:1 provide bankside habitats more contiguous with the open water channels, supporting the two primary active season habitat requirements in close proximity.

Population/Density Estimates

Density estimates from 2004 may indicate some significant trends in giant garter snake populations. However, because these data were collected in an agricultural water conveyance system, the estimates must be interpreted cautiously. The population/density estimators used in program CAPTURE assume the population being sampled is a closed population; that is, that neither immigration nor emigration occurs during the sampling period. Clearly, water conveyance features are highly interconnected, not only to one another but also to the rice fields they serve. Giant garter snakes are highly mobile, and vary significantly in their activity over time and between years. Therefore, the assumptions of the population/density estimators are violated and the resulting estimates are biased to an unknown degree.

In addition to the problems summarized above, the conversion of population estimates to indices of linear density may also be problematic. The conversion to linear density is a reasonable approach because traplines are established along linear ditches and channels. However, these linear segments typically lie adjacent to rice fields, wetlands, uplands, or other ditches that are also used by giant garter snakes. Linear analysis fails to account for movement of snakes between habitats or outside the boundaries of the linear segment defined by the trapline. Density indices projected by area, however, would be of little long-term value due to the dynamic nature of rice farming and the practice of fallowing and crop rotation. Indices of linear density that are based on the more permanent water conveyance infrastructure, on the other hand, are more likely to produce consistent long-term results. Unfortunately, there are few, if any, alternatives. While population and density estimates may be imprecise or biased, taken in context they are still useful for analyzing general trends.

Finally, caution must be taken when comparing results across years. Results from reference sampling conducted during the full 5-month sampling period show that population projections vary significantly depending on the timing and duration of the sampling period. For example, analyses of data from the T Drain for each month of the season produced population estimates ranging from 27 (S.E. 12.3472; 95% C.I. = 14–95) to 8 (S.E. 0.8831; 95% C.I. = 8–11), while that pooled for the entire season produced a population estimate of 46 (S.E. 3.8662; 95% C.I. = 42–58). This may be due in part to seasonal variation in snake activity as well as variation in density due to changes in the distribution of suitable habitat through time (e.g., as snakes move into rice fields as vegetation matures and becomes more suitable). Analyses of seasonal densities in the T Drain provide some support for this possibility: the lowest population estimate coincides with the diminished capture success experienced Basin-wide during July (Figure 3-6).

3.5 Connectivity Assessment

Changing agricultural regimes, development, and other shifts in land use create an ever-changing mosaic of available habitat. In response to such changes, giant garter snakes move to find suitable sources of cover and prey. Connectivity between regions is consequently vital for maintaining access to available habitat and for genetic interchange. In an agricultural setting, giant garter snakes rely largely for such connectivity on the network of canals and ditches that provide irrigation and drainage. The canals and ditches in the study area serve an important role in giant garter snake movement, providing a critical linkage among reserves and other suitable habitats. The importance of these connective corridors was explicitly recognized in the NBHCP, which calls for an assessment of connective corridors throughout the Basin (Chapter VI, Section E (2)(a)(5) of the 2003 NBHCP).

3.5.1 Methods

Field evaluation of connective corridors was conducted by driving along canals, ditches, or drains within the Basin that were accessible by either public ownership or specific right of entry. Potential connective corridors were identified by reference to aerial, topographic, and hydrographic maps. Potential corridors that could not be accessed directly were identified from adjacent roadways through binoculars and photographed using a digital camera with a telephoto lens. If a corridor could be viewed from one or both ends, but could not be viewed along its entirety, it was assumed that observed conditions were continuous throughout.

Segments were defined along all ditches and drains on the basis of habitat conditions. Each segment was scored using several habitat variables; the total scores were used to quantitatively assess habitat suitability using a hierarchical classification of known giant garter snake habitat correlates. Impediments to giant garter snake movement, such as roadways, culverts, and zones of urban development, were noted and mapped. Habitat scoring criteria used in the evaluation were drawn mainly from the *Draft Recovery Plan for the Giant Garter Snake* (U.S. Fish and Wildlife Service 1999) and adapted for use in GIS analyses. The location of each segment was digitized on screen to create a GIS layer, which was then attributed with the segment's habitat scores. The results of this analysis were used to identify potential dispersal corridors for giant garter snake, and will be used as the foundation for more quantitative analyses of giant garter snake habitat suitability and connectivity in the future.

Preliminary classification values are based on factors discussed in both published and unpublished literature, as well as the personal experience of the biologists involved in the current effort (Hansen and Brode 1980; Brode 1988; Hansen 1988; U.S. Fish and Wildlife Service 1999; Hansen 2001a, 2001b; Wylie et al. 2001). The preliminary habitat valuation categories are defined below. Point breaks between the valuation categories are based on generalized giant garter snake habitat and ecological requirements and are, consequently, somewhat arbitrary.

Suitable habitat is characterized by all the features necessary to support permanent populations of garter snakes, as listed below.

- Sufficient water during the active summer season to supply cover and food such as small fish and amphibians; emergent, herbaceous aquatic vegetation; and vegetated banks to provide basking and foraging habitat.
- Bankside burrows, holes, and crevices to provide short-term aestivation sites.
- High ground or upland habitat above the annual high water mark to provide cover and refugia from floodwaters during the dormant winter season (Hansen and Brode 1980; Hansen 1988).

Marginal habitat is characterized by any combination of those features listed above needed to support transient giant garter snakes on a temporary basis, or to act as connective corridors between areas of more stable or desirable habitat. This habitat need only possess the water, vegetation, and refugia required to provide minimal coverage for dispersing snakes. Marginal habitat is incapable of supporting permanent populations of giant garter snakes and is typically ephemeral, providing no permanent source of prey.

Unsuitable habitat is devoid of the water, vegetation, and/or refugia necessary to support giant garter snakes for any extended time. Such habitat is generally composed of small roadside ditches, gunite drains, or temporary swales that contain no water during the active spring and summer seasons. Unsuitable habitat corridors are no more likely to support giant garter snakes than any non-aquatic environment; if giant garter snakes are present in such habitats, it is only by chance.

The point range assigned to each valuation category is shown below.

Habitat Value	Point Range
Unsuitable	0–7
Marginal	8–12
Suitable	13–21

3.5.2 Results

General

Habitat variables were documented and scored throughout the majority of the Basin, with some gaps remaining in areas that could not be accessed directly or viewed from a distance. Gaps in the analysis lie mostly in the area surrounding the Teale Bend Golf Course and Reservoir Road west of SMF and reaches east of SR 99 between Elverta Road and Elkhorn Boulevard. The resulting figure (Figure 3-7) indicates the relative quality of connective corridors in the Basin and identifies features (generally box or pipe culverts) linking regions otherwise separated by major roadways or urban development.

The most significant corridors spanning the Basin from north to south are the primary drainages managed by Reclamation District 1000; these include the North Drainage Canal, East Drainage Canal, West Drainage Canal (including Fisherman's Lake), and Main Drainage Canal, all of which the NBHCP has identified as most likely to remain during the permit term. Habitats east and west of SR 99 are at minimum linked through culverts by the V Drain, R Drain, H1 Drain, and Central Main Canal; each of these connects to a series of ditches, drains, and canals in their respective regions. Habitats north and south of I-5 are linked through culverts by the West Drainage Canal, the N Drain (parallel to Powerline Road), and the Lone Tree Canal. The West Drainage Canal passes north under I-5 from the Fisherman's Lake area to west of SMF, where it lies disconnected from other hydrologic features. The N Drain and Lone Tree Canal pass north under I-5 to the west and east of MAP, respectively, where each connects to a series of ditches, drains, and canals linked throughout the Basin. Several of these features are threatened by development.

Metro Air Park

MAP is a 756.7-hectacre (1,870-acre) industrial and commercial development project situated directly east of the SMF between I-5 and Elverta Road. Except for the West Drainage Canal, all aquatic migration corridors originating in Area 1 south of I-5 pass through MAP before entering the AOA and Area 1 to the north. The Meister Canal flows into SMF at the southern edge of the AOA, where it connects via culvert to the Airport East Ditch. Both these ditches support giant garter snakes (California Natural Diversity Database 2004; Wylie et al. 2004;

Hansen unpublished notes) and provide a potential migration corridor to habitat north of Elverta Road via the Airport East Ditch and Powerline Ditch.

Projected future hydrologic conditions indicate that drainage or agricultural flows between MAP and SMF may lack connectivity. As currently planned, drainage from MAP will be directed south and east, away from the SCAS properties. MAP will eliminate the Powerline Ditch, No. 4 and 4a Ditches, and Meister Canal (West Yost 2004). MAP will also eliminate water sources to the Airport East Ditch, which could potentially become dry during summer months (West Yost 2004). Such drying could result in the loss of critical north-south migration corridors and the degradation or loss of giant garter snake habitat (i.e., Meister Ditch and Airport East Ditch) within SMF and adjacent SCAS properties.

Without connectivity across the AOA, habitat adjacent to MAP (e.g., the section of Meister Ditch west of Powerline Road) may act as a sink for giant garter snakes displaced there by development.

MAP drainage plans also include replacing the open Central Main Canal with an underground pipe. This will eliminate connectivity to the Flume and the Pullman Highline, both of which connect southern giant garter snake populations to the Prichard Lake Wetland Restoration Area. Only the P Drain, P4 Drain, and Lambert Ditch will provide connectivity to the Prichard Lake Wetland Restoration Area from the northern end of the AOA.

Sutter SOI

At the boundary between Sacramento and Sutter Counties, the proposed footprint of the South Sutter County Specific Plan will bisect the Natomas Basin from Steelhead Creek to the North Drainage Canal west of SR 99 (El Centro Boulevard). These changes will affect the movement of giant garter snakes from lost or degraded habitat in the southern Basin to mitigation and reserve lands in Sutter County.

While the footprint will not bisect the entire width of the Basin, the impact on giant garter snake may be the same as if it did. The footprint extends west to the North Drainage Canal, and will interrupt all other canals between that canal and the eastern boundary of the study area. Any remaining ricelands or water conveyance infrastructure to the west could be affected by wastewater effluent, increased human activity, and urban infrastructure.

3.5.3 Discussion

To achieve the goals and objectives of the NBHCP with respect to giant garter snake, it is critical that areas of suitable habitat be interconnected. If aquatic connectivity is lost, the system of reserve lands could become isolated patches of habitat separated from one another by expansive tracts of urban land that block the snakes' passage between them. Reserves would then have to have the capacity to support snake populations large enough to maintain genetic diversity. On small reserves, giant garter snake fitness could be reduced by the loss of genetic variation associated with inbreeding that results from small populations or gene pools.

Genetic divergence can potentially occur in a short time and may result from seemingly simple impacts, such as widened roads. Genetic research conducted by Melanie Paquin at California State University San Francisco in conjunction with USGS indicates that variation of this kind may have already occurred to some extent in giant garter snakes in areas separated by the major highways that transect the Basin (Paquin 2001).

The discrete numeric data collected for each habitat segment associated with linear water conveyance features can be used for detailed modeling of connective corridors based on habitat suitability. Modeling of this nature will be conducted as the dataset is completed to test hypotheses concerning the suitability of potential migratory routes throughout the Basin.

3.6 Effectiveness

Biological effectiveness is measured on the basis of acquisition of reserve lands and land management activities designed to meet the goals and objectives outlined in the NBHCP for giant garter snake.

As noted above in *Habitat Characteristics*, preliminary data collected in 2004 are consistent with the hypothesis that giant garter snakes are more abundant where upland habitats with terrestrial vegetation and abundant cracks or burrows are in close proximity to aquatic habitats.

After consultation with the biological effectiveness monitoring team and in accordance with their recommendations, TNBC modified the design of the Cummings Reserve west of Fisherman's Lake in the southern portion of the Natomas Basin to emphasize a greater proportion of steep slopes in bank construction.

During the course of the survey season, TNBC had several discussions with the biological effectiveness monitoring team concerning the potential effects of cattle grazing on giant garter snake at the BKS reserve. Although cattle were restricted to a relatively small area of wetland habitat, the concern remained that cattle have the potential to destroy crayfish and other burrows in unstable seasonal wetland areas that may be used by giant garter snake. There was also concern that cattle could potentially be the source of some of the excessively foul-smelling water noted on portions of the reserve during 2004. TNBC acted promptly to alleviate these concerns by preventing cattle from watering in wetland habitats and removing cattle from the irrigated pasture that drains into one of the ditches where excessively foul-smelling water was noted.

Giant garter snakes were captured for the first time in 2004 in created marsh habitats in the Bennett North, Bennett South, and Lucich South Reserves.

3.7 Recommendations

3.7.1 Reserve Design

- Continue to incorporate steeper slopes or other design features that increase the proximity of bankside and aquatic habitats into future reserves, as allowed for in the SSMPs.
- If monitoring data continue to support the hypothesis that steeper slopes are preferred over shallow slopes, consider retrofitting existing reserves to incorporate this feature.

3.7.2 Grazing

- In consultation with the design management team and the biological effectiveness monitoring team, TNBC should consider modifying vegetation management practices on the BKS reserve in such a way as to allow for the testing of hypotheses concerning the potential effects of grazing on giant garter snake abundance and habitat use.

Giant garter snake habitat may be negatively affected by the elimination of bankside vegetative cover caused by overgrazing by cattle (Fisher et al. 1994; Szaro et al. 1985). Overgrazing may also degrade habitat by eliminating underground and aquatic retreats such as rodent and crayfish burrows (Hansen 1986; U.S. Fish and Wildlife Service 1999). Radiotelemetry studies in perennial wetlands indicated that giant garter snakes tended to avoid otherwise suitable habitats where grazing was allowed (Hansen 2003a).

With the exception of Natomas Farms and Cummings, the BKS Reserve is the only managed marsh in the reserve system where giant garter snakes have not been found, despite 3,300 and 3,500 trap days in constructed wetlands during 2003 and 2004, respectively. The absence of giant garter snakes from these apparently suitable habitats is puzzling given the consistent presence of snakes in the ditches around and between these habitats (e.g., ditch along west edge of Silva tract, ditch extending north from water control structure K). The fact that the BKS Reserve uses grazing as a vegetation management tool while the other reserves do not suggests the hypothesis that grazing may be associated with the lack of giant garter snakes in the constructed wetlands on BKS. However, several alternative explanations are also possible.

3.7.3 Connective Corridors

- Prioritize and give high consideration to the protection of movement corridors during reserve acquisition. The canals and ditches in the Basin serve an important role in giant garter snake movement, providing a critical linkage among reserves and other occupied habitats. However, no mechanism currently exists to ensure that these movement corridors are maintained or managed to benefit giant garter snake

3.8 References

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